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Measures to Prevent, Intercept and Respond to Illicit Uses of Nuclear Material and Radioactive Sources

INTERNATIONAL ATOMIC ENERGY AGENCY

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FOREWORD

As nuclear programmes have evolved, the quantities of nuclear material in use or storage, and the number of facilities operating or shut down has increased. In particular, the dismantling of nuclear weapons has resulted in greatly increased stockpiles of weapons usable plutonium and highly enriched uranium. Concern over the security of these and related materials has been further raised by the continued occurrence of cases of illicit trafficking. The risks are theft, leading to trafficking and possible illicit use, and sabotage which could lead to the creation of radiological hazards. The challenge is threefold: prevention, detection and interception, and response. Prevention starts with effective national systems for accountancy, control and protection. Detection and interception involves effective measures to combat illicit trafficking, and response requires planning for the consequences of theft and sabotage. Responsibilities in these fields are national, but nuclear security also has a powerful international dimension. The consequences of failures in national measures reach beyond national boundaries. The effectiveness of national nuclear security can be enhanced through international measures: through agreed international norms, standards and guides, through training and advice, through information exchange and the sharing of experience, and through developing common understandings and perceptions. The Stockholm Conference contributed by focusing on the threats, including terrorist, to nuclear and other radioactive materials; on how to assess them and on how to develop the appropriate security measures. National measures to protect nuclear material and facilities and the continuing development of international standards and obligations were described. The conference discussed the patterns and trends in the illicit trafficking of nuclear and other radioactive materials and national and international measures to combat such trafficking. Finally, it considered what lessons had been learned and appropriate steps for the future.

P. Ek of the Swedish Nuclear Power Inspectorate (SKI) made a major contribution to the preparations for the conference. Sadly, he passed away shortly before it was held. All those involved in the organization of the conference wish to record their deepest sympathies to his wife and family.

The IAEA officer responsible for this publication was R. Hoskins of the Department of Safeguards.

EDITORIAL NOTE

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WELCOMING REMARKS

J. Melin
Swedish Nuclear Power Inspectorate (SKI),
Sweden

Distinguished delegates, ladies and gentlemen:

Welcome to Stockholm and to the Conference on Security of Nuclear Material. I hope you will have a pleasant stay in our capital and from the presentations and posters announced in the programme I foresee an interesting week of fruitful discussions.

Before the conference is formally opened, I would like to say a few words in memory of Paul Ek. Less than one year ago, Paul Ek took the initiative arranging this conference. Paul is not with us today as he died last April. He left behind his wife, Ann-Marie, and his children, Thomas and Regina, and their families.

For more than 30 years, Paul was devoted to issues related to the physical protection of nuclear installations and transport, to non-proliferation and to combating illicit trafficking. He became well recognized in the international community and most certainly many of you have got to know him as an appreciative colleague and friend in the different assignments he had. First of all, within the framework of the IAEA, for example as Chairman of SAGSI and later in his position at the Swedish Nuclear Power Inspectorate to support Central and Eastern Europe in combating illicit trafficking, Paul made significant achievements. He had an ability to rapidly identify areas where work was needed. He then carried out tasks with enthusiasm, professionalism and true commitment. He never deviated from his tasks or their goals, but was flexible in choosing ways to fulfil them.

I will miss Paul as a colleague in my team at SKI as well as his demanding but friendly personality. I will now ask you to join me in a minute of silence for Paul.

Now I would like to present Mr. Lars-Hjalmar Wide, Director for Global Security at the Ministry for Foreign Affairs, and Ms. Anita Nilsson, Head of the Office of Physical Protection and Material Security in the Department of Safeguards at the International Atomic Energy Agency. Mr. Wide and Ms. Nilsson will now formally open the conference, and I hereby give the floor to Mr. Wide.

L.-H. Wide
Director, Head, Global Security Department, Ministry for Foreign Affairs,
Sweden

Let me begin where Ms. Melin left off and thank Mr. Paul Ek posthumously, on behalf of the Swedish Government, for all his dedicated and successful work through the years. Mr. Ek's professionalism and persistence were decisive factors in the Government's decision to support this Conference, and to underscore our commitment to the combating of illicit trafficking by organizing it against the backdrop of the Swedish Presidency of the EU.

The Swedish government assigns a high priority to the topic of this Conference. We believe that all necessary measures must be taken in order to prevent, intercept and respond to illicit trafficking of nuclear material and other radioactive sources, a message which was reinforced in the final document of last year's NPT review conference and in several IAEA General Conference Resolutions.

The object of international co-operation in this field is our common interest in preventing nuclear proliferation, but also to protect the environment and the health of populations. These are concerns that do not respect any national borders. And nor do the kind of criminal groups, against which we must always remain vigilant. Any strategy for preventing or deterring illicit trafficking must be developed with this in mind.

It is, however, equally evident that each country has a responsibility for implementing national infrastructure. International co-ordination and co-operation for the successful combating of illicit trafficking should bear this in mind.

Therefore efforts should be made in every state to ensure that their national systems for preventing and combating illicit trafficking are adequately effective. Such a system should include co-ordinated functions and operations of authorities and nuclear facilities in a State, which all have a role to play in the State's efforts to prevent and combat illicit trafficking.

Given the international dimension of illicit trafficking it goes without saying that there is need for a degree of international co-ordination, and Sweden is very supportive of the role of the IAEA in this field. We believe that the IAEA plays an important role in co-ordinating and supporting bilateral efforts, both by assisting states to establish and implement national systems against illicit trafficking and by auditing such systems.

There are evidently certain components and instruments that are not incorporated in IAEA's programme and arsenal of procedures and tools, such as law enforcement measures, or acts of investigation and intervention. An international strategy must, therefore, also involve other international organisations, which are mandated such responsibilities, such as Interpol, Europol and the World Customs Organisation (WCO). I would like to extend a special welcome to the representatives of those institutions at this meeting.

With those comments I would like, on the behalf of the Swedish Government, to welcome you to Sweden and Stockholm and wish you all success in your important work during this week.

KEYNOTE ADDRESS

R. Ekeus
Ambassador, Chairman of the Governing Board of the
Stockholm International Peace Research Institute, (SIPRI), and
Member of the Board of Directors of the Nuclear Threat Initiative
Sweden

This conference is one of the most important initiatives in a time when the security of nuclear material has been deteriorating over the years to the serious situation that currently exists. It is high time that those able to work together to improve it joined forces and moved forward. Ever since the world learned about the devastating consequences of the atomic bomb over Japan at the end of Second World War, anxiety about proliferation of nuclear weapons has been a fact of life. This led to the conclusion of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), which came into force in 1970 and has been extended for an indefinite time.

Five nuclear-weapon States and 182 non-nuclear-weapon States (defined as such in 1970) are now parties to the treaty. However, the number of States with nuclear weapons has grown. Pakistan and India are known to have them and Israel, though it has not declared itself, can be taken as the third non-NPT nuclear-weapon State.

To recall some salient points of the NPT: under Articles I and II, the nuclear-weapon States undertake not to transfer nuclear weapons to any recipient whatsoever and the non-nuclear weapon States undertake not to receive nuclear weapons or any other nuclear explosive devices or to control such nuclear weapons directly or indirectly. Furthermore, the nuclear-weapon States undertake not to assist, encourage or induce any non-nuclear-weapon State to manufacture or otherwise acquire nuclear weapons or other nuclear explosive devices and non-nuclear weapon States undertake not to manufacture or otherwise acquire them.

The safeguards requirements of the NPT are specified in Article III, which mandates the IAEA to verify the fulfilment of the NPT obligations of the parties to the Treaty in accordance with their safeguards agreements. Article VI contains the undertaking by all parties to the Treaty (addressing, in particular, the nuclear-weapon States) to pursue negotiations in good faith on effective measures related to the early cessation of the nuclear arms race and to disarmament. The significance of these articles is highly political as it restores the balance of rights and duties between the nuclear-weapon and non-nuclear-weapon parties. Without the obligation of disarmament and its implementation, the prospect of upholding the non-acquisition commitment by the non-nuclear-weapon States would be precarious.

As a non-nuclear-weapon State, my country, Sweden, from a purely national perspective, sees its strategic and security interests best served by retaining the non-nuclear-weapon status it adopted in 1968. However, many States, especially developing countries, complain that the NPT upholds what they call nuclear apartheid, i.e. the uneven distribution of rights and duties. Therefore, for the long term health of the NPT, progress must be made under Article VI towards abolishing new nuclear weapons. Success in negotiating the Fissile Material Cut-off Treaty at least partly depends upon non-nuclear-weapon States feeling sure that nuclear-weapon States are seriously addressing the matter of tangible reductions.

Before the special UN inspection regime began its work in Iraq, the IAEA safeguards system had not been able to detect any production facilities for nuclear weapons or any major traces of a nuclear weapons programme through its inspections of declared facilities. However, in the context of the special inspections (also covering undeclared facilities and material) mandated by the Security Council in 1991, Iraq’s major nuclear weapons programme was detected. This experience shows that a State party to the NPT, having signed and ratified the treaty, does not hesitate to clandestinely gain possession of nuclear material and production equipment with the aim of acquiring nuclear weapons.

The events in Iraq exposed the weakness of the existing safeguards regime and posed the challenge of strengthening it. I recall my visit to Iraq in June-July 1991 together with Dr. Hans Blix, Director General of the IAEA, and Mr. Yasushi Akashi, UN Under-Secretary for Disarmament Affairs, the three of us facing the country's entire leadership with the exception of Saddam Hussein. We squarely questioned the Iraqi side, including Mr. Tariq Aziz, Iraq's Deputy Prime Minister, and Lt. Gen. Hussein Kamel, head of the weapons programme, about the existence of a nuclear weapons programme, which they all emphatically denied. Two months later, IAEA and UNSCOM inspectors entered a derelict building in Baghdad and found huge quantities of paper work which gave a full description of a major nuclear weapons programme in Iraq.

Although I don't believe that safeguards inspections should necessarily be so aggressive, we should be very naive to think that the old system will continue to work. The IAEA drew the right conclusions from these events, bringing about considerable improvements with the Model Additional Protocol and the safeguards strengthening measures undertaken under Dr. Blix's leadership. Now it is up to Member States to adhere to the Additional Protocol and to accept IAEA guidance on implementation. Steeled by the Baghdad experience, the IAEA carried out an impressive operation in North Korea, showing that North Korea had much to declare. So far, IAEA inspectors have not been given the complete access required but progress under the 'Agreed Framework' is quite satisfying, again to the credit of the IAEA.

In May 1998, India and Pakistan declared their nuclear weapons programmes, which alarmed the world. Also, Israel's unofficial status as nuclear-weapon State has created a psychopolitical problem, rather than a military threat, of great significance in the Middle East region and led to the Arab States abstaining from joining the Chemical Weapons Convention. Thus, retention of nuclear weapons clearly creates problems that have to be faced. The most important issue for this conference is the situation in the former Soviet Union, where State control of civil and military activities at both the central and regional level was relaxed at the end of the Cold War and has not been replaced by an effective nuclear material control regime. Moreover, the dismantling of major parts of the nuclear weapons programme led to the lay-off of highly competent scientists and technicians, who are potential recruits to illegal weapons manufacturing abroad. Economic and institutional difficulties have weakened regulatory control and law enforcement, so when it comes to prevention of criminal activities such as theft of material and equipment from nuclear facilities, the institutions responsible are not satisfactorily fulfilling their tasks. International or local terrorists could gain access to and use nuclear weapons or obtain nuclear material to manufacture such weapons.

It is well known that Pakistan succeeded in developing and manufacturing nuclear weapons by using its own uranium resources, by obtaining nuclear material from other countries, and by purchasing equipment needed for fuel enrichment and hiring experts from countries in Western Europe. The establishment of a complete and independent nuclear weapons programme by a State is a complicated, time consuming and expensive process, involving high levels of technical competence and organization of resources. Iraq's now dismantled programme is assessed to have cost more than 10 billion dollars. Here, we must differentiate between illegal manufacturing and terrorist activities. Terrorists can use simpler devices with lower precision, which means that demands on technical know-how and competence are not so great and there is no comprehensive testing. Therefore, terrorists do not leave the same fingerprints and clues in the nuclear field, which also affects detection in terms of both time and cost, increasing the overall challenge of preventing illicit trafficking.

The IAEA maintains a database, participated in by 61 Member States, on illicit trafficking of nuclear material and other radioactive sources. As of January 1999, the database contained information on 304 incidents, of which 237 had been reported by States. Most of these incidents involved unintentional trafficking of radiation sources and only a few cases involved high enriched uranium or plutonium. The development of the Pakistani nuclear weapons programme and the testing of the nuclear explosive in 1998 is an illustration of an advanced case of trafficking. It is of particular interest as it shows how export control in western industrial countries can be circumvented. In an interview on German television, the head of the Pakistan Atomic Energy Commission could openly describe how relatively easy it was to buy all the equipment needed to build a centrifuge facility for the enrichment of weapons grade uranium. He insisted that the suppliers were quite aware of what Pakistan was doing, showing that sanctions didn't work.

In the 'Swedish case', a Sprytron (used to ignite nuclear explosive devices) was smuggled from Sweden to Iran. These are dual use items, according to the trigger list. In 1998, a Sprytron was illegally exported to a nuclear research centre in Iran. The next effort to smuggle such an item, in September 1999, was unsuccessful and the smuggler was apprehended and given the heavy sentence of four months in a Swedish prison — not a great deterrent. There is also a recent unconfirmed report of illegal export of nuclear equipment from Germany to Iran. One may conclude that the known events of illicit trafficking are serious enough to call for an overall upgrade of systems for combating it, on both the national and international level.

With regard to the international non-proliferation regime, systems and procedures for prevention and deterrence need to be improved and completed. National systems for physical protection and control of nuclear material should be further developed with close co-operation between authorities and operators. More efficient communication links must be created across borders. The overall aim should be to prevent nuclear material, equipment, technology and know-how relevant to nuclear weapons manufacturing from getting into the wrong hands. Another problem is the proliferation of radioactive sources. For the safe handling and use of radiation sources, the IAEA — in co-operation with other international organizations — published the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS).

The number of incidents of unintentional trafficking with radiation sources and other non-nuclear radioactive material out of regulatory control has increased during the last decade. Salient examples are shipments of radioactively contaminated scrap metal of undefined origin, thefts of radioactive waste from intermediate storage with insufficient security arrangements, and looting of abandoned medical facilities where radioactive sources have been used. Such incidents threaten human life and health and impose considerable recovery and cleanup costs. Often the perpetrators themselves suffer serious or even fatal injuries because they have been either unaware of the presence of the radioactive material or ignorant about the radiological hazard.

The foundation for State responsibility for, and supervision of, safe and secure use of nuclear material and radiation sources is clear and complete legislation, which should be accessible to the community. Recommendations and guidelines based on the NPT have been developed under the co-ordination of the IAEA. They could be incorporated into national legislation and should be made compulsory and legally binding.

The IAEA's role is to assist States in establishing national laws and to promote their harmonization internationally. The overall aim should be to implement international standards. This is particularly important for the implementation of national systems of physical protection and for import control of nuclear material and, where applicable, radiation sources. Legislation must be supported by supervision and law enforcement measures. An important factor in nuclear legislation is identification of the responsibilities assigned to both companies and individuals. The Three Mile Island and Chernobyl accidents were caused primarily by human factors. These emergencies have demonstrated the need to maintain a high level of safety culture in nuclear operations. This is also valid for non-proliferation or safeguards measures, which must be assigned a high degree of quality assurance. The Iraq experience has led to the strengthening of safeguards with the development of additional protocols to safeguards agreements. Improvement in international safeguards depends on States' willingness to sign and ratify additional protocols, which is happening too slowly.

Illegal export of nuclear equipment, including dual use items, is a serious problem as the Pakistani case has shown. Export law based on the nuclear supply group's trigger list and IAEA recommendations gives supervision and law enforcement authorities the necessary tool to implement strict export regulations for nuclear material and equipment. In industrial countries, such as the EU States, the number of manufacturers of technical equipment is immense. Effective implementation of a system of licensing and the granting of export permits is difficult. The manufacturer of a dual use item may not even understand what the product can be used for in the nuclear context. One way of improving State export control could be to establish national registers of manufacturing programmes and enterprises, possibly with IAEA assistance and co-ordination.

Nuclear proliferators and makers of nuclear explosives need to have nuclear material and equipment and technical competence, but also special know-how. They may gain access to designs and specifications, as Pakistan did to develop its weapons programme, but they can also hire unemployed scientists and technical experts from the former Soviet Union or South Africa, for example. Also here, the IAEA should take the initiative in dealing with this difficult problem. The United States, in its co-operative threat reduction programme based upon the Nunn-Lugar legislation, has taken an impressive lead. One thousand tonnes of high rich uranium and 150 tonnes of weapon grade plutonium is estimated to exist in Russia. For the next 10 years, it is estimated that some 30 billion dollars must be mobilized to cope with the threat from this material and its potential. Therefore, improving the security of Russian nuclear facilities, providing gainful and peaceful occupation to the nuclear scientists who had been working in the nuclear cities, and ensuring the security of nuclear material are key elements in the nuclear threat reduction programme. It is high time that the EU developed a large scale, aggressive, nuclear threat reduction programme, whether in co-operation with the US initiative or independently. This is all the more important because the US administration is purported to be downsizing its programme. "Loose Nukes" are a threat to security in Europe, too, and must be seen in the context of tactical nuclear weapons. In 1991, Russia and the USA, in parallel but unilateral decisions, undertook to account for their tactical nuclear weapons and to start programmes to eliminate them. As little is known about Russia's activities here, important initiatives are called for from Europeans. It is the task of governments to include relevant sanctions and penalties in their national laws for the most serious cases of illicit trafficking, including the transfer of knowledge and know-how, which should be treated as an international crime. This also implies that States where alleged offenders are detected shall take them into custody for the purpose of prosecution or extradition.

I would like to conclude by affirming that we have seen some improvement in ways and means of preventing illicit trafficking in nuclear material at both the national and international level. All such initiatives must be taken in co-operation, consultation and negotiation, not only between States but also with the appropriate international organizations, whereby the IAEA should be given the leadership role. This is the message that this conference should convey worldwide and I wish it every success.

OPENING ADDRESS

M. ElBaradei
Director General
International Atomic Energy Agency
Vienna

From the earliest days of discovery and experimentation with nuclear science, nuclear and radioactive materials have held extraordinary potential — the potential for being of great benefit to humankind, as well as for causing significant harm. For the past forty four years, the IAEA has played an important role in ensuring that nuclear technologies and materials are used only for peaceful purposes — in producing nuclear energy, and in helping to fight disease, enhance agricultural production, manage water resources and monitor the environment. At the same time, the Agency's safeguards programme has been providing assurances that international undertakings to use nuclear facilities and materials for peaceful purposes are being honoured.

An area of recent focus for the Agency has been the prevention of illicit trafficking in nuclear and radioactive material. In the wake of the Cold War, the smuggling of these materials has emerged as a real and dangerous threat. Since 1993, over 370 cases of illicit trafficking have been confirmed. While most of these incidents do not involve material that can be used for making nuclear weapons, the high number of events shows that we have reason to be concerned. In response, the international community, working through the Agency and through bilateral assistance, has stepped up efforts to prevent unauthorized uses of or trafficking in nuclear material and other radioactive sources.

For any State, the first step in ensuring the security of their materials is an effective national system of control. Such a system must contain multiple elements, including physical protection measures, material accountability arrangements, reliable detection capabilities, and plans for rapid and effective response when material is found to be lost, stolen or otherwise not under proper control. The system must also cover illegal waste dumping and other activities that would result in the release of radioactive material into the environment. All these measures should be based on well founded legal and regulatory structures. In many cases, the responsibility for these various elements lies with different bodies, and co-operation between them is vital to the success of the national system.

For many States, some of the elements of a viable national system for the security of nuclear and radioactive material already exist. They may be in place as part of the State's safeguards undertakings, or as a result of the State's being party to the Convention on the Physical Protection of Nuclear Material. Where already in place, these elements can work together to serve multiple purposes, thereby leveraging the resources devoted by the State to security measures. In other words, where the State already has a safeguards system in place, the efforts to combat illicit trafficking should be integrated into this overall system.

The International Atomic Energy Agency can be of service to a State that is seeking to upgrade its security measures for nuclear and radioactive material — through the transfer of technology, exchange of information, assistance and training in the implementation of internationally accepted standards, and help with regional co-operation. An important component of our efforts has been to work in close association with responsible national and international authorities, including customs and law enforcement organizations, to share best practices and conduct assistance visits. In response to requests, we also have organized International Physical Protection Advisory Services (IPPAS), using experts from our Member States to conduct peer evaluations of national systems for physical protection. Since 1996, we have conducted these missions in 11 States in various regions of the world.

An increasing number of States are also requesting our assistance in training their customs officers in radiation monitoring at border stations — as well as providing support to national authorities and border officials in preventing, detecting, and responding to illegal uses of nuclear and radioactive materials. We have initiated a co-ordinated research project that consolidates ongoing research activities to improve the technology used to detect nuclear material at border stations. And we will continue to work with Interpol, Europol, the World Customs Organization and other international organizations in conferences such as this one, to bring together experts in the field and determine how progress can best be achieved.

In November 1999, I convened an informal, open ended meeting of experts to discuss whether the Convention on Physical Protection of Nuclear Material should be revised. I expect to receive a report from the Expert Group within the next few months.

Looking towards the future, it is clear that broad international co-operation will be needed to upgrade security measures, to improve capabilities for intercepting and responding to illicit trafficking, and to enhance the protection of facilities against terrorism and sabotage. The most difficult challenge will be the effective consolidation of all these measures into integrated, efficient national systems, ensuring that the security of nuclear and other radioactive material is woven into the infrastructure of nuclear safety and security. It is my sincere hope that this conference will provide a forum for productive discussion and comprehensive consideration of these issues, and I wish you every success in these endeavours.

THREATS AND RESPONSES

(Session 1)

Chairperson

M. GREGORIC
Slovenia

Keynote Address

NUCLEAR TERRORISM: HOW REAL IS THE THREAT?

A. SCHMID[1]
Terrorism Prevention Branch, United Nations Office at Vienna

Abstract. After the end of the Cold War the threat of proliferation of weapons of mass destruction to non-state actors has increased and since non-territorial actors cannot be deterred as easily as states, new responses have to be found. The author offers a definition of nuclear terrorism which includes also attacks on, and sabotage of, nuclear reactors and the dispersal of radioactive waste, in addition to the possession or use of weapon-grade nuclear materials. It is held that the main bottleneck for would-be nuclear terrorists is not so much bomb design than access to nuclear material for which the territories of the former Soviet Union are a likely source, due to gaps in safety and security. The article discusses the smuggling of nuclear material from the former USSR's territories and lists seven possible methods of acquisition of nuclear materials by terrorists. The intentions of various types of groups to use weapons of mass destruction and their possible goals are analyzed and the question whether or not Osama Bin Laden has acquired nuclear materials is raised. A discussion of possible motivations for nuclear terrorism by non-state actors and a listing of facilitating and inhibiting factors with regard to terrorist use of weapons of mass destruction lead to the conclusion that nuclear terrorism by non-state actors is still a low probability event but that no risks can be taken and that a broad action plan to counter the threat is needed whereby the IAEA should stand in the forefront.

INTRODUCTION

It is a pleasure to be here in this city which is also the home of Stockholm International Peace Research Institute (SIPRI), one of the world's leading peace research institutes. The fearful consequences of nuclear war were one of the reasons why SIPRI was established. For many years it was thought that the spread of nuclear weapons was a problem created by, and confined to, states. During the course of the Cold War, nearly eighty thousand nuclear weapons were fabricated.[2] This is a UN estimates. Others put the figure close to 100,000. Dismantling them is a slow business. The United States have a capacity to dismantle up to 2,000 per year, the Russian Federation can handle up to 3,000.[3]

Many nuclear warheads are now considered redundant but there are still between 35,000 and 45,000 strategic and tactical nuclear warheads in the hands of the five permanent members of the UN Security Council.[4] In the last years it dawned on us that there is an emerging threat posed by non-state proliferation of weapons of mass destruction At the dawn of the atomic age in 1945, Henry L. Stimson, the US Secretary of War, wrote to Harry Truman:

> "The future may see a time when such a [nuclear] weapon may be constructed in secret and used suddenly and effectively with devastating power by a wilful nation or

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[1]. Alex P. Schmid is Officer-in-Charge of the Terrorism Prevention Branch at the United Nations Office in Vienna, PO Box 500, A-1400 Vienna. The views and opinions expressed in this paper are solely those of the author and do not represent official UN positions.

[2] Carnegie Commission on Preventing Deadly Conflicts. Comprehensive Disclosure of Fissionable Materials. A Suggested Initiative. New York, Carnegie Corporation, June 1995, p.1.- Other estimates are even higher. The Economist wrote:"According to a recent study, over the years the United States built some 70,000 nuclear warheads and bomb....Its stockpile of useable weapons rose to about 30,000 at its peak in the early 1960s....The Russians have not disclosed exactly how many nuclear weapons they built in total, but their useable stockpile is thought to have peaked at around 45,000 by the mid-1980s, dropping to 33,000 in the early 1990s". — *The Economist*, 4 January 1997, p. 30.

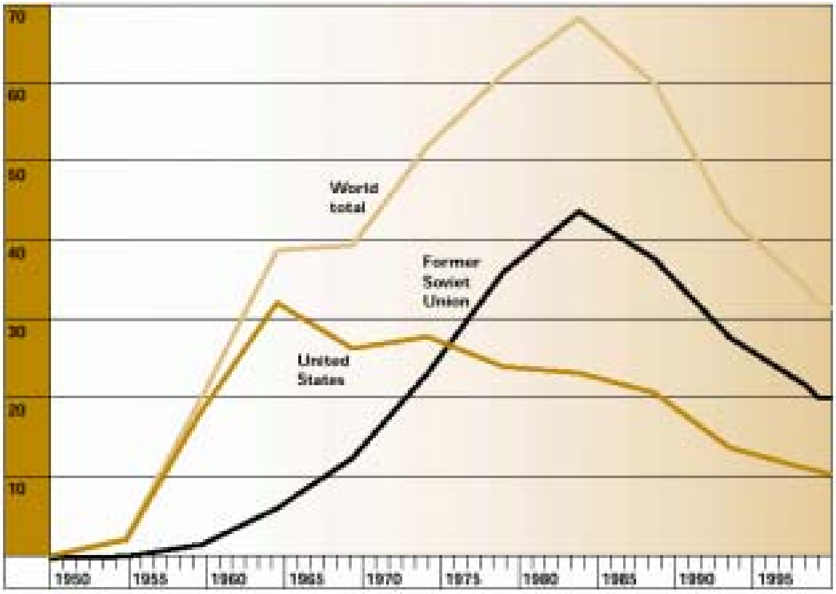
[3] *The Economist*, 4 January 1997, p. 30.

[4] 'Nuclear powers pledge to disarm'. *Financial Times*, 21 May 2000.

group against an unsuspecting nation or group of much greater size and material power”.[5]

Has that time come? In April 2001 there was yet another newspaper article claiming that Osama Bin Laden had acquired nuclear warheads from Russia through Chechen middlemen.[6] Fact or fiction? Most probably fiction. Such reports have been in the press before.[7] However, I can speak on the basis of Open Sources only. It should be kept in mind that there may be two realities — the one of intelligence services and the one of the public domain.[8]

Table 1. Nuclear stockpiles, estimated, 1950-2000[9] (thousands of weapons)



Source: US National Resources Defense Council, 2000.

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[5] 25 April 1945 Henry Stimson to Harry Truman; cit. Roberta Wohlstetter, ‘Terror on a Grand Scale’. *Survival,* XVIII/No. 3 (May-June 1976), p. 98.

[6] *World News,* 28 April 2001. Bin Laden Said to Have Nuclear Weapons. The paper cited as sources the intelligence newsletter *Geostrategy-Direct.com* and the intelligence *World Net Daily*, which, in turn, was said to rely on Russian and Arab sources.- The BBC Monitoring South Asia, on the other hand, reported “that an intelligence service of a European country has foiled an attempt to ship nuclear warheads to Bin Laden and the ruling Taleban in Afghanistan. These nuclear warheads, estimated to be 20, came from nuclear arsenals in Ukraine, Kazakhstan, Turkmenistan, and even Russia”. — BBC Monitoring South Asia — Political, ‘Afghan: Bin-Laden, Taleban said to be trying to acquire nuclear weapons. 26 December 2000, p. 1(Text of report by London-based newspaper *Al-Sharq al-Awsat* web site on 25 December 2000).The US attacks against AlQaeda following 11 September 2001, and the intelligence gained in this ‘war on terror’ found no evidence to support such claims.

[7] The Arab news magazine *Al-Watan Al-Arabi* reported on 13 November 1998 about a ‘nuclear warheads deal’ between Chechen organized crime figures in Grozny and Bin Laden followers.

[8] It is the task of intelligence agencies to check the accuracy of news accounts. Among the more intriguing incidents reported which required checking were the following:
1. A March 1994 German intelligence reported that 11 nuclear warheads from the Ukraine had disappeared while being shipped to Russia to be scrapped;
2. The April 1993 discovery at a shipping port of 80 tons of unattended nuclear fuel, which lacked proper export papers and was believed to be heading to Bulgaria and Libya. — Bill Schackner. More and more, nuclear fuels are being stolen. *Pittsburgh Post-Gazette*, 16 July 1995, p. A1.p. 2; see also: Phil Williams and P.N. Waessner. ‘The Real Threat of Nuclear Smuggling’. *Scientific American*, 274:1 (January 1996, pp.40-44.

[9] US Natural Resources Defense Council, 2000, cit. United Nations General Assembly, The Millennium Assembly of the United Nations, We the Peoples: The Role of the United Nations in the Twenty-first Century, Report of the Secretary-General, A/54/2000, New York, UN, 2000, p. 38.

Table 2. Selected High Fatality (>100) Incidents, 1977-1999[10]

1977: The hijacking and crash of a Malaysian Airlines System Boeing 737	100
1978: The bombing of an apartment building in Beirut, Lebanon	161
1979: Arson in Abadan, Iran movie theatre	477
1981: The sabotage of a Far Eastern Air transport near Taiwan	110
1983: The derailing of a train in India	>200
1983: The bombing of an Emirates Boeing 737 near Dubai	111
1985: Bombing of Air India/747 off the Irish coast	329
1987: The Tamil Tigers' shooting of Sinhalese civilians on a number of buses	>100
1987: Car bomb in bus station in Sri Lanka	113
1987: The bombing of Korean Airlines Flight 858 over South East Asia	115
1988: Pan Am 103 in-flight bombing over Lockerbie	270
1989: In-flight bombing of French UTA/DC 10 over Niger	171
1989: In-flight bombing of Colombian Avianca/727, Bogota	107
1993: One hour bombing campaign in Bombay	235
1995: Oklahoma City, Alfred P. Murrah Federal Bldg. Bombed	168
1997: GIA-attributed massacre in Algeria's Relizane province	412
1998: Bin Laden-attributed car bomb in Kenya	213
1999: The bombing of a Moscow apartment block	119
2001: Destruction of the World Trade Centre in New York	2830

In sociology there is a theorem called the Thomas theorem. It says: "Whatever people believe to be real, is real in its consequences". Threat perceptions and threat reality are not the same; one can — as the Thomas theorem postulates — lead to the other by means of self-fulfilling prophecies. Since the Sarin attack on the Tokyo underground in 1995, much has been written about terrorism and weapons of mass destruction. The term 'weapons of mass destruction' covers nuclear, biological, chemical and, sometimes also, radiological devices.[11] Attacks with such weapons are not necessarily producing mass destruction. The Tokyo Sarin attack led to the death of 12 people and more than 40 people were seriously wounded.[12] There have been terrorist attacks with conventional explosives that were fare more deadly.[13] However, there have been less than twenty terrorist high fatality attacks on civilians in more than two decades. Terrorists are not per definition mass murderers. As Brian Jenkins once put it

[10] US Congress, Office of Technology Assessment. Technology Against Terrorism: The Federal Effort (Washington, DC: GPO July 1991) p.40; R. A. Falkenrath, 'Confronting Biological and Chemical Terrorism', Survival, 40/3(Autumn 1998)p. 52; Brian M. Jenkins, "Future Trends in International Terrorism', in Robert O. Slater and Michael Stohl (Eds) Current Perspectives on International Terrorism (London: Macmillan 1988) p. 254; PIOOM Database; as quoted in A.P. Schmid, Terrorism and The Use of Weapons of Mass Destruction: From Where The Risk?, ***Terrorism and Political Violence*, England, Volume 11, Number 4, Winter 1999, p. 107;** Nadine Gurr, Benjamin Cole, The New Face of Terrorism, Threats From Weapons Of Mass Destruction, London, Tauris 2000, pp. 37-38; Brian M. Jenkins, Will Terrorist Go Nuclear?, ORBIS, Vol. 29, No. 3, Fall 1985, p. 511.

[11] Milton Leitenberg Terrorism and Weapons of Mass Destruction. In: Alex P., Schmid (Ed.) Countering Terrorism Through International Cooperation. Milan, ISPAC, May 2001, p.38.

[12] Most authors on Aum Shinrikyo quote more than 5,000 people injured. However, that number refers to people who went to hospitals for a health check; it is not the number of people actually wounded. In addition to the 40 people who got seriously hurt, hundreds suffered from post-traumatic stress disorders. — For a discussion of some studies on the Japanese cult, see: Angus M. Muir. Terrorism and Weapons of Mass Destruction: The Case of Aum Shinrikyo. *Studies in Conflict and Terrorism*, 22:79-91, 1999.

[13] See: Alex P. Schmid. Terrorism and the Use of Weapons of Mass Destruction: From Where the Risk? *Terrorism and Political Violence*, Vol. 11, No. 4, Winter 1999, p.107, Table 1.

"Terrorists want a lot of people watching, not a lot of people dead." Since the attack on the World Trade Centre of 11 September 2001, the validity of this statement can be questioned but it should be kept in mind that the collapse of the Twin Towers exceeded the expectations of Osama bin Laden.

Some clarification is necessary about the concept of 'nuclear terrorism'. Atomic weapons, by their very nature, are terrifying. If they are in the hands of a non-territorial actor who cannot be deterred by retaliation like a state possessing nuclear weapons, the terror component is potentially even larger. I have define nuclear terrorism in a way that both explosions and non-explosions, as well as means (e.g. suitcase bomb) and targets (e.g. nuclear reactor) are covered:

Table 3. Definition of Nuclear Terrorism[14]

The use, or credible threat of use, of destructive force against non-combatant/civilian targets for purposes of propaganda, blackmail/extortion or intimidation of a target audience, whereby a) the perpetrator has managed to trigger a fission (or fission/fusion) of nuclear material, or b) is credibly held to be in possession of weapon-grade nuclear (U, Pu) material and signals intent of first use; or c) is attacking or sabotaging nuclear reactors or vital support systems (e.,g. cooling system) at power stations or nuclear materials (e.g. reactor rods or high-radiation level waste) in transport or at storage sites in order to produce, then or later, an accident or a controlled release/ explosion of radioactive substances, or d) disperses in water, soil or air radioactive waste or isotopes, etc. by conventional explosion or dispersion/diffusion.

[14] Ely Karmon notes that "....the exact meaning of nuclear terrorism is not always clear. Nuclear terrorism can range from the actual detonation of nuclear weapons or acts of nuclear violence, for example, in the form of the release of radioactive substances or the radioactive contamination of drinking water, to acts of sabotage by the terrorists (nuclear weapons) or to their target (reactors). — Ely Karmon. Olympic Bomb Plot to Blow Up a Nuclear Reactor in Sydney Foiled. How Serious the Threat?. Paper, 29 August, 2000, p.7. — Morten Bremer Maerli considers 'nuclear terrorism' as a subset of 'radiological terrorism' and defines the former as "acts of violence and destruction where the means applied are nuclear devices, or threats of use of such means, to create a condition of fear, to get attention, or to blackmail to have a wider effect on others than the directly targeted victim(s).'. — M. B. Maerli. The Threat of Nuclear Terrorism. Extended Synopsis of a paper prepared for the May 2001 IAEA Stockholm conference, p.1.

Let me stress that this working definition is not a UN definition. The UN has so far not been able to agree on a definition of terrorism.

It is widely held that when it comes to the potential uses of weapons of mass destruction by terrorists, chemical attacks are more likely than biological, nuclear and radiological ones.[15] When it comes to nuclear and radiological attacks, it is obviously easier to stage a radiological one. As Jessica Stern put it, the "[d]etonation of a nuclear device is the least likely form of terrorism involving weapons of mass destruction".[16]

Before exploring the potential of proliferation of nuclear materials to non-state actors, it should be recalled that, on the state level, proliferation is a fact. There are at least eight, and possible more, nuclear powers.

Table 4. Estimated Nuclear Weapon Stockpiles, 1990 and 2000*[17]

	1990	*2000*
United States	21,000	10,500
USSR/Russia	38,000	20,000
United Kingdom	300	185
France	504	450
China	432	400
Israel		[100-200?]
India**		[30-50?]
Pakistan**		[60-90?]
North Korea		
South Africa		[6, now dismantled]

** Includes strategic and tactical nuclear weapons in the active and reserve stock[piles], but does not include weapons awaiting dismantlement. Except for about 20 tonnes of highly-enriched uranium in civil facilities, all weapon-grade uranium is in the hands of the military.*[18]
*** Refers to earlier date than 2000.*

15 John Deutch. Proliferation of Weapons of Mass Destruction. Hearings, Permanent Subcommittee on Investigations, Committee on Governmental Affairs, United States Senate, Part II, March 13, 20, 22 1996, p. 75; cit. G. E. Schweizer. Superterrorism. New York, Plenum Trade, 1998, p. 86; see also: Alex P. Schmid. Chemical Terrorism: Precedents and Prospects. The Hague, OPCW, 7-9 February 2001 paper. — Richard Betts, on the other hand, argued in 1998 that "Biological weapons should now be the most serious concern, with nuclear weapons second and chemical a distant third". — cit. Cit. Nadine Gurr and Benjamin Cole. The New Face of Terrorism. Threats from Weapons of Mass Destruction. London, I.B. Tauris, 2000, p.9. According to Glen E. Schweitzer. (Super-Terrorism. Assassins, Mobsters , and Weapons of Mass Destruction. New York, Plenum Trade, 1998, p. 67), "Some Western experts believe that sufficient HEU has already been removed from the former Soviet Union to create an active international black market".

16 Jessica Stern. The Ultimate Terrorists. Cambridge, Mass., Harvard University Press, 1999, p.54. The detonation of a thermonuclear bomb is least likely.

17 US Natural Resources Defense Council, cit. Joseph Circincione (Ed.). Repairing the Regime. Preventing the Spread of Weapons of Mass Destruction. London, Routledge, 2000, p.306; and cit. Ken Larson. Nuclear Emergency. How to Protect your Family from Radiation. Suwanee, GA, Rhema Publ., 1997, p. 5.; in brackets: estimate from other sources.

18 Frank Barnaby. Instruments of Terror. London, Satin Publ., 1996, p. 155.

South Africa had six nuclear devices, which are now dismantled. Pakistan and India are estimated to possess more than one and two dozen nuclear devices respectively, Israel is assumed to possess up to two hundred of them. It is now assumed by the CIA that North Korea might also have the nuclear materials for one or two nuclear devices.[19] Since the early 1990s, Libya has also been suspected of working on a nuclear weapons programme, allegedly assisted by scientists recruited from CIS states.[20] Iraq, and reportedly also Iran, have been suspected to be involved in a nuclear weapons programme.[21]

Availability of Nuclear Material to Terrorists. The trafficking of highly enriched nuclear materials and less radioactive materials in the post-Cold war period (focusing on the smuggling from the former Soviet Union and from former Warsaw Pact countries).

Nuclear terrorism requires three basic things:

1. a decision by a group to acquire a nuclear capability;
2. the know-how to design and build a nuclear device; and
3. the nuclear material.[22]

The main bottleneck for potential nuclear terrorist is not so much bomb design[23] than access to nuclear material.[24] The quantities of nuclear material to be protected from terrorists are very large.

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19 According to Deputy CIA Director John McLaughlin, North Korea probably has one or two nuclear bombs and may also have biological weapons in addition to chemical weapons. — *IIMCR's Weekly Global Intelligence Report* 23 April 2001, p. 2

20 N. Gurr and B. Cole, op. cit., p. 210.

21 Ibid., pp. 209-210. — With regard to Irak, Shyam Bhatia and Daniel McGrory write:"Saddam's original order had been for his scientists to create a stockpile of fifty nuclear bombs, which was what he expected from his $ 18 billion investment". According to the same authors, already in 1990 Saddam Hussein possessed a stockpile of thirty kilograms of weapons-grade uranium. 13 kilograms he had allegedly bought from France for the experimental nuclear Osirak reactor and another 17 kilograms had arrived in fits and starts from the Soviet Union for an experimental reactor built in 1959 — Bhatia, Shyam and Daniel McGrory. Brighter than the Baghdad Sun. Saddam Hussein's Nuclear Threat to the United States. Washington, D.C., Regnery Publ., 2000, p. 38, 41. The *IIMCR's Weekly Global Intelligence Report* of 23 February 2001 wrote:"Germany's Federal Intelligence Service (BND) has evidence that Baghdad is stepping up efforts to produce chemical weapons and has increased buying abroad of the inputs needed to make biological weapons. Meanwhile, several former aides to Saddam Hussein contend that Iraq has several nuclear weapons in storage". — <http://www.iimcr.org/events/hereandnowfeb23.asp#1>; The *London Sunday Times* reported in early 2001 that Saddam Hussein had two fully operational nuclear bombs and was working to construct others, according to an Iraqi defector who helped to oversee the completion of the weapons program. — cit. *Homeland Defense*, Vol. 2, No. 5, 2 February 2001, p. 1.

22 Brian M. Jenkins. International Cooperation in Locating and Recovering Stolen Nuclear Materials. *Terrorism: An International Journal*, Vol. 6, No. 4, p. 569.

23 Theodore Taylor, himself involved in bomb design, wrote that "using information that is widely published and materials and equipment available from commercial sources, it is quite conceivable that a criminal or terrorist group, or even one person working alone, could design and build a crude fission bomb that could be carried in a small automobile and that would be likely to explode with a yield equivalent to at least 100 tons of high explosive". — Theodore B. Taylor. Statement before the US Congress' Joint Committee on Atomic Energy, 18 June 1975, p.2; cit. N. Livingstone. Megadeath: Radioactive Terrorism. In Yonah Alexander and Charles K. Ebinger (Eds.). Political Terrorism and Energy. The Threat and Response. New York, Praeger, 1982, p.147.

24 Nuclear materials come in two sorts:
a) fissile materials, such as Plutonium-239 or Uranium-235, and
b) other radioactive materials, such as Uranium-238, Cesium-137, Strontium-90 or Cobalt-60.

The total stocks of plutonium (civil and military) is, according to one estimate, about 1,500 tonnes while the total stock of highly enriched uranium is about 1,900 tonnes.[25] The International Atomic Energy Agency monitors about 30 per cent of the plutonium reserve and less than one per cent of the enriched uranium reserve in the world. The IAEA does not have access to military nuclear facilities.[26]

Table 5. Military Uranium and Plutonium Stock Size in mid-1990s[27]

	Highly Enriched Uranium	Weapon-Useable Plutonium
USA	700 tons	98 tons
Former USSR	1,000 tons	130-200 tons
United Kingdom	ca. 15 tons	
France	ca. 15 tons	
United Kingdom	ca. 15 tons	
Pakistan	ca. 150 kilograms	
South Africa	ca. 360 kilograms	

According to a Rand study from the mid-1990s, 1,500 tons of military and civilian plutonium in the world would be enough to make 87,000 small nuclear bombs.[28] It has been estimated that 7-15 kilograms of Pu-240 would be needed for a crude, low-yield fission bomb producing a blast of up to 1 Kiloton of TNT equivalent. [29]

Where could terrorists obtain nuclear materials from? Anita Nilsson from the IAEA has pointed out that since 1993 over 370 incidents of smuggling have been confirmed. According to a database developed by Bruce Hoffman and David Claridge which contains almost 500 incidents of illicit nuclear materials trafficking in the 1990s, the Warsaw Pact countries accounted for 79 per cent (379) of all smuggling and trafficking incidents and the countries of the former Soviet Union for 68 per cent (326 incidents).[30] I shall therefore concentrate on that part of the world.

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[25] Frank Barnaby, op. cit., p. 179; others offer different figures. S. Bhatia and D. McGrory write: "More than 2,000 tonnes of weapons-grade uranium and plutonium are stockpiled in military storage sites of more than half a dozen states." — Shyam Bhatia and Daniel McGrory. Brighter than the Baghdad Sun. Saddam Hussein's Nuclear Threat to the United States. Washington, D.C., Regnery Publ., 2000, p. 304.

[26] N. Gurr and B. Cole, op. cit., p.229.

[27] Frank Barnaby. Instruments of Terror. London, Satin Publ., 1996, p.155; *The Economist*, 4 January 1997, p. 30 (for plutonium).

[28] Cit. F. Barnaby, op. cit., p. 179.

[29] J. Carson Mark, Theodore Taylor, Eugene Eyster, William Marman and Jacob Wechsler. 'Can Terrorists Build Nuclear Weapons?'. In: Paul Leventhal and Yonah Alexander (Eds.). Preventing Nuclear Terrorism. Lexington, Mass., Lexington Books, 1987, p. 58.; cit. N. Gurr and B. Cole, op. cit., p. 46. — A blast of 0.5 kiloton in New York would cause, according to an estimate by Theodore Taylor, 50,000 deaths. — cit. N. Gurr and B. Cole, op. cit., p.82.

[30] Bruce Hoffman with David Claridge. Illicit Trafficking in Nuclear Materials. *Conflict Studies* 314/315, January/February 1999, p. 8

Table 6. Nuclear Legacy of the USSR[31]

Strategic nuclear warheads:	5, 870
Tactical nuclear warheads:	ca. 17, 000
Plutonium stockpile:	125-165 tons
Highly Enriched Uranium:	1,100-1,200 tons
Nuclear waste:	640 million cubic metres of radioactive (U, Pu) waste

In the Russian Federation, which has inherited most of the nuclear materials of the USSR, there are three types of nuclear materials. First, there are the strategic nuclear weapons such as warheads to be used in missiles and by bombers. There were almost 6,000 of these in 2000, a figure which includes silo- and submarine-based ballistic missiles and air-launched systems [32].Then there are some 17,000 tactical nuclear warheads such as artillery shells and portable small missiles with a nuclear tip.[33] Their storage is less secure than the one of strategic weapons.[34] According to Richard Butler, "... there have been reports that some are kept in tin sheds secured with a single padlock".[35] Some of these tactical weapons are vulnerable to theft or sale, especially by insiders. While strategic weapons, and probably suitcase bombs as well, have built-in safeguards and self-destruction mechanisms which pose a big challenge for terrorists, it is said that not all Russian tactical nuclear weapons are secured that way.

Thirdly, there is a large amount of weapon-grade fissionable material, mainly reactor-grade plutonium. Since there was no accurate accounting system of this material in the late Soviet Union, current theft , diversion or loss are difficult to prove.[36]

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[31] Nadine Gurr and Benjamin Cole The New Face of Terrorism. London, Tauris, 2000, p.57; Gavin Cameron. Nuclear Terrorism. New York, St. Martin's Press, 1999, p.2.

[32]United States. Department of Defense.. Office of the Secretary of Defense. Proliferation: Threat and Response. Washington, D.C., DOD, January 2001 (available under <http://www.defenselink.mil>), p.55.

[33] *Newsweek*, 6 October 1996, p. 43.

[34] Jessica Stern notes:"While Russia's 6,000 long-range strategic weapons are protected by locks, making it impossible — at least in principle — to launch them without high-level authority, thousands of smaller tactical weapons have less sophisticated protection or no locks at all, making them both easier to steal and easier to detonate". — Jessica Stern. The Ultimate Terrorists. Cambridge, Mass., Harvard University Press, 1999 , p.9.

[35] Butler adds:"Some of these weapons could fit into a large briefcase or a small trunk, which could then be picked up and carried away by an Iraqi or other terrorist". — R. Butler. The Greatest Threat. Iraq, Weapons of Mass Destruction and the Crisis of Global Security. New York, Public Affairs, 2000, p.231. — Gavin Cameron reported that "One US official, visiting the Kurchatov Institute, found about 160 pounds of weapons-grade uranium stored in lockers secured only by a chain through the handles of the lockers. There was no other security.(...) In March 1994, the Russian Counterintelligence Service reported to President Yeltsin that there had been 900 thefts from military and nuclear plants and 700 thefts of secret technology in the second half of 1993 alone. The Ministry of Internal Affairs reported 900 attempts to gain illegal entry into nuclear facilities in 1993.(...)Much of the theft is insider crime: Staff employed within the industry making the most of their access to nuclear material" (G. Cameron. Nuclear Terrorism. A Threat Assessment for the 21st Century. New York, St. Martin's Press, 1999, p.3). It should be noted that one follower of Aum Shinrikyo worked in the Kurchatov Institute of Atomic Energy (G. Cameron, op. cit., p. 5). The Kurchatov Institute has been linked to the theft of 6g of 99.75% pure Plutonium-239 in the case of the German businessman Adolf Jaeckle. — Bruce Hoffman with David Claridge. Illicit Trafficking in Nuclear Materials. *Conflict Studies* 314/315, January/February 19999, p.21.

[36] R. Butler, op. cit., p.231. — It should be noted that in the United States nuclear material also gets 'lost', or, in the terminology of the trade, is "MUF"(Material Unaccounted For). According to Mullins: "In the U.S., some estimates suggest the yearly MUF of nuclear material to be between 1,500 and 6,000 pounds (Rosenblum, 1978).- Wayman C.Mullins. A Sourcebook on Domestic and International Terrorism. An Analysis of Issues, Organizations, Tactics and Responses. Springfield., Ill., Charles C. Thomas, 1998 (2nd edition), p.329.

Table 7. Estimates of Quantities of Fissionable Nuclear Material In the Russian Federation [37]

	Inventory (Metric Tons) Pu	HEU	weapons equivalents
Total	190	1200	150,000
Military	160	1200	140,000
In 25, 000 weapons	~50	~500	60,000
Outside weapons	~80	~700	80,000
Inside weapons	50	500	50,000

* Assumes 4kg Pu or 12kg HEU per fission weapon.

In the Russian Federation there are between 50 and 100 sites where there are stockpiles of 125-165 tons of plutonium, up to 1,200 tons of Highly Enriched Uranium (HEU) and 640 million cubic metres of radioactive waste containing uranium or plutonium.[38]

Most of the weapons-useable nuclear materials in the kilogram range are stored in nearly 400 buildings which are not all guarded the way they should be guarded.[39] These dangerous but precious materials offers a temptation for adventurers and desperados.

In the period January 1992 to August 1994 alone, 300 employees at storage and production facilities in Russia were stealing, illegally transporting or possessing radioactive waste.[40] Also, in September 1996, at the Komsomolsk-on-Amur military base there was an apparent attempt by Russian soldiers to steal a nuclear warhead. However, they were killed by a non-nuclear explosion they triggered in the attempt.[41] There have been persistent and worrying accounts of 'loose nukes' from the Soviet arsenal.[42]

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[37] Source: US Government data provided by Dr. Steve Fetter to Milton Leitenberg, as quoted in: Milton Leitenberg Terrorism and Weapons of Mass Destruction. In: Alex P., Schmid (Ed.) Countering Terrorism Through International Cooperation. Milan, ISPAC, May 2001, pp. 62-63, pp. 62-63. — For comparison, the US has 100 tons Pu, 645 tons HEU, about 35 tons Pu and 225 tons HEU are in 10,000 weapons and 50 tons Pu and 175 tons HEU have been declared excess.

[38] N. Gurr and B. Cole, op. cit., p. 57. The estimates for the amount of nuclear material in Russia vary. Gavin Cameron writes:"One estimate puts the Russian inventory at 150 metric tonnes of weapons-grade plutonium, 1,000 metric tonnes of enriched uranium, and at Chelyabinsk alone about 685,000 cubic metres of radioactive waste. Others put the figures higher, at 165 tonnes of separated weapons-usable plutonium and 1,100 to 1,300 tonnes of highly enriched uranium. However, no one really knows what quantities are involved because, during the Cold War, Soviet facilities were set production targets. When they exceeded these, material was kept aside rather than declared, so as to compensate for any shortfalls in subsequent targets" (.G. Cameron, Nuclear Terrorism. A Threat Assessment for the 21st Century. New York, St. Martin's Press, 1999, p. 2). — The number of storage sites was reduced from some 1,000 to fewer than 100 over the years. — J. Stern, op. cit., p. 92.

[39] Matthew Bunn. A Detailed Analysis of the Urgently Needed New Steps to Control Warheads and Fissile Material In: Joseph Cirincione (Ed.). Repairing the Regime. Preventing the Spread of Weapons of Mass Destruction. London, Routledge, 2000, p.74.

[40] David Claridge and Bruce Hoffman. 'Illicit Trafficking in Nuclear Materials'. *Conflict Studies* 314/315, Research Institute for the Study of Conflict and Terrorism'. January-February 1999, p.10.

[41] Steve Boggan. 'For Sale: A Russian Nuclear Bomb, A Snip at $ 250,000. One Careless Owner. *The Independent*, 25 July 1998; cit. N. Gurr and B. Cole, op. cit., pp. 78-79.

[42] According to Frank Barnaby, who bases himself on intelligence sources, a number of former Soviet nuclear weapons are unaccounted for. — Cit. N. Gurr and B. Cole, op. cit., p. 79. — The minimum amount of plutonium needed for a bomb is only about 4 kilograms, an object the size of a softball or soda can. The minimum amount of HEU is about three times that for a plutonium bomb — three soda cans. While the first atomic weapons built in 1945 were heavy — some 10,000 pounds — miniaturization has brought the size of some of them down to man-portable suitcase bombs weighing approximately 60 pounds. — Matthew Bunn. A Detailed Analysis of the

If one would translate all the Russian nuclear materials into weapons equivalents, some 150,000 bombs could be constructed.

In addition, we also have to be concerned about radiological bombs which can even be built with the help of radioactive waste of which there are enormous quantities lying around (see Table 6).

In order to protect weapon-grade nuclear materials, background checks of personnel, training and adequate salaries for guards are required, as well as a modern three-tier system of Material Protection, Control and Accounting. The old Soviet system of "Guards, Guns and Gates" was not constructed with thieves and terrorists in mind but focused more on spies. A modern system of protection and control consists of three elements:

Table 8. Material Protection, Control, and Accounting (MPC&A)[43]

· *Physical protection:* barriers, sensors, and alarms to deter, delay, and defend against both intruders from outside and theft from inside. · *Material control:* locked vaults for storage of nuclear materials; portal monitors to prevent workers from walking off the site with nuclear material in their pockets; continuous monitoring of nuclear-material storage sites with tamper-proof cameras, seals, and alarms; and prohibition of access to sites of sensitive materials unless personnel enter in pairs (the two-man rule); · *Material accounting* : a regularly updated measured inventory of weapons-useable material, based on regular measurements of material arriving, leaving, lost to waste...within the facility, including a program to ensure the accuracy of the measurement equipment.

Urgently Needed New Steps to Control Warheads and Fissile Material. In: Joseph Cirincione (Ed.). Repairing the Regime. Preventing the Spread of Weapons of Mass Destruction. London, Routledge, 2000, p. 74. — It should be noted that these so-called formula quantities require cutting-edge technology beyond the reach of terrorists. The quantity of uranium or plutonium required for a crude weapon is several times — possibly ten times — higher. — Milton Leitenberg Terrorism and Weapons of Mass Destruction. In: Alex P., Schmid (Ed.) Countering Terrorism Through International Cooperation. Milan, ISPAC, May 2001, p.58. The special nuclear material required by a terrorist for the construction of a bomb is, according to the open literature "11-15.42 kilograms of U-238, 25 kilograms of metallic uranium (U-235), 35 kilograms of highly enriched uranium oxide (UO-2, 200 kilograms of intermediately enriched UO-2, 4-7 kilograms of enriched plutonium, or 10 kilograms of plutonium oxide (Clark, 1980, Rosenblum, 1978, Willrich & Taylor, 1979). — Wayman C. Mullins. A Sourcebook on Domestic and International Terrorism. An Analysis of Issues, Organizations, Tactics and Responses. Springfield., Ill., Charles C. Thomas, 1998 (2nd edition), p.328. — Mullins notes: "The U.S. and USSR both have developed "backpack"nuclear weapons, used primarily by NATO forces. These low-yield weapons are carried and detonated by a two-man crew. The backpack, weighing approximately 60 pounds, is carried by one person. The carrier and one other person have to enter a secret code into the Permissive Action Link (PAL) system to arm the nuclear device. Once armed, the device is placed in a secure spot, such as a locker, and then at a predetermined time it detonates. The small size, light weight, and portability of the backpack make them an ideal weapon for the terrorist". — Wayman C.Mullins. A Sourcebook on Domestic and International Terrorism. An Analysis of Issues, Organizations, Tactics and Responses. Springfield., Ill., Charles C. Thomas, 1998 (2nd edition), p.331.- With regard to PAL, the Gilmore Report noted in 1999:"....many tactical nuclear weapons, and most strategic nuclear devices, are equipped with permissive action links (PALs) or other protective mechanisms designed to prevent accidental or unauthorized detonation. In addition, some nuclear devices have tamper-proof seals that will disable the weapon if unauthorized personnel attempt to disassemble it. It would be extremely difficult, therefore, for terrorists to circumvent or overcome these built-in protective measures; some of the smaller tactical weapons (including the KGB's alleged nuclear bombs concealed in small suitcases) admittedly may have had little or no protective devices or locks installed and, thus, the safety measures designed to thwart unauthorized detonation would be more easily overcome". -Gilmore Report. First Annual Report to the President and the Congress of the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction. Washington, 15 December 1999, p. 29.

[43] J. Stern. The Ultimate Weapon. Cambridge, Mass., Harvard University Press, 1999, p. 95.

According to Jessica Stern, none of the three elements of an MPC&A system are adequate at many former Soviet nuclear facilities. She quotes the Russian Ministry of Internal Affairs, which admitted that 80 per cent of these facilities have no monitors to detect nuclear materials being carried out through the gates.[44]

Many Russian nuclear storage sites still do not meet such standards. One researcher recently summarized the state of Russian nuclear stockpiles as follows:

Table 9. Safety and Security of Nuclear Materials after the Demise of the Soviet Union[45]

- The Soviet System relied on well-paid personnel; armed guards; closed facilities, borders, society; KGB surveillance;
- There were no portal monitors at most sites; existing alarm systems are easily disabled;
- There are no accurate, measured inventories;
- Production quotas created the incentive for falsifying data (as was the case for Soviet production enterprises and commodities);
- There was no national accounting system;
- Existing fences have holes and are overgrown with vegetation;
- Wax seals used to indicate tampering are easily faked;
- Guards are poorly equipped and poorly paid;
- There is a very large disaffected population with access to materials;
- Documented cases of insider theft have occurred since 1993.

According to a Russian source, of 278 radioactive theft incidents recorded by the Russian MVD between January 1992 and December 1995, only eight cases involved a purchase. The purchases were all to middlemen, not to terrorists.[46] The head of the German Federal Intelligence Service, Konrad Porzner, revealed in January 1996 that of 32 cases in which interested buyers had been registered by German intelligence in 1995, sixteen involved states. He identified two Middle Eastern countries as interested buyers.[47]

As a consequence there have been several hundred cases of theft and illicit trafficking in nuclear materials. The following table list half a dozen major incidents involving quantities in the kilogram range and purity levels which make them suitable for bomb making. While in the early 1990s there were many cases involving only small quantities, now there are fewer incidents but involving greater quantities.

The existence of a black market presupposes that there are also buyers, not only sellers. However, according to an Interpol assessment there seems to have been more sellers than

[44] J. Stern, op. cit., p. 95.
[45] **M. Leitenberg, op. cit., p. 63.**
[46] Rensselaer Lee III, Address to: Institute For National Security Studies, Special Material Smuggling', 13 September 1996, p. 21; cit. G. Cameron, op. cit., p.5.
[47] J. Stern, op. cit., p. 99.

Table 10. Examples of Enriched Nuclear Material Trafficked 1992-2000s[48]

1992	9 October: Yuri Smirnov, an engineer at the Luch Scientific Production Association in Podolsk, Russia stole 3.7 pounds of HEU (45% U-235). He was caught leaving for Moscow to find a buyer;
1993	29 July: 1,8 kg of 36% enriched U-235 was stolen by Pavel Popov and Dimitri Antonov from two fuel assemblies at a facility of the Northern Fleet naval base at Andreeva Guba, Russia. Ties to organized crime were suspected;
1994	14 December: Czech police seized 2.7 kilograms of HEU (88% of U-235) in a parked car in Prague. A Czech physicist, Jaroslav Vagner, a Russian and a Balarusian citizen were arrested. A month later, police found another kilogram from the same shipment;
1999	Late 1999: The Russian Federal Security Service (FSB) reportedly announced that it had foiled an attempted theft by workers at a nuclear facility of 18.5 of uranium suitable for the production of nuclear weapons components from a facility in the Chelyabinsk oblast.
2000	19 April: Police in Batumi: Georgia, arrested four residents and seized 770 grams of 30% enriched uranium.

buyers, at least in the early 1990s.[49] Carol Fortin from Interpol summarized the situation of the nuclear black market as one where most of the sellers were amateur criminals who, inmost cases, did not belong to a criminal organization and who were arrested while carrying the materials or while trying to find a buyer and where buyers and end-users could seldom be positively identified.[50]

Table 11. Interpol Assessment of Nuclear Black Market (1994)[51]

- The aim of the sellers from the former USSR was to earn money;
- Their access to the material they had obtained was coincidental and facilitated by family members or friends;
- they had no anticipated buyers; once past Russian borders, they sought opportunistic and random encounters to sell what they had. In addition, a substantial portion of 'the market' was being supplied by a 'pull' effect from 'sting' operations by German security services. Once that practice was curtailed, the number of intercepted export attempts dropped off sharply;
- No terrorist group was among the purchasers.

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48 Terrorism Prevention Branch. Database on Significant Nuclear and Radiological Incidents, Events, Threats and Hoaxes. Vienna, TPB, May 2001; G. Cameron, Nuclear Terrorism. A Threat Assessment for the 21st Century. New York, St. Martin's Press, 1999, pp.7,9; Nadine Gurr and Benjamin Cole..The New Face of Terrorism. Threats from Weapons of Mass Destruction. London, I.B. Tauris, 2000, pp.; *Newsweek*, 6 October, 1997, p. 43; J. Stern, op. cit., pp. 98-99. Matthew Bunn. A Detailed Analysis of the Urgently Needed New Steps to Control Warheads and Fissile Material In: Joseph Cirincione (Ed.). Repairing the Regime. Preventing the Spread of Weapons of Mass Destruction. London, Routledge, 2000, p. 76; The Christian Science Monitor, 5 Dec. 2001.

49 In 1993 Germany recorded 234 incidents of suspected smuggling of various types of nuclear-related materials. — Karl Heinz Kamp. The Risk of Nuclear Terrorism is Overstated. In: Jennifer A. Hurley (Ed.). Weapons of Mass Destruction. Opposing Viewpoints. San Diego, Cal., Greenhaven Press, 1999, p.35.

50 Carol Fortin. Interpol and Terrorism. In: Alex P. Schmid (Ed.). Countering Terrorism Through International Cooperation. Milan, ISPAC, 2001, p. 239.

51 As summarized by M. Leitenberg, op. cit., p. 61

There appears to have been a decline in seizures in Western Europe since the mid-1990s. This could signify one or several of four things:

Table 12. Explaining the Decline in Seizures of Nuclear Materials: Four Hypotheses.

1. There has, since the mid-1990s, been a shift of smuggling to the Middle East and Asia where less material has been discovered by the authorities; [52]
2. This decline in seizures is the result of a greater professionalism of the smugglers;
3. The decline is the result of better safeguarding in the territories of the former Soviet Union; or
4. The sellers discovered that there is no significant market for nuclear material among non-state actors.

Probably all four factors play a role.

Yet smuggling of nuclear materials is only part of the problem. Another problem area are the formerly closed nuclear cities in Russia where nuclear weapons were constructed or assembled. Some 125,000 people work in these cities and receive less than $ 100 as average monthly salary and at times even that salary had not been paid for lack of funds.[53] This increases the pressures for theft or emigration to other countries, including countries with secret nuclear weapons programmes, and this is an unfortunate fact.

It is true that since 1994 efforts are under way by Russian and US authorities to develop and deploy a modernized system of Material Protection, Control and Accounting (MPC&A) at nearly all known vulnerable former Soviet sites. The MPC&A programme of the US Department of Energy aims to secure and keep track of 715 tonnes of nuclear material currently not used in nuclear weapons; a programme costing $ 383 million as of March 1999. Total US funding for the protection of Russian nuclear material has been over 1 $ billion. That might look like a lot of money but if that material is not secured, it is enough to build tens of thousands of nuclear bombs.[54] These efforts were originally scheduled to be completed by the year 2002[55] but it is now clear that this date cannot be met as the size of the problem is larger than originally anticipated.[56]

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[52] A leaked report from the German Federal Criminal Office noted that since the BND started tracking the activities of nuclear smugglers, alternative routes out of the former Soviet Union were chosen. Turkey was one exit point, the Baltic states a second and Vladivostock a third. — F. Barnaby, op. cit., p. 159. In the case of Turkey, 18 nuclear trafficking incidents were reported between 1993 and 1999. — Sandi Arnold and Michael Barletta. Overview of Reported Nuclear Trafficking Incidents Involving Turkey, 1993 — 1999. Monterey, Institute of International Studies, July 1999, p.1(<http://www.nyu.edu/globalbeat/nuclear/CNS080299.html>).

[53] Ibid., pp. 77-78.

[54] Carnegie Endowment for International Peace. U.S. Programs Face Growing Russian Threat. *Proliferation Brief*, Vol. 2, No. 4, 4 March, 1999, p.2.

[55] J. Stern, op. cit., p. 135. Writing in May 1999, Matthew Bunn commented on the Russian MPC&A efforts:"The MPC&A program has made substantial progress in recent years but has an enormously long road yet to travel. There are now [US-Russian, AS] agreements in place to cooperate at virtually every facility in the former Soviet Union where HEU or plutonium outside of weapons is located. The United States has allocated $ 573 million to this cooperation through March 1999, with the program budget at $ 140 in fiscal year 1999 and planned to remain in the $ 140 million to $ 145 million range for each of the following five years. (...)As of May 1999, security and accounting system upgrades had been declared completed at all of the nine sites in the non-Russian states of the former Soviet Union where separated plutonium or HEU is still located, along with eleven

Notwithstanding these efforts, a panel of the Center for Strategic International Studies, chaired by former US Senator Sam Nunn, concluded only recently, that, despite a decade of efforts, the risk of "loose nukes" is greater than ever.[57] The Chairman of the US President's Committee of Advisers on Science and Technology, John P. Holden, in turn had stressed already in 1995 that "There is now a clear and present danger that the essential ingredients for a nuclear bomb could fall into the hands of radical states and terrorist groups".[58]

Phil Williams will, I understand, discuss smuggling of nuclear materials from the territory of the former Soviet Union in more detail but let me at least give you here the conclusion of two eminent researchers Bruce Hoffman and David Claridge. In their study on 'Illicit Trafficking in Nuclear Materials' they found that:

"Perhaps most disquieting, however, is the realization that the quantities and qualities of the nuclear materials which have been most suitable for creating some sort of nuclear weapon have in fact already appeared on the market — albeit infrequently, but nonetheless it is undeniable that weapons-grade material has surfaced". Furthermore, as William Potter also notes, while 'the number of proliferation significant instances remains small, the quantity of nuclear material offered for sale has increased"[59]

Yet despite the increasing availability of nuclear material on the black market[60], so far we have not seen an attack by non-state actors. However, this is no guarantee that all will be quiet on this front.

The capabilities of terrorist and other groups in acquiring, handling and delivering nuclear and radiological materials.

What makes nuclear terrorism less likely than biological and chemical terrorism is that the raw materials are more difficult to acquire. In principle, nuclear terrorists can either go for a uranium-based device or a plutonium-based device. The disadvantage of highly enriched uranium is, from the terrorist point of view, that it is very difficult to acquire since practically all except some 20 tons is in military hands.[61] The advantage of uranium-235 is that once you have a sufficient quantity it is relatively easy to create a nuclear fission[62]. The problem with plutonium is the reverse: there is plenty of plutonium in the world — enough for more than

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sites in Russia.(...)Despite this record, the vast majority of the work required remains to be done. Most fissile material in the former Soviet Union is housed in buildings whose security and accounting systems have not been upgraded at all. There are still some sensitive facilities with very large quantities of fissile material that Russia has been unwilling to grant any access to..... — M. Bunn, in J. Cirincione (Ed.), op. cit., p. 81.

56 M. Bunn, in J. Cirincione (Ed.), op. cit., p. 82.

57 Cit. United States. Report of the National Commission on Terrorism. Countering the Changing Threat of International Terrorism. Washington, D.C., 15 March 2001, p. 7.

58 Statement of Dr. John P. Holdren to the US Senate Foreign Relations Committee, August 1995; cit. B. Hoffman with D. Claridge, op. cit., p. 27.

59 B. Hoffman with D. Claridge, op. cit., p. 29.

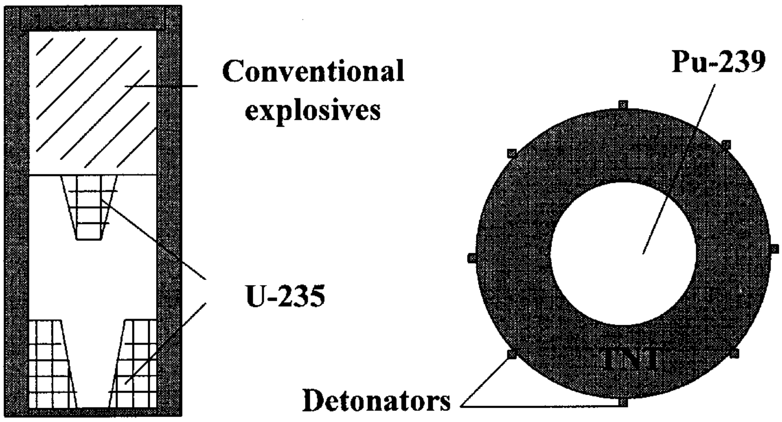
60 The existence of such a black market is a question of controversy. According to Frank Barnaby, "The Sudanese government has even admitted that Khartoum airport has been used by a number of government agents and arms dealers to conduct illicit discussions on nuclear deals". — F. Barnaby, op. cit., pp. 158-159.

61 F. Barnaby, op. cit., p. 155.

62 F. Barnaby writes:"Highly enriched uranium of the right purity generates a low level of neutrons and an explosion can be achieved simply by slamming together two lumps of HEU of sufficient quantity". — F. Barnaby, op. cit., p. 165. (He defines "sufficient as 40kg plus 15 kg = 55 kg; ibid., p. 166).

100,000 small nuclear weapons[63] — and it is increasingly in civilian hands. However, the construction of a plutonium implosion bomb is much more difficult than a simple gun barrel uranium bomb.[64]

Diagram: Uranium and Plutonium Bomb Design[65]



Source: H.A. Tolhoek, G. Aupers, Nuclear Terrorism, Polemological Institute Groningen, March/April 1982

The separation of plutonium from nuclear fuel rods is an easier chemical process than the enrichment of natural uranium from 0.7 per cent uranium-235 to highly enriched uranium. However, according to Robert Mullen, member of a US Task Force studying the risk of nuclear terrorism, plutonium separation is still quite difficult and therefore "not a credible option for a terrorist group".[66] On the other hand, if a crude plutonium bomb would malfunction — that is, the conventional explosives surrounding the plutonium would not be able to create a chain reaction — the result could still be catastrophic. The failed fission plutonium bomb could turn into a successful radiological dispersal device[67] and contaminate the site of the conventional explosion and a sizeable downwind area.[68]
What are the options, potential nuclear non-state terrorists have? Basically, there are seven options.

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[63] A Rand Corporation study for the US Department of Defense from the mid-1990s put the figure at 87,000; since then the amount of reactor-grade plutonium has increased. — F. Barnaby, op. cit., p. 179.

[64] For a discussion, see F. Barnaby, op. cit., pp. 168-169.

[65] H.A. Tolhoek, G. Aupers, Nuclear Terrorism, Polemological Institute Groningen, March/April 1982.

[66] N. Gurr and B. Cole, op. cit., p. 56, 77.

[67] A radiological dispersal device (RDD) has been defined as "any device, including weapons or equipment other than a nuclear explosive device, that is specially constructed to scatter radioactive material to cause destruction, damage, or injury by means of radioactive decay." — US Department of Defense definition, as quoted in Robert Burke. Counter-Terrorism for Emergency Responders. London, Lewis Publishers, 2000, p.141.- Depending on concentration, radiation damage might take weeks if not months or years to produce large numbers of fatalities. According to one estimate (Krieger, 1977), the release of 4.4 pounds of plutonium oxide in powder form in a population center could produce a 100 per cent probability of bone and lung cancer for every person within a distance of 1,800 feet downwind of the release point and a one per cent risk as far as 40 miles downwind. Amount and type of radioactive material used also determine damage and fatality — James L. Form. Radiological Dispersal Devices. Assessing the Transnational threat. *Strategic Forum*, No. 136, March 1998, p .3.

[68] F. Barnaby, op. cit., pp. 170-171.

Table 13. Methods of Acquisition of Nuclear Materials

1.	Constructing a nuclear weapon from scratch;
2.	Stealing warhead or HEU or plutonium from a processing site, storage site or weapons facility;
3.	Intercepting, hijacking or diverting a warhead or HEU or Pu in transport;
4.	Attacking a civilian nuclear power plant;
5.	Occupying a nuclear power plant with the help of insiders;
6.	Obtaining a nuclear device from a state-sponsor;
7.	Buying a ready-made (strategic or tactical) warhead or nuclear materials from needy, greedy or dissatisfied insiders or on the black market.

I will briefly illustrate how terrorists explored some of these options:

Ad 1:

As to the first option, building a bomb from scratch is obviously the least attractive option. Nevertheless, Aum Shinrikyo bought for $ 400,000 a 500,000-acre sheep farm in Australia along with eight mining leases for $ 4,700 each, where it intended to mine uranium. Aum Shinrikyo also spent millions of dollars on laser enrichment technology.[69] I have already referred to the second option, stealing. As far as the third option is concerned, we know that Aum Shinrikyo and before then, the German Rote Armee Fraktion collected information on the transportation of nuclear weapons and materials.

Ad 3 (intercepting en route):

In the 1980s, a member of the German Red Army Faction recorded on camera the loading of nuclear weapons on military aircraft at the US air base near Aviano, Italy, apparently in an effort to explore opportunities for theft. [70] Aum Shinrikyo [71]also collected information about the transport of nuclear materials.

Arguably, the greatest danger comes, for the time being, from options 4 and 5.

Ad 4 (Attacking civilian nuclear power plant):
There are 438 nuclear power reactors operating in 30 countries.[72] Attacks on such reactors have occurred in Argentina, France, the Philippines, Spain, South Africa[73]. Yet in all these

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[69] Robert Jay Lifton. Destroying the World to Save It. Aum Shinrikyo, Apocalyptic Violence, and the New Global Terrorism. New York, Henry Holt and Co., 1999, p. 36; Melissa Chirico. Changing Perceptions of the Nuclear Terrorism Threat: A Case Study of the Aum Shinrikyo Cult. Washington, D.C., George Washington University school of Foreign Service paper, Fall 1999, pp. 3-4.

[70] Terrorism Prevention Branch. Database on Significant Nuclear and Radiological Incidents, Events, Threats and Hoaxes. Vienna, TPB, May 2001, p. 2. — On the level of the state, there have been thefts en route. In November 1968, an entire shipment of uranium, with 220 tons of European-owned uranium-oxide disappeared on the ocean. The empty ship, the vessel 'Scheersberg' which departed from Antwerpen, later turned up in Iskenderum, Turkey. Years later it emerged that it was a Mossad operation, allegedly with the connivance of some Western governments.

[71] TPB Database, op. cit., entry 29 March 2000.

[72] Frank Barnaby. Instruments of Terror. Mass Destruction Has Never Been So Easy.... London, Satin Publications, 1996, p.175. Die Presse (Vienna), 4 May 2001, p. 23.

cases the reactors were not yet operational. Especially in the 1970s there were many such attempted attacks on nuclear power stations under construction. For instance, in the United States, there were 14 actual and attempted bombings of nuclear facilities between 1969 and 1975 alone.[74] In one case, on 12 November 1972 three men with guns and grenades hijacked a Southern Airlines DC-9 and threatened to crash it into a reactor at the Oak Ridge National Laboratory in Tennessee if their $ 10 million ransom demand was not met. The hijackers circled over the installation and the personnel had to be evacuated before the hijackers' bluff was called. On March 25 1973, 15 heavily armed Trotskyist Argentinian guerrilleros of the Revolutionary Peoples' Army (ERP) disarmed and wounded several guards and seized the nearly completed nuclear power station Attucha which is situated 62 miles north of Buenos Aires. They held it for a short time, throwing smoke grenades before escaping with stolen weapons. They did not enter the reactor area or damage the facility itself. The main goal was probably publicity. On May 3,1975 two bombs exploded at the site of a French nuclear power station under construction in Fessenheim, south of Strassbourg, causing extensive damage at the casing of the reactor. The 'Meinhof-Puig Antich' group claimed credit for this incident. Other attacks have been staged by the Breton Liberation Front (15 August 1975) and by the Basque ETA (December 1977).[75] The attack on a power station is probably the easiest of all terrorist nuclear options.[76] Simulation exercises to test the capabilities of local security forces to prevent sabotage or access into the reactor containment have produced some alarming outcomes in the United States.

Ad 5 (Occupying a nuclear power plant with the help of insiders):

In April 1997 the director of security and safeguards of the Rocky Flats nuclear facility in Colorado, USA, resigned, claiming that he could no longer ensure the safety of the citizens of Denver who lived 15 miles from the facility in which large amounts of weapon-grade material was stored. He warned that the Montana Militia, a right-wing group, had tried to recruit members from among the plant's guards — an attempt which was not successful but indicative of the interest of US groups in nuclear or radiological weapons.[77]

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73 Ely Karmon. Olympic Bomb Plot to Blow Up a Nuclear Reactor in Sydney Foiled. How Serious the Threat? Paper, 29 August, 2000, p. 3.

74 Ibid.- Mullins offers another set of figures: "Between 1969 and 1977, for example, the U.S. experienced 194 threats against nuclear facilities, four pipe bombs were discovered at nuclear facilities, and 15 people penetrated the intrusion alarm systems of nuclear facilities (Norton & Greenberg, 1979). — Wayman C. Mullins. A Sourcebook on Domestic and International Terrorism. An Analysis of Issues, Organizations, Tactics and Responses. Springfield., Ill., Charles C. Thomas, 1998 (2nd edition), p. 334.

75 TPB Database.

76 Gordon Thompson, a nuclear expert from Cambridge, Mass., concluded:"There can be no doubt that a successful attack [on a nuclear power plant] can be accomplished by a skilled commando-type military force, or its terrorist equivalent. This force would need technical advice from people who are familiar with the design and operation of nuclear plants. There are thousands of people around the world who possess the necessary knowledge. Plant security systems are not designed to resist determined attacks of this kind, and knowledge about vulnerabilities of security systems is widely available"- cit. F. Barnaby, op. cit., p. 176. — Nuclear power plants in the United States are also facing difficulties to meet security threats from terrorists. Paul Leventhal, the president of the Nuclear Control Institute, commenting on exercises to test the capabilities of US plant operators to successfully repel an adversary whose objective is radiological sabotage, noted that in 27 out of 57 plants tested there was a failure to respond adequately.. He noted that "At the 27 plants that failed, security forces were unable to deny entry to mock intruders or to prevent simulated sabotage of vital equipment in one or more on-site exercises. At 14 of these plants, the mock intruders were able to gain simulated access into the reactor containment itself". — Testimony of Paul Leventhal on behalf of the Nuclear Control Institute on the Recommendations of the NRC Safeguards Performance Assessment Task Force, presented to the U.S. Nuclear Regulatory Commission. Washington, D.C., 5 May, 1999, p .3 (<http://www.nci.org/t5599.htm>.

77 J. Stern, op. cit., p. 58.

The attack on, or occupation of, existing nuclear power plants for purposes of nuclear blackmail or for the creation of a Chernobyl-type disaster[78] is one of the scenarios the Russian government is concerned about. Already in 1992 the Russian Ministry of Security warned about this possibility, after having received threats against three nuclear power plants.[79] By early 2001, this possibility was — in the wake of the suppression of Chechen terrorism and separatism in the second Chechen war, again on the forefront of Russian concerns. Concern that Khattab or another Chechen warlord would target and sabotage a Russian power plant — of which there are 29[80] — was voiced by the director of the Russian FSB during an international conference in St. Petersburg on 18 April 2001.[81] According to an opinion poll conducted in Russia in November 1999, 90 per cent of Russians surveyed fear a terrorist attack on nuclear facilities while 86 per cent fear that a nuclear weapon in the hands of a terrorist could be used against Russia.[82]

Ad 6 (Obtaining nuclear device from a state-sponsor):

The most convenient way for terrorist groups to acquire nuclear weapons would be by state-sponsorship. However, it would be a foolish state who would do this.[83] While the terrorist group as a non-territorial actor cannot be easily hit in retaliation, any state caught in providing weapons of mass destruction to terrorists would face massive international sanctions if not

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[78] The nuclear accident at Chernobyl on 26 April 1986 initially killed only two persons but subsequently 28 persons suffering from radiation sickness died within four months. 237 persons were hospitalized with an acute radiation syndrome. 24,000 of the 116,000 persons evacuated received fairly serious radiation doses of about 45 rem. There were also about 1,800 cases of childhood thyroid cancer reported in the Ukraine, Belarus and the Russian Federation. A 30 kilometer exclusion zone around the reactor was established by the government. However, farmers as far away as 100 kilometers from the disaster zone abandoned their land. — Maxine Angela Roberts. The Chernobyl Incident of 1986: Its Impact on Soviet Agriculture. MSc dissertation, Wye College, University of London (July 1993), p. 42; cit. N. Gurr and B. Cole, op. cit., p. 103; U.N. Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 200 report; cit. UNIS Press Review, 27 April 2001.

[79] N. Gurr and B. Cole, op. cit., p. 14.

[80] "It's Business, Not Religion". *Nuclear Engineering International* (June 1994), p. 16; cit. George Thomas Kurian. Fitzroy Dearborn Book of World Rankings. Chicago, Firtzroy Dearborn Publishers, 1998, p.P.161. Die Presse (Vienna), 4 May 2001, p. 23. There are another 13 nuclear power plants in the Ukraine.

[81] Notes Alex Schmid from conference: International Terrorism: Origins and Counteraction. St. Petersburg, CIS Inter-Parliamentary Assembly, 18 April 2001. — During the first Chechen war (1994-1996) the Russian government formed an interagency group to address the issue of attacks against nuclear power plants and additional safeguards were put in place. However, an official of the Ministry of Atomic Energy told Jessica Stern that an intelligent terrorist could circumvent the new controls. — J. Stern, op. cit., p. 100.
Reports linking nuclear materials to Chechens have surfaced in the past. The *Sunday Times* reported in 1996 that a large cache of radioactive materials (including Plutonium-239 and Uranium-235) had disappeared from a site in Chechnya, along with a large quantity of highly radioactive nuclear material, possibly waste. — - *PPNN Newsbrief* (Fourth Quarter 1996), p.14; cit. N. Gurr and B. Cole, op. cit., p. 5. — Frank Barnaby wrote:"That large quantities of plutonium-239 and uranium- 235 have "disappeared"from a plant in war-torn Chechnya beggars belief. I also understand that 800 cubic meters of radioactive material, including unknown quantities of strontium-90 and caesium-137, have recently disappeared from a Russian factory near Tolstoy-Yurt, a village north of Grozny, the Chechen capital". F. Barnaby, op. cit., p. 182.

[82] Cit. Graham T. Allison and Sam Nunn. Chance for a Safer World: We Must Embrace Russia's New Willingness to Fight Nuclear Terrorism. *Washington Post*, 24 April 2000. — US public opinion, on the other hand was, in 1995, more apathetic about nuclear terrorism: 59 per cent of those surveyed in a nationwide Pew Research Center survey professed not to worry about such dangers. — The Pew Research Center. Public Apathetic About Nuclear Terrorism. — <http://www.people-press.org/terrep.htm>; N. Gurr and B. Cole, op.cit.,p. 112.

[83] "The likelihood of a state providing such a weapon to a terrorist groups is believed to be low", reports a Pentagon study of early 2001. United States. Department of Defense.. Office of the Secretary of Defense. Proliferation: Threat and Response. Washington, D.C., DOD, January 2001 (available under <http://www.defenselink.mil>), p. 61.

retaliation in kind. British intelligence sources have, so far, not received indications that states have passed the expertise on how to develop NBC weapons to terrorist groups[84]. John Deutch, from the US CIA, said in 1996 that there was, at that time, "....no evidence that any terrorist organization has obtained contraband nuclear materials".[85]

Ad 7 (Purchase):

There are still tens of thousands of ready-made nuclear weapons in the world[86] and terrorists might want to buy some of them. When Aum Shinrikyo attempted to acquire nuclear capability in 1993 they sought a meeting with the Russian Minister of Nuclear Energy, Victor Mikhailov, but their request was denied. There have also been reports that the Islamic Jihad had tried to obtain small quantities of plutonium and uranium from Russia.[87]

The intentions of various groups to use CBRN weapons and the goals they might pursue.

Are terrorists motivated to use weapons of mass destruction? In the late 1970s Brian Jenkins, then at the RAND organization, argued that "Nuclear terrorism is neither imminent nor inevitable... simply killing a lot of people is not an objective of terrorism".[88]

Why should a terrorist group strive for possession of a nuclear weapon? Neil Livingston has argued:

"The possession of only one weapon ensures the possessor a place on the 'first team'. (...)The possession of a nuclear weapon by a terrorist group would dramatically alter the international balance of power, not to mention the internal balance of any particular nation, and could put the terrorists beyond the reach of authorities. Confronted with the threat of nuclear catastrophe, even a major power would have to seriously consider capitulating to the demands of the terrorist group". [89]

In the open sources, there are relatively few attempts recorded in which terrorists were trying to threaten or use nuclear weapons of mass destruction. The database of the Monterey Institute contained — some time ago -282 terrorist incidents, of which only 26 per cent (73 incidents) involved the actual use of a chemical, biological or nuclear weapon[90]. More than half of the incidents (52%) registered by the Monterey Institute concerned chemical weapons; more than a quarter (25.9%) involved biological weapons or the threat thereof. In only 3.7%

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84 'Russians Help Syria to Make Chemical Arms'. *The Times, 25 January 1999; cit.* N. Gurr and B. Cole, op. cit., p. 199.

85 John Deutch. Testimony to: US Senate, Committee on Government Affairs, Permanent Subcommittee on Investigations. Global Proliferation of Weapons of Mass Destruction. 104th Congress, 2nd Session. 20 March 1996. Washington, D.C., GPO, 1996; cit. G. Cameron, op. cit., p. 12.

86 Jonathan Schell. Nuclear Abolition is the Goal. In: McCuen, Gary E. (Ed.). Biological Terrorism and Weapons of Mass Destruction Hudson, Wisc., G. McCuen Publ., 1999, p. 109 [Reprint from . J. Schell. 'The Gift of Time'. *The Nation*, 2/9 February, 1998,9-60].

87 TPB Database, op. cit., entry for June 2, 2000.

88 Cit. Nadine Gurr and Benjamin Cole. The New Face of Terrorism. Threats from Weapons of Mass Destruction. London, I.B. Tauris, 2000, p.7.

89 Livingstone, N. Megadeath: Radioactive Terrorism. In Yonah Alexander and Charles K. Ebinger (Eds.). Political Terrorism and Energy. The Threat and Response. New York, Praeger, 1982, p.174.

90 Jonathan B. Tucker and Amy Sands. 'An Unlikely Threat'. *The Bulletin of the Atomic Scientists* (July/August 1999), p. 48; cit. N. Gurr and B. Cole, op. cit., p. 32. — Over half of the recorded incidents were "unsubstantiated reports". — Ibid., p. 35.

of the recorded cases was a nuclear weapon or the threat thereof involved[91] Nadine Gurr and Benjamin Cole concluded:

"From known conspiracies it appears that no terrorist group has even attempted to develop a nuclear explosive device, and there have been only a few cases of groups attempting to purchase a nuclear device. Instead, the use of radioactive materials for contamination, either through a contamination bomb or otherwise, has been the preferred option for nuclear terrorism. But what few incidents have occurred, have mainly been in the 1990s, although it is too early to determine whether this constitutes a possible trend towards a greater number of incidents".[92]

Who are the groups interested in weapons of mass destruction? Millenarian, religious groups, far-right and racist groups as well as ethnic and national liberation groups have been associated with attempts to acquire CBRN weapons.[93] In some cases individual politicians have threatened to use nuclear weapons. The leader of the Bosnian Serbs, Radovan Karadzic and the Russian nationalist Vladimir Zhirinovsky have both threatened to use nuclear weapons against "The West".[94]

On the basis of a series of empirical case studies, the following is a profile of the terrorist personality most likely to engage in the use of weapons of mass destruction.

Table 14. Profile of the Terrorist Personality Most Likely to engage in CBW attacks[95]

1.	**Manifest personality traits of paranoia and grandiosity;**
2.	**Are innovative in their use of violence;**
3.	**Tend to escalate over time;**
4.	**Typically have no clearly defined base of political support and hence are unconcerned about adverse public opinion; and**
5.	**Are often convinced that they are fulfilling a divine command or prophecy that legitimizes murder.**

The most likely candidates for using weapons of mass destruction are thought to be religious millenarian groups, small terrorist cells, and brutalized groups seeking revenge ore facing destruction.[96] However, these conclusions were reached on the basis of a rather small number of cases and should be regarded as very tentative.

[91] N. Gurr and B. Cole, op. cit., pp. 32-34. — The authors do not explain why the three figures do not add up to 100%.
[92] N. Gurr and B. Cole, op. cit., pp. 34-35.
[93] N. Gurr and B. Cole, op. cit., p. 36.
[94] Karl Heinz Kamp. The Risk of Nuclear Terrorism is Overstated. In: Hurley, Jennifer A. (Ed.). Weapons of Mass Destruction. Opposing Viewpoints. San Diego, Cal., Greenhaven Press, 1999, p.37.
[95] Jonathan B. Tucker (Ed.). Toxic Terror. Assessing Terrorist Use of Chemical and Biological Weapons. Cambridge, Mass., MIT Press, 21000, pp. 266-267.
[96] Ehud Sprinzak. The Great Superterrorism Scare. *Foreign Policy*, No. 112, Fall 1999; cit. Steve Bowman and Helit Barel. Weapons of Mass Destruction — the Terrorist Threat. CRS Report for Congress. Washington, D.C., CRS, 8 December 1999, p.3.

The U.S. Department of State's report on Global Terrorism Trends has put 130 international terrorist groups on a watch list. Of these 130 groups posing a potential unconventional weapons threat, 55 groups have an ethnic agenda, 50 have a religious agenda, 20 have a left-wing agenda, and 5 a right-wing agenda.[97]

Yet perhaps only ten per cent of these are serious sources of concern with regard to weapons of mass destruction. According to George J. Tenet, the Director of the Central Intelligence Agency, there are "about a dozen terrorist groups that have expressed an interest in or have sought chemical, biological, radiological, and nuclear agents". [98]

Groups that have claimed or are said to possess nuclear, biological or chemical weapons or have issued threats of NBC use or have attempted to acquire such weapons, include some Middle East and North African groups, Caucasian rebels, ethnic separatists, and right-wing groups. A recent empirical study on terrorists and weapons of mass destruction singles out two kind of ideological groups as particularly dangerous:

1) religious extremists (both religious-fundamentalist terrorists and millenarian cults), and
2) right-wing extremists.[99]

Characteristics found among the groups involved in chemical and biological weapons incidents were

Table 15. Selected Motivational Factors Associated with CBW Terrorism

1. Charismatic leadership;
2. The absence of an external constituency;
3. Apocalyptic vision;
4. Loner or splinter group;
5. Sense of paranoia/grandiosity; and
6. Preemptive aggression.

Two characteristics shared by all groups investigated for their use of weapons of mass destruction were the lack of an outside constituency and a sense of paranoia/grandiosity. The question is whether these are also characteristics of Osama bin Laden's Al-Qaeda organization.

There has been much speculation whether he has nuclear weapons or not.

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[97] Dennis Pluchinsky, Paul de Armond, Ehud Sprinzak. The Classic Politically-Motivated Non-State Groups: In: Chemical and Biological Arms Control Institute and the Center for Global Security Research, Lawrence Livermore National Laboratories, p. 7.

[98] Testimony before the US Senate Armed Services Committee, 2 February 1999; cit. Simon Reeve. The New Jackals. Ramzi Yousef, Osama bin Laden and the Future of Terrorism. London, Andre Deutsch, 1999, p.262.

[99] In: Jerrold M. Post. Psychological and Motivational Factors in Terrorist Decision-Making: Implications for CBW Terrorism: Jonathan Tucker. (Ed.). Toxic Terror. Assessing Terrorist Use of Chemical and Biological Weapons. Cambridge, Mass., MIT Press, 2000, p.287. — The number of members of such groups can be quite large. As far as right-wing extremist groups are concerned, there were, for instance some 400 race hate groups in the United States, with between 20,000 and 40,000 supporters — Simon Wiesenthal, as quoted in N. Gurr and B. Cole, op. cit., p. 114.

Steve Bowman and Helit Barel, two researchers from the US Congressional Research Service, wrote in late 1999 that: "Despite Bin Laden's efforts, there is no strong open source evidence indicating that he or his organization have acquired WMD". [100]

Osama bin Laden has shown an interest in NBC weapons since the early 1990s and spoke publicly in 1999 about acquiring such a capability, calling the pursuit of those weapons a religious duty". [101] There have been some vague reports in the press — unconfirmed by official instances — that he has acquired at least 20 nuclear weapons — including 'suitcase' nuclear bombs and other materials from Chechen rebels.[102]

Russian "suitcase bombs"- the so-called "lost nukes", are tactical nuclear weapons from the Soviet arsenal. The issue of these ca. 30 kilogram weighting Special Atomic Demolition Munitions (SADMs) with a yield of 2 kilotons was first raised by Russian general Alexander Lebed, who was briefly the Secretary of Boris Yeltsin's National Security Council and as such had access to "Russia's darkest defense secrets". [103] He claimed that out of 132 "Suitcase bombs"(atomic demolition munitions) he had been able to locate only 48, leaving 84 unaccounted for.[104] While this claim has been denied in public by most officials in Russia and the West, some researchers find that there is substance to the story while others claim the opposite.[105]
Why Chechen warlords on the brink of defeat would sell what could be their most priced asset, is hard to imagine. However, it remains a fact there are indications that Osama Bin Laden has sought to acquire both chemical and nuclear weapons.

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[100] Bowman, Steve and Helit Barel. Weapons of Mass Destruction — the Terrorist Threat. CRS Report for Congress. Washington, D.C., CRI, December 8, 1999, p.6.

[101] United States. Department of Defense. Office of the Secretary of Defense. Proliferation: Threat and Response. Washington, D.C., DOD, January 2001 (available under <http://www.defenselink.mil>), p. 62.

[102] World News, 28 April 2001. Bin Laden Said to Have Nuclear Weapons. — The paper cites as sources the intelligence newsletter *Geostrategy-Direct.com* and the intelligence *WorldNetDaily* which, in turn, quoted Russian and Arab sources. — Yossef Bodanasky, Director of the US Congressional Task Force on Terrorism and Unconventional Warfare also professed such views: "Bin Laden is reported to have spent well over $ 3 million since 1996 in an effort to purchase a nuclear suitcase bomb from the former Soviet Union. Most of these efforts known to Western intelligence took place in Kazakhstan. Bin Laden's own Arab buyers and were frequently offered and at times even purchased radioactive junk and other useless stuff. But there might be other sources for these bombs.(...)Bin Laden has very close relations with the Chechens since he contributed both 'Afghan' forces and financial resources to their war against Russia.(...)"- Yossef Bodansky. Bin Laden. The Man Who Declared War on America. Rocklin, Cal., Forum, 1999, pp. 328.

[103] Cockburn, Andrew and Leslie. One Point Safe. New York, Anchor Books, 1997, p.250.

[104] J. Stern, op. cit., p. 90.

[105] Two authors from the Monterey Center for Nonproliferation Studies concluded:"....given the secrecy surrounding Soviet nuclear weapons, it is impossible to reach any definitive conclusion about the veracity of Lebed's claims. There is no convincing evidence that any former Soviet nuclear warheads have been lost, stolen, or misplaced. But since both the Russian and US governments would have powerful incentives to keep any such evidence confidential, and we have very little information about the number of nuclear weapons in the Russian stockpile and the location of the depots where they are stored, we also have no way of disproving Lebed's claim that some weapons are unaccounted for". — Scott Parish and John Lepingwell. Are Suitcase Nukes on the Loose? Monterey, Cal., Center for Non-Proliferation Studies, Monterey Institute of International Studies, 1998, available at:<http://cns.miis.edu/publs/reportslebedlg.htm>, p.10. — Milton Leitenberg, on the other hand, writes"....it seems overwhelmingly likely that General Lebed's claim was groundless". — Milton Leitenberg Terrorism and Weapons of Mass Destruction. In: Alex P. Schmid (Ed.) Countering Terrorism Through International Cooperation. Milan, ISPAC, May 2001, 62.

Table 16. Bin Laden and Nuclear Materials: Chronology of Alleged Acquisition Attempts[106]

1993/94:	According to the testimony of Jamal Ahmad al-Fadl, a Sudanese formerly employed by Bin Laden's Al-Qaeda organization, Bin Laden attempted to buy a 2-3 feet tall cylinder with uranium for $ 1.5 million in Sudan in late 1993/early 1994, possibly originating from South Africa.
Ca. 1995:	25 September 1998: Bin Laden's aide Mamdouh Mahmud Salim was arrested in Munich, Germany, and charged with acting on behalf of Bin Laden to obtain highly enriched nuclear materials in 1995.
1998:	16 August: Israeli military intelligence sources reported that Bin Laden paid over 2 million British pounds to a middle-man in Kazakhstan, who promised to deliver a 'suitcase' bomb to Bin Laden within two years.

On 24 December 1998, in an interview with TIME Magazine, Bin Laden said that, when asked whether he was seeking to obtain chemical or nuclear weapons:"Acquiring weapons for the defense of Muslims is a religious duty"(...)How we use them is up to us". From the conflicting evidence that is publicly available, it is clear that Bin Laden was actively seeking to acquire weapons of mass destruction. However, it does not appear that Bin Laden managed to get closer to nuclear weapons than possibly acquiring some lower-level radio nuclides strontium-90 and cesium-137 or low-level uranium wast which would only be suitable for a radiological dispersion device — a 'dirty bomb' the impact of which would have been predominantly psychological.[107] So far there is, at least according to credible open sources, no confirmed case of a non-state terrorist to be found in possession of nuclear material or being caught in the act of acquiring such materials.[108] At the same time it is a fact that criminals and some state agents have been found both possessing and trying to acquire nuclear materials.

Assuming that current buyers and terrorists would strike a deal: Why would terrorists wish to possess, threaten with, or use nuclear weapons? Jonathan Tucker, in one of the few works based on an empirical study of terrorist attempts to deploy weapons of mass destruction, offers the following motives:

1. Destroying a corrupt social structure;

2. Fighting a tyrannical government;

3. Fulfilling an apocalyptic prophecy;
4. Exacting revenge against evil-doers or oppressors, or as a form of "defensive aggression" against outsiders believed to be seeking the destruction of the group".[109]

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106 Resch, Kimberly and MattHEU Osborne. WMD Terrorism and Usama Bin Laden. Monterey, Center for Nonproliferation Studies, 2001, at <http:// www.cns.miis.edu /pubs /reports/ binladen.htm>,p.2.

107 Barton Gellman. Bush goes on high alert against nuclear threat — White House years up to repel domestic attack. The Toronto Star, 10 March 2002; Nick Fielding. Bin Laden "almost had uranium bomb'. Sunday Times, 3 March 2002.

108 N. Gurr and B. Cole, op. cit., p. 59.

109 Joathan B. Tucker (Ed.). Toxic Terror. Assessing Terrorist Use of Chemical and Biological Weapons. Cambridge, Mass., MIT Press, 2000, p.266.

The American Gilmore Report (1999) lists five reasons why terrorists may perpetrate a WMD attack:[110]

1. Simply the desire to kill as many people as possible;

2. To exploit the classic weapon of the terrorist — fear;

3. To negotiate from a position of unsurpassed strength;

4. Because there are certain logistical and psychological advantages that such weapons might offer terrorists (esp. in the case of biological weapons);

5. To cause economic and social damage by targeting a state's or region's agricultural sector.

Based on one database, 10 possible motives emerge:

For most of these motivational categories some indications can be found in the literature and TPB's database.

Table 17. Possible Motives for Acquisition, Possession, Threat with, or Use of Nuclear Weapons

1.	Propaganda;
2.	Revenge;
3.	Blackmail and Extortion;
4.	Intimidation;
5.	Provocation to Trigger Apocalyptic War;
6.	Deterrence;
7.	Defeat avoidance;
8.	Economic Damage;
9.	Individual or Collective Assassination;
10.	Financial Gain.

Ad 1 (Propaganda):

In November 1995 Chechen separatists placed a container with Cesium-137 near the entrance of Moscow's Izmailov Park and tipped NTV television about it. The 30-pound container was probably stolen from a hospital in Budyonnovsk, which the Chechens had briefly occupied in the spring of 1995.[111] They also threatened to detonate radiological devices in and around Moscow.[112]

Ad 2 (Revenge):

[110] Gilmore Report. First Annual Report to the President and the Congress of the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction. Washington, 15 December 1999, pp.9-11.

[111] Terrorism Prevention Branch. Database on Significant Nuclear and Radiological Incidents, Events, Threats and Hoaxes. Vienna, TPB, 2001, p.15.

[112] Gilmore Report. First Annual Report to the President and the Congress of the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction. Washington, 15 December 1999, p. 19.

In the Biafra war, in the late 1960s, which took near-genocidal proportions, Biafran exiles in Europe sought revenge for actions of Nigeria's central government. For this purpose they collected material for the construction of a radiological bomb which they planned to explode in the Nigerian capital Lagos. Nothing came in the end of this Ibo initiative as the radiological substance they had collected got 'lost' in Portugal on its way to Nigeria.[113]

Ad 3 (Blackmail):

In late 1994, Dzokar Dudayev, a former Russian rocket force general, anxious to win the independence of Chechnya, claimed to have obtained two tactical nuclear warheads. Since he had paraded tactical missile launchers through the streets of Grozny in the summer of 1992, the threat had to be taken seriously. He reportedly threatened to offer them to President Gadhaffi of Libya unless the United States recognized the independence of Chechnya. It was an empty threat — he had no such weapons although the Soviets had deployed such warheads in the Caucasus.[114] There have been criminal instances of nuclear blackmail: After a death sentence was issued against an organized crime leader, associates issued such credible threats of nuclear sabotage that two units of the Ignalina power station in Lithuania were closed down for a week on government orders[115]

Ad 4 (Intimidation):

A nuclear weapon is by definition an intimidating weapon.[116] So far there has been no successful credible intimidation according to open source materials, except for criminal blackmail.

Ad 5 (Provocation to Trigger Apocalyptic War):

In the early 1980s, a group of Jewish fundamentalists around Rabbi Meir Kahane planned to destroy Jerusalem's Dome of the Rock, Islam's third holiest shrine. They hoped that this would infuriate the Muslim world to such an extent that Israel, in self defense, would have to use its nuclear arsenal. The end result, they hoped, would then be the complete annihilation of Israel's Arab enemies and the establishment of a new 'Kingdom of Israel' ruled by a divinely anointed Jewish king. [117] In a similar way, Aum Shinryko apparently hoped to trigger a

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[113] Terrorism Prevention Branch. Database on Significant Nuclear and Radiological Incidents, Events, Threats and Hoaxes. Vienna, TPB, 2001, p.2. -Irak has been experimenting with radiological weapons. J. Stern writes: "At the end of 1987 the Al Muthanna State Establishment and the Nuclear Research Center at Al Tuwaitha began exploring the use of radiological "area denial"weapons to prevent enemy forces from entering certain territory. Iraq conducted field experiments of lead-shielded containers weighing 1,400 kilograms, loaded with about a kilogram of irradiated zirconium oxide. Three prototypes were tested in 1987, one in a ground-level static test and two dropped from aircraft. Iraq subsequently modified 100 bombs for use as radiological weapons. These bombs weighed only 400 kilograms so they could fit in bomb bays of aircraft. Iraq claims the tests were unsatisfactory and the program was abandoned in mid-1998. The fate of the 100 bomb casings specially constructed for use as radiological weapons is unknown". — J. Stern, op. cit., p. 120.

[114] Cockburn, Andrew and Leslie. One Point Safe. New York, Anchor Books, 1997,pp. 101, 55.

[115] Nadine Gurr and Benjamin Cole, op. cit., p.p.294-295.

[116] 25 April 1945; cit. Roberta Wohlstetter, 'Terror on a Grand Scale'. *Survival*, XVIII/ No.3 (May-June 1976), p.98.

[117] Bruce Hoffman. Inside Terrorism. London, Gollancz, 1998, p.103. — For this 'Temple Mount; operation, that was to trigger nuclear war, the Jewish terrorist had constructed 28 precision bombs to bring the Islamic holy shrine down.

nuclear war between Japan and the United States, notwithstanding the fact that they assumed that 90 per cent of the Japanese population would die in such a war.[118]

While the plot of the Jewish fundamentalist contained an element of dangerous plausibility, there was no logic to the Aum Shinrikyo scenario.

Ad 6 (Deterrence):

In an asymmetric power situation where one side has nuclear weapons, the other side is likely to consider that option if within reach. While it is highly unlikely that Palestinians can ever match the nuclear arsenal of Israel[119], some of them apparently do not exclude the acquisition of weapons of mass destruction. In May 1994, former PLO official Shaaban claimed in a newspaper interview that he had purchased two neutron bombs, hidden them in /southern Lebanon and Southern Jordan and threatened to attack Tel Aviv and West Jerusalem respectively.[120]

Ad 7 (Defeat avoidance):

When an abrupt regime changes, elements of the old regime might still hold on to some of the weapon systems while having lost political power. It has been claimed in this context that South Africa did not destroy all its nuclear weapons in 1993 but that some nuclear devices or raw materials to make them might have fallen into the hands of “white patriots” of the Afrikaner Resistance Movement.[121]

Ad 8 (Economic Damage):

There is no example of nuclear economic damage in the TPB database. However, a planned but aborted IRA incident in 1996 illustrates the scale of damage that is within reach of terrorists: In the summer of 1996 the IRA intended to simultaneously destroy six electric substations that link the London and the South East of England to the National Electric Grid. The destruction of the transformers, if successful, could have interrupted the flow of electricity to London for months.[122]

Ad 9 (Individual or Collective Assassination):

In 1996 (1994?) three members of the “Long Island UFO Network” were reported as having 5 canisters of radium with which they planned to poison three prominent Long Island

[118] N. Gurr and B. Cole, op. cit., p. 137; see also: Robert Jay Lifton. Destroying the World to Save It. New York, Henry Holt and Company, 1999, p. 194.

[119] According to Richard Butler, the undeclared nuclear arsenal of Israel is estimated by most experts as around 200 weapons — almost twice the size of China’s nuclear arsenal. — Richard Butler. The Greatest Threat. New York, Public Affairs, 2000, p. 240.

[120] Ariel Cohen (The Heritage Foundation) Prepared Testimony before the US House of Representatives International Affairs committee. Crime and Corruption in Russia and the New Independent States: Threats to Markets, Democracy and International Security.. US Federal News Service, 31 January 1996, p.5.

[121] FBIS Report, 23 October 1995, based on Johannesburg SAPA. Allegations in this sense had been made by journalists Peter Hounam and Steve McQuillan.

[122] Stewart Tendler, ‘How Police Watched the Ä Team’, *The Times*, 3 July 1997, and ‘The Men Who Tried to Shut London’, ibid., cit. G. Cameron, .op. cit.,p.68.

Republican Party politicians who were allegedly covering up the crash landing of space aliens.[123]

Ad 10 (Sale):

According to Rensselaer Lee, an US researcher, the Islamic Jihad, reportedly sent a fax to Russia's Arzamas-16 nuclear research center, offering to buy a nuclear weapon. The center's director, according to Rensselaer Lee, was also approached by Iraqi representatives in 1993. They allegedly offered him $ 2 billion for a warhead.[124]

Terrorism is often an unpredictable weapon and its use might backfire. When it comes to weapons of mass destruction, that uncertainly is even bigger. This is also recognized by some terrorists. One Chechen warlord, Salman Raduyev, when asked whether or not Chechens would attack Russian nuclear power plants during the 1999-2000 war, said they would not, "....because the consequences of this cannot be predicted".[125] Some of the reasons, which have

refrained states from using nuclear weapons might, after all, also apply to non-state terrorists. The following two tables list facilitating, as well as inhibiting factors, which might guide terrorist decision making.

Whether on balance the incentives or the disincentives prevail should not be left in the hands of the terrorists. The international community has to make sure that terrorists are incapacitated and dissuaded.

Table 18. Terrorist Use of Weapons of Mass Destruction: Facilitating Factors[126]

1.	Some of the current conflict zones (e.g. in the Caucasus) contain civilian nuclear facilities or research institutes that can be used for theft or fabrication of WMD;
2.	The civilian nuclear industry produces huge amounts of plutonium[127] which, especially if separated, is attractive to thieves;
3.	The information revolution (Internet), in combination with the migration of nuclear physicists, has increased the likelihood of people getting access to critical information about how to produce a nuclear weapon;
4.	Organized crime might become involved in the procurement and transport of nuclear materials.[128]
5.	Concealment and transport of some of these weapons is, due to their small size, relatively easy;
6.	Urbanization has increased the chance of mass fatalities in the case of an attack.

123 N. Gurr and B. Cole, op. cit., p.p.293-294.

124 The price seems rather high. According to Frank Barnaby, "A kilogram of weapons-grade plutonium...would be...worth one or two million dollars on the black-market". — For a nuclear materials black-market price- list, see B. Hoffman with David Claridge, op. cit..

125 'Sergeyev: Troops Won't Stop at Terek'. *Moscow Times*, 13 October 1999; cit. N. Gurr and B. Cole, op. cit., p.121. — However, during the first Chechen war there were numerous threats. According to one Russian intelligence official, during the years 1995 — 1997, there were 50 instances of nuclear blackmail in Russia, most of them hoaxes. — Ely Karmon. Olympic Bomb Plot to Blow Up a Nuclear Reactor in Sydney Foiled. How Serious the Threat? Paper, 29 August, 2000, p. 3.

126 Alex P. Schmid. Terrorism and The Use of Weapons of Mass Destruction: From Where The Risk? *Terrorism and Political Violence*, Vol. 11, No. 4, Winter 1999, pp. 120-121.

127 Gavin Cameron writes:"The global stock of plutonium in 1995 was around 1,500 tonnes, of which 1,200 were civilian, the overwhelming majority remaining unseparated as reactor fuel. The 1996 ratio of used military to used civilian plutonium was 50:50. However, by 2010, 70 per cent of the world's used plutonium will be civilian, much of it in state such as France, Japan, the United Kingdom as a result of reprocessing, as well as in

Historical Evidence of Terrorist Incidents or Threats which have Involved Nuclear or Radiological Material, and Forecasts About the Future.

Given the fact that there have been very few cases of terrorism based on the threat or use of nuclear materials, it is impossible to establish trends. One database constructed by the International Policy Institute for Counter-terrorism (ICT) in Israel, includes some 300 incidents of chemical, biological and nuclear terrorism. As one of its authors writes:

Table 19. Terrorist Use of Weapons of Mass Destruction: Inhibiting Factors[129]

1.	General reluctance to experiment with unfamiliar weapons;
2.	Lack of familiar precedents;
3.	Fear that weapon would harm the producer (radiation hazard) or user;
4.	Fear of alienating relevant constituencies and potential supporters on moral grounds;
5.	Fear of unprecedented governmental crackdown and retaliation to them, their constituencies or sponsor states;
6.	Lack of a perceived need for indiscriminate, high-casualty attacks for furthering goals of the group;
7.	Lack of money to buy nuclear material on the black market.

"From the statistical analysis of this database it appears clearly that most of the terrorism involving nuclear targets (167 incidents for the period 1970-1999) happened mostly in the 1970-1979 period (120) and diminished dramatically in the next two decades. Even so, the great majority of the incidents refer to threats (98) or involved mainly actions against facilities (43).[130]

This fact also comes to the foreground from the following table which covers twenty years of protest against nuclear energy.

Russia. By contrast almost all HEU is military; only about one per cent is classified as civilian". (G. Cameron, pp. 4-5). Col. Guy Robert adds:"Growing stockpiles of civilian or reactor grade plutonium in Western Europe and Japan alone will be sufficient for 47,000 bombs. — G. B. Roberts, 'Nuclear Weapons-grade Fissile Materials. The Most Serious Threat to US National Security Today? *Airpower Journal* , (Special Edition 1996), p. 4.

[128] A public prosecutor in Florence, Pier Luigi Vigna, had revealed in the early 1990s that the Italian mafia was interested in nuclear, chemical and bacteriological weapons from Eastern Europe. In January 1993 three men, including a former Bulgarian secret service agent, were arrested in the Italian town of Brescia for trafficking in radioactive materials. According to the prosecutor, Guglielmo Ascione, members of the mafia clan were involved who had earlier tried to sell nuclear materials sufficient for the production of nine atomic bombs, to the Middle East. *Volkskrant*.(Amsterdam), 15 February 1993.According to Stephen Handelman "Police in Western Europe have even intercepted Russian gang members trying to sell a nuclear warhead" — S. Handelman. Inside Russia's Gangsster Economy. Why Capitalism and the Mafia Mean Business. *The New York Times Magazine*, 24 January 1993.

[129] List partially based on Ron Purver, 'Chemical and Biological Terrorism: The Threat According to the Open Literature', *Canadian Security Intelligence Service*, June 1995, p. 7.

[130] Tad Daley. Halting a Thousand Suns. Bridging the Chasm between the Nuclear Haves and Have-Nots., *United Nations Chronicle,* , No 3, 2000, pp.16-17.

Table 20. Nuclear-Related Incidents, 1966-1985, by Type of Incident[131]

Incident	N. America	West. Europe	Others
Kidnaping & Assassination	0	8	0
Theft & Smuggling	5	8	11
Bombing on-site location where nuclear material or equipment is present	9	24	9
Bombing off-site	79	30	4
Other attacks off-site	5	19	1
Other incidents	1	6	7

These actions were due mainly to the activity of extremist left-wing organizations which opposed the US and Western nuclear armament and deployment of nuclear missiles, especially in Europe.[132]
In addition, there have been reports of cases of criminal dispersal of radioactive substances and attempts at poisoning, in at least one case involving a secret service. There have also been many extortion threats of a criminal nature, especially in the United States. Smugglers of nuclear materials from Eastern Europe have, in at least one case, threatened to disperse radioactive materials in the city of Prague, if their arrested colleagues were not released. There have been several threats which had to taken seriously, given the past record of the groups involved, especially in the case of Chechens. In March 2000 Chechen rebels threatened to use radiological agents against Russian troops, claiming they had obtained the necessary radioactive substances from a site 30 kilometers southeast of Grozny.[133] In July 2000, for instance, the "Supreme Military Council of Holy Warriors of the Caucasus" informed the Russian government that its members would attack, inter alia, Russian nuclear power plants in retaliation for Russian military activities in Chechnya.[134]

There have been numerous hoaxes in the field of weapons of mass destruction, especially biological hoaxes, but also some nuclear ones. So far, however, there have been no cases of nuclear terrorism by non-state actors. Yet the tide might be turning.

Conclusion

After the Cuban Missile crisis which brought the two superpowers to the brink of nuclear war, the US president, John F. Kennedy, expressed grave concern about the possible emergence of some 20 or 30 countries possessing nuclear weapons.[135] This concern led to the Treaty on the Non-Proliferation of Nuclear Weapons which came into force in 1970. By January 2000, it

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131 Nuclear Control Institute in co-operation with SUNY's Institute for Studies in International Terrorism, 1986; cit. The 1987 World Almanac (New York, World Almanac 1997) p. 35.
132 Ely Karmon. Olympic Bomb Plot to Blow Up a Nuclear Reactor in Sydney Foiled. How Serious the Threat? Paper, 29 August, 2000, p.3;U.S. Department of State. Washington File. Dod Proliferation Report Updates Threat from Nuclear, Bio, Chemical Weapons, by Susan Ellis. 10 January 2001.
133 TPB Database, entry for 1 March 2000.
134 TPB Database, entry for 22 July 2000.
135 Richard Butler. A Likely Result of Missile Defense? More Missiles. *International Herald Tribune*, 3 May 2001.

had 187 parties.[136] Nearly 50 countries today are considered "nuclear-weapon capable" and eight, if not more, actually posses such weapons — almost twice as many as when the Non-Proliferation Treaty was opened for signature in 1970. There is an undeniable trend towards proliferation among states. When presenting, in January 2001, a new Report on Proliferation of Weapons of Mass Destruction, the US Secretary of Defense Cohen remarked that at least 24 countries either possessed weapons of mass destruction or were in the process of acquiring them.[137] While this figure of "at least 24 countries" covers mainly states possessing or seeking chemical and biological weapons, it also applies to nuclear proliferation. What is even more worrisome is that we might also see such a trend among non-state actors — that is among criminal or terrorist organizations and religious sects and sub-national ethnic groups striving for statehood. If the nuclear 'haves' are not taking more decisive steps to disarm, as they promised in 1970 and again in 1995, the argument that "What is good for them is good for nuclear 'have-nots' too" might gain the upper hand. Especially in situations where there is a large power asymmetry between conflict parties, nuclear weapons and other weapons of mass destruction might be seen as "big equalizers". While nuclear deterrence against a territorial state is widely held to work (though it did not deter Iraq from attacking Israel during the Gulf War), it is more questionable whether a non-territorial actor can be deterred effectively.
Nuclear terrorism by non-state actors is, at this moment, still a low probability event. It is less likely than chemical or biological terrorism. Yet if it materializes, it is one of high consequences for world order.[138] Time might not be on our side. The amount of plutonium in the world is increasing. Russia, for instance, will accumulate another 60 tons of weapons-grade plutonium by the year 2003 as a result of dismantling its nuclear warheads under current treaty obligations.[139] How will these nuclear materials be protected? There is still no comprehensive international agreement establishing standards of physical protection for all — civilian and military — nuclear materials.[140]

The United Nations has, for some time, discussed a draft for an international convention for the suppression of acts of nuclear terrorism. The draft text, proposed by Russia, was meant to cover the gaps left by the 1980 Convention on the Physical Protection of Nuclear Materials, which only covers peaceful uses but not nuclear material of a military nature and only addresses criminal theft, not nuclear terrorism.[141] However, the UN Ad Hoc Committee on International Terrorism which has been working on a new convention for the Suppression of Nuclear Terrorism, has not been able to reach consensus so that the treaty text can be submitted to the General Assembly and subsequently opened for signature and ratification. The main stumbling block has been a divergence of views between those Member States which wanted to confine the treaty to non-state actors and those states which wanted to include the activities of the armed forces of a state as well as acts of state terrorism.[142] The world can ill afford such a stalemate. Vigorous efforts need to be made to keep the nuclear genie in the bottle and out of the hands of terrorists. The International Atomic Energy Agency

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[136] Among the major non-signatories were (as of 1997) Brazil, Cuba, India, Israel and Pakistan. — US Congressional Record, Senate, 105th Congress, 1st Session, 5 March 1997 (Vol. 143, No.27).

[137] S. Ellis. DOD Proliferation Report Updates Threat from Nuclear, Bio, Chemical Weapons. U.S. Department of State. Washington File, 10 January 2001"

[138] Parachini, John V. Combating Terrorism: Assessing Threats, Risk Management, and Establishing Priorities. Statement before the US House of Representatives Subcommittee on National Security, Veterans Affairs, and International Relations, 26 July 2000. Monterey, Center for Nonproliferation Studies, 26 July, 2000, p.5.

[139] Interfax (Moscow), 20 March 1997.; cit. FBIS, 20 March 1997.

[140] N. Gurr and B. Cole, op. cit., p. 229.

[141] Ibid., p.227.

[142] Hans Corell. Possibilities and Limitations of International Sanctions Against Terrorism. In: Alex P. Schmid (Ed.). Countering Terrorism Through International Cooperation. Milan, ISPAC, 2001, p.255.

should stand in the forefront in these efforts. Yet a broad plan of action is needed. It should cover the following five fields:

1. Intelligence collection priorities ought to focus more strongly on proliferation issues and on desperate actors (liberation movements, religious sects, racist groups and chauvinist nationalists) likely to be tempted to acquire WMD.

2. The trade in (precursor) materials for chemical, biological and nuclear substances must be subjected to better monitoring and greater control.

3. Existing Conventions in the field of NBC weapons, terrorism and organized crime must be strengthened by adding (better) monitoring, implementation and sanction mechanisms.

4. International co-operation to counter proliferation and terrorism must be enhanced and bureaucratic red tape and turf fighting have to be dealt with by creating more flexible and intelligent organizations.

5. Existing governments stockpiles of NBC weapons must be better guarded and accounted for, and gradually be phased out and destroyed. A credible, multilateral NBC disarmament programme by governments will also put moral pressure on non-state actors to refrain from the acquisition and use of such weapons.

BIBLIOGRAPHY

Barnaby, Frank. Instruments of Terror. Mass Destruction Has Never Been So Easy.... London, Vision Paperbacks, 1996.

Bhatia, Shyam and Daniel McGrory. Brighter than the Baghdad Sun. Saddam Hussein's Nuclear Threat to the United States. Washington, D.C., Regnery Publ., 2000.

Bodansky, Yossef. Bin Laden. The Man Who Declared War on America. Rocklin, Cal., Forum, 1999.

Bowman, Steve and Helit Barel. Weapons of Mass Destruction — the Terrorist Threat. CRS Report for Congress. Washington, D.C., CRI, December 8, 1999.

Burke, Robert. Counter-Terrorism for Emergency Responders. London, Lewis Publishers, 2000.

Butler, Richard. The Greatest Threat. Iraq, Weapons of Mass Destruction and the Crisis of Global Security. New York, Public Affairs, 2000.

Cameron, Gavin. Nuclear Terrorism. A Threat Assessment for the 21st Century. New York, St. Martin's Press, 1999.

Cirincione, Joseph (Ed.). Repairing the Regime. Preventing the Spread of Weapons of Mass Destruction. London, Routledge, 2000.

Cockburn, Andrew and Leslie. One Point Safe. New York, Anchor Books, 1997.

Deutch, John. Proliferation of Weapons of Mass Destruction. Hearings, Permanent Subcommittee on Investigations, Committee on Governmental Affairs, United States Senate, Part II, March 13, 20, 22 1996.

Gilmore Report. First Annual Report to the President and the Congress of the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction. Washington D.C., 15 December 1999.

Gurr, Nadine and Benjamin Cole. The New Face of Terrorism. Threats from Weapons of Mass Destruction. London, I.B. Tauris, 2000.

Hoffman, Bruce. Inside Terrorism. London, Indigo, 1999.

Hurley, Jennifer A. (Ed.). Weapons of Mass Destruction. Opposing Viewpoints. San Diego, Cal., Greenhaven Press, 1999.

Karmon, Ely. Olympic Bomb Plot to Blow Up a Nuclear Reactor in Sydney Foiled. How Serious the Threat? International Policy Institute for Counter-terrorism (ICT) Paper, 29 August, 2000.

Larsen, Ken Nuclear Emergency. How to Protect your Family from Radiation. Suwanee, GA, Rhema Publ., 1997.

Laqueur, Walter. The New Terrorism. New York, Oxford University Press, 1999.

Leitenberg, Milton. Terrorism and Weapons of Mass Destruction. In: Alex P. Schmid (Ed.) Countering Terrorism Through International Cooperation. Milan, ISPAC, May 2001 (pp. 38-69).

Livingstone, N. Megadeath: Radioactive Terrorism. In: Yonah Alexander and Charles K. Ebinger (Eds.). Political Terrorism and Energy. The Threat and Response. New York, Praeger, 1982.

Mark, J. Carson Mark, Theodore Taylor, Eugene Eyster, William Marman and Jacob Wechsler. 'Can Terrorists Build Nuclear Weapons?'. In: Paul Leventhal and Yonah Alexander (Eds.). Preventing Nuclear Terrorism. Lexington, Mass., Lexington Books, 1987.

McCuen, Gary E. (Ed.). Biological Terrorism and Weapons of Mass Destruction Hudson, Wisc., G. McCuen Publ., 1999.

Muir, Angus M. Terrorism and Weapons of Mass Destruction: The Case of Aum Shinrikyo. *Studies in Conflict and Terrorism*, 22:79-91, 1999.

Mullins, Wayman C. A Sourcebook on Domestic and International Terrorism. An Analysis of Issues, Organizations, Tactics and Responses. Springfield., Ill., Charles C. Thomas, 1998 (2nd edition).

Parachini, John V. Combating Terrorism: Assessing Threats, Risk Management, and Establishing Priorities. Statement before the US House of Representatives Subcommittee on National Security, Veterans Affairs, and International Relations, 26 July 2000. Monterey, Center for Nonproliferation Studies, 26 July, 2000.

Parish, Scott and John Lepingwell. Are Suitcase Nukes on the Loose? Monterey, Cal., Center for Non-Proliferation Studies, Monterey Institute of International Studies, 1998, available at:<http://cns.miis.edu/publs/reportslebedlg.htm>.

Potter, William C. and Jessica Matthews. Nuclear Successor States of the Soviet Union. Status Report on Nuclear Weapons, Fissile Material, and Export Controls. No. 5, Monterey, Institute of International Studies, March 1998.

Reeve, Simon. The New Jackals. Ramzi Yousef, Osama bin Laden and the Future of Terrorism. London, André Deutsch, 1999.

Resch, Kimberly and Mathieu Osborne. WMD Terrorism and Usama Bin Laden. Monterey, Center for Nonproliferation Studies, 2001, at <http:// www.cns.miis.edu /pubs /reports/ binladen.htm>.

Schmid, Alex P. Terrorism and the Use of Weapons of Mass Destruction: From Where the Risk? *Terrorism and Political Violence*, Vol. 11, No. 4, Winter 1999, pp.106-132.

Schmid, Alex P. (Ed.). Countering Terrorism Through International Cooperation. Milan, ISPAC, 2001.
Schmid, Alex P. Chemical Terrorism: Precedents and Prospects. The Hague, OPCW, 7-9 February 2001. Forthcoming publication.

Schweitzer, G.E.. Superterrorism. New York, Plenum Trade, 1998.

Stern, Jessica E. The Ultimate Terrorists. Cambridge, Mass., Harvard University Press, 1999.

Tanter, Raymond. Rogue Regimes. Terrorism and Proliferation. Updated Edition. New York, St. Martin’s Griffin, 1999.

Tucker, Jonathan B. and Amy Sands. ‘An Unlikely Threat’. *The Bulletin of the Atomic Scientists* (July/August 1999),

Tucker, Jonathan B. (Ed.). Toxic Terror. Assessing Terrorist Use of Chemical and Biological Weapons. Cambridge, Mass., MIT Press, 2000.

United States. Department of Defense. Office of the Secretary of Defense. Proliferation: Threat and Response. Washington, D.C., DOD, January 2001 (available under <http://www.defenselink.mil>).

Webster, William H. et al. Wild Atom. Nuclear Terrorism. Global Organized Crime Project. Washington, D.C. Center for Strategic and International Studies, 1998.

QUESTIONS & ANSWERS

K. Hirano (Japan): Referring to the sarin gas attack on the Tokyo metro, I would like to point out that — although there were few casualties due to the timing of the incident — we still have to regard it as an indiscriminate use of a weapon of mass destruction (WMD). We cannot rule out the possibility of the same group perpetrating a radiological attack or attempting to sabotage a reactor.

A. Schmid (UN): Certainly, 40 people were seriously injured and hundreds traumatized. Nevertheless, in this incident, the nuclear taboo was not broken.

G. Bunn (USA): What is the chance of a compromise on the Russian draft for a UN treaty against nuclear terrorism? One group opposes any such treaty unless it prohibits the use of nuclear weapons by States as well as terrorists but the nuclear-weapon States would not accept that.

A. Schmid: It is difficult to speculate, but there is a slight hope for progress since there could be some trade off with other conventions and treaties currently under consideration at the UN.

THREATS AND RISKS: NEW THREATS IN TERRORISM

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Abstract. The presentation considers the types of attack we can expect from terrorists of the future, what methods may apply to achieve their goals or what weapons they could use. These new kinds of weapons are the so-called Weapons of Mass Destruction (WMD) which include nuclear, chemical and biological weapons. Also considered is the use of cyber-space by terrorist groups. The types of weapons, their manufacture, their likely use and the kinds of groups and individuals who might use them are discussed, together with preventative and response measures.

INTRODUCTION

The topic I am going to talk about is the new threats in the domain of terrorism. The subject of my presentation will be to study the types of attacks that we can expect from the terrorists of the future, what methods they may apply to achieve their goals or what weapons they could use whatever their ideology or origin is. These new kind of weapons are the so called Weapons of Mass Destruction (WMD) and inside this category, nuclear, chemical and biological weapons are included. I will speak finally about the use of the cyber -space by terrorist groups as it could be considered as well as a new threat.

During my presentation I will try to give you an idea of what these types of weapons are, how easily they could be manufactured, their likely use by terrorists, what kind of groups or individuals may use them and what measures can be taken to try to prevent terrorists using them. I will also discuss measures that can also be taken to prepare ourselves and the population in general to minimize the consequences of an attack.

My purpose is to give you a general idea under a police perspective of what kind of attacks we may expect.

THE THREAT OF WEAPONS OF MASS DESTRUCTION

Nowadays, the terrorists have easy access to sources of information. Instructions on how to build a chemical or biological device and where to obtain the necessary materials can be found in open literature or simply through Internet. Many of these materials are commonly used for legitimate commercial purposes. The installations and technical equipment to produce a chemical or biological device are small and thus difficult to detect. They can also be camouflaged under the activity of a commercial enterprise apparently exercising normal and legal trade.

The materials can be obtained in different ways. For example Nuclear Materials are obtained mainly through illicit trafficking. Toxic chemicals can be obtained by the processing of legal substances or through diversion of dual use substances. Biological Materials can be diverted from legal trade, cultivated in clandestine laboratories or obtained in the nature.

Regarding technical expertise, only a basic technical knowledge of chemistry or biology is needed to build a simple but deadly device of this kind. On the other hand nuclear bombs almost certainly would need state sponsorship to be developed or manufactured, however devices that can disperse radiation are also easy to make. The terrorist only has to obtain a sufficient amount of radioactive or nuclear material and put it together with a traditional explosive. The radiation would be dispersed around.

Having said that, the next step is trying to identify the type of terrorist groups that can cross the line of the traditional weaponry and commit an attack employing WMD.

The world's terrorist organizations have changed. Groups that were very active in the 70's and 80's have disappeared. We do not hear any more about terrorist attacks from the Red Army Faction, neither Action Directe nor the CCC. Groups representative of the nationalism-separatism like IRA or ETA have declared cease-fires in the past and although the question of their complete renounce to violence for the IRA is not clear yet, progress has been made. Even the PKK and GIA activities have decreased significantly.

The type of terrorist groups that could possibly consider employing Weapons of Mass Destruction now or in the future are the apocalyptic groups or sects, the neo-fascist groups and the "fringe" terrorists. Other groups have not sought to use these weapons in the past because they did not comply with their requirements regarding targets or objectives because it is very difficult to predict their action ratio and the quantity of people harmed, therefore their usage may not be approved by their supporters. On the contrary WMD are more attractive to groups or sects considered "fanatical" and the so-called "fringe" terrorists.

Sects members generally follow without hesitating the doctrine imposed by the leader of the movement who in a given moment can decide that the end of the world has come or that it is time for followers and sympathizers to commit suicide in order to pass to the promised land. While the "traditional" terrorist groups might have doubts to cause a great number of victims, those who believe they are following the path to paradise will not hesitate to kill as many people as possible to accompany them.

THE NUCLEAR THREAT

There are many books, stories and press articles about the nuclear threat. Sometimes, reality and fiction are mixed up.

One of the necessary steps for terrorists trying to commit an attack of this nature is to obtain the material. Contrary to traditional bombs that can be manufactured from a wide range of ingredients including commercial substances which can be found in the open market, like for instance agriculture fertilizers; nuclear/radioactive devices need specific material subject to strict control regulations and generally more difficult to acquire.

In order to get the nuclear/radioactive substances terrorists have to turn to illicit trafficking. There have been many (Interpol) reported arrests & seizures related to radioactive material in the past few years, none were terrorism related.

In an analytical study made by Interpol in 1994 at a time where the problem was the subject of the highest concern, it was established that generally speaking, the traffickers were almost always amateur criminals, often with connections through friends or relatives working in nuclear enterprises. In most of the cases they did not appear to belong to a criminal organisation. They usually got arrested while carrying the materials or in their attempt to find a buyer for the material. Buyers and end-users could seldom be positively identified.

The fact that terrorists are not interested at the present time in the radioactive/nuclear market does not exclude that they could change their tactics in the future. Bearing in mind that this is an added threat besides the existing ones we should set the fight against illicit trafficking and proliferation as a priority.

Many efforts have already been done in this domain; measures have been taken at all levels. International treaties have been signed, international organisations have this fight as a priority, but nevertheless it is not always possible to prevent the misappropriation of radioactive substances. Although such agreements are essential, they cannot prevent or stop the trafficking in radioactive substances thus this type of crime falls into law enforcement jurisdiction. Police services have an important responsibility to face.

Interpol has been aware of this problem and has made efforts to enhance and promote the international police co-operation in this field. We are involved in co-operation programs along with international organisations having an interest in prevention, detection and response to illicit practices involving radioactive material. We regularly participate in meetings, conferences and training programs within this domain together with the IAEA (International Atomic Energy Agency), the WCO (World Customs Organisation), Euratom etc.

These inter agency co-operation meetings constitute an unique forum to discuss initiatives to combat the illicit trafficking in nuclear/radioactive material. Each International Organisation has a different point of view of the problem and a different way to deal with it under the scope of their particular purpose, mandate or internal rules. So let me stress the importance of the continuation of this form of international co-operation that in my opinion represents an example in the way on how international organisations could make common efforts to approach a complex international problem that requires technical expertise, scientific knowledge and law enforcement application all together.

To achieve this technical expertise and scientific knowledge, Interpol has been involved in training courses on combating smuggling on nuclear/radioactive materials in close co-operation with the IAEA, the WCO and the Austrian Customs Administration. These training courses have been addressed to custom and police officers. The aim is to provide front line officers and investigators with the required knowledge to deal with this type of cases.

THE CHEMICAL THREAT

Production and traffic of chemical weapons are banned by the convention on the Prohibition of the Development, Production Stockpiling and use of Chemical Weapons. The implementing body OPCW (Organisation for the Prohibition of Chemical Weapons) was established in April 1997 and is located in The Hague. The OPCW conducts inspections in different countries .The adherent nations to the CW Convention have implemented domestic laws to control the illegal production and traffic of the chemical agents listed in the convention. Industry needs chemicals for different purposes and they are processed through different phases. In those phases, some resultant products could be, with further small manipulation, converted into chemical agents or precursors included in the chemical weapons convention.

Let me talk for a minute about the most typical examples of the use of chemicals in the history of terrorism. I am referring to the only two cases of terrorism linked use of *chemical* products that have been reported to Interpol. the June 1994 use of Sarin gas in Matsumoto

(7 dead and 270 injured) and the 1995 Sarin gas attack in the Tokyo subway system (11 dead and more than 5000 injured). Both incidents have been linked to the Aum Supreme Truth sect.

One of the most extraordinary characteristics of Aum was their strong intention to militarize themselves by using machine guns, biological/bacteriological weapons, nuclear, laser weapons etc. We can learn from this incident that a noxious gas “Sarin”, which has generally been considered to be difficult to obtain, was produced inside ordinary laboratories. After the attacks police raids were conducted and a large numbers of chemicals were seized such as sodium fluoride and isopropyl alcohol among others which could be used in the production of sarin.

It was discovered that Aum was a complex organisation and had a ramified structure with special incidence in Russia. It had between 35 000 and 55 000 followers and among them good scientific students were recruited, some of them with the objective of creating a procurement network for materials to be used to develop the chemical weapons. It also received financial contributions from followers to sustain its activities and traitors were punished, some times killed.

THE BIOLOGICAL THREAT

If a chemical attack is described as very lethal and dangerous, a biological one represents still a higher danger. Comparisons have been made between potential effects of attacks using either nuclear, chemical and biological weapons and they demonstrate that the effects of a biological attack would be much greater than those from a chemical attack and similar or even worse than those from a nuclear attack.

Biological weapons have been often described as the “nuke of the poor”.

When talking about biological weapons we can classify them into three categories: the first category are those that can be delivered in water or food causing poisoning. To this category belongs for instance the salmonella, intentionally placed in food to cause the disease. This kind of attack has a limited action ratio.

The second category is composed by agents that could be dispersed through aerosolization. This is much more dangerous because the reached area as well as the victimization is larger. The third category is genetically modified viruses and bacteria that can resist antibiotics or other medicines.

From the previously described biological weapons and agents we have at Interpol records regarding an attack of this kind belonging to the first category.

I am referring to the attack committed by two followers of the cult group Bhagwan Shree Rajneesh when they placed salmonella typhimurium bacteria in ten different restaurants in the Dalles, Oregon, during September 1984. 619 people exhibited symptoms of salmonella poisoning after having a meal in the restaurants. The purpose of the poisoning was simply an experiment to learn if the followers of the sect could incapacitate a large number of potential voters in Wasco county to disrupt the general election of November 1984. The sect maintained a secret laboratory which was used to culture salmonella bacteria.

CYBER TERRORISM

The sophistication of the modern nation state and its inevitable dependency on computer - based information and communication technologies renders the state more vulnerable. Information has become a strategic resource, as valuable and influential in the post-industrial age as capital and labour were in the industrial age. Information Technology offers new opportunities to terrorists. A terrorist organisation can reap low-risk, highly visible payoffs by attacking the information infrastructure. In an effort to attract the attention of the public, terrorists perpetrate their acts with the media at the forefront of their strategy: this strategy calculus is based on the assumption that access to the communication structure is directly related to power. Because of this some organisations engaged in terrorist activities are inclined to use the Internet in pursuit of political goals.

In this respect, cyber-space has become a new forum for politically motivated extremist groups to project their message and cause and through which to wage their campaigns. Moreover, these groups can now reach within seconds a worldwide audience, a possibility of which a terrorist group could only dream of a few years ago. Also, the use of the Internet offers the terrorists groups the possibility of conducting large-scale misinformation campaigns.

This new phenomenon "internet-war" can be simply defined as the process of disrupting, damaging or modifying what the international society knows or thinks about itself. These activities could concentrate on international public opinions and they might involve propaganda, psychological campaigns, political and cultural subversion, deception of, or interference with, local media, infiltration of computer networks and databases and efforts to promote dissident or opposition movements across computer networks.

Therefore, net-war represents a new phenomenon on the spectrum of conflict that spans economic, political and social, as well as traditional forms of warfare. Net-wars will be distinguished by their targeting of information and communications. Net-wars would take various forms; between rival nation states, between governments and non-state actors such as organisations involved in terrorism and criminal activities.

Most organisations involved in terrorist activities have been using the Internet for two main purposes; propaganda, that is, spreading their message to the outside world; communication, that is, primarily to their own members and sympathizers. They may sometimes provide open information available to all, but some sites also appear to be passwords, suggesting a private or even clandestine communication.

At Interpol we have been monitoring many groups that in one way or another are using the cyber-space for one or more of the previously mentioned purposes. Almost every terrorist organisation is using this technology nowadays.

CONCLUSION

Now that we have discussed the different types of groups and attacks that we can expect, let me talk about measures that can be taken to prevent or to minimize the consequences of such an attack.

Intelligence gathering is the most important preventive measure to be taken. Police services should focus their attention and monitor groups like the ones I mentioned in the course of my presentation likely to use these methods.

Technical training for police officers is also of major importance. A first response police officer as well as investigators dealing with these crimes should have a basic notion of what they are facing in order to protect themselves and the rest of the community. The availability of technical equipment is also basic to handle these incidents.

Co-operation among international organisations, such as the IAEA, WCO, Interpol the United Nations, ICAO etc as well as intergovernmental groups or institutions like the Australia Group, or the G-8 is a must. Much has been done in this sense and every day we advance a step further in this co-operation, with information exchange, participation in seminars, training courses, harmonization of databases etc. there are still however many things to do.

Even if all preventive measures are taken, we can not exclude the possibility of an attack. In case of such an attack, a response mechanism should be in place. A concerted, integrated and quick response should be activated.

I would like to conclude my presentation by reiterating two points I have tried to make. The first point is that the possibility of a terrorist attack using WMD is relatively low, especially compared with more traditional attacks using guns and explosives.

The other point is that, although the likelihood is low, the consequences of an attack using WMD are much more severe. There is therefore a real need for countries to, firstly try to prevent such an attack with all available means and, secondly, to prepare an appropriate response in order to protect their populations should they be unsuccessful in preventing it.

QUESTIONS AND ANSWERS

M. Gregoric (Slovenia): How does Interpol co-operate with other international organizations, especially with regard to databases? How satisfied are you with this co-operation?

R. Maroto (Interpol): Currently we co-operate to our full satisfaction with the IAEA and the WCO. We participate in seminars on databases, in technical meetings and in joint training courses for police and customs officers.

THE THREAT OF NUCLEAR TERRORISM

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Abstract. Though remote, the risk of nuclear terrorism cannot and should not be ignored. While conventional means are likely to remain the weaponry of choice for the majority of terrorists, others have tried to acquire nuclear weapon capabilities. The use of crude nuclear weapons may provide an opportunity for fairly reliable, prestigious, and highly visible acts of large-scale terrorism. Acquisition of fissile material is a prerequisite and probably the most formidable obstacle to the production of terrorist nuclear weapons. Preventing the access to fissile materials through rigorous standards of MPC&A is essential.

1. INTRODUCTION

Apart from an all-out nuclear exchange, the worst of all nuclear nightmares could be terrorists with nuclear weapons. Suddenly, sub-nationals would then possess weapon capabilities superseding the military powers of many nations, with adverse effects on national security. With a stroke, terrorism would have moved on from primary a psychological level to a real threat of mass extinction and huge casualties. This is a frightening scenario indeed, and a long-time favorite plot for novels and films, in Hollywood and elsewhere.

Fortunately, we have yet to experience such acts of terrorism. Is nuclear terrorism therefore, as suggested by some, "an overrated nightmare" [1], or are we really facing new and real security threats? It is the goal of this paper to pragmatically examine the threat of nuclear terrorism. This will be done by exploring the likelihood of weapons of mass destruction (WMD) terrorism in general and, more specifically, by assessing the potential terrorist value of nuclear devices. Emphasis will be given to the technical hurdles and opportunities faced by potential nuclear terrorists in their pursuit for devices meeting their "standards", rather than investigating possible motivations for large-scale nuclear terrorist attacks.

The analysis shows that while the risk of nuclear terrorism may be remote, it should not and cannot be excluded. Rigorous standards and means for the protection, control and accounting of fissile materials are thus essential.

2. THE LIKELIHOOD OF WEAPONS OF MASS DESTRUCTION TERRORISM

There have always been enormous gaps between the potential of a weapon and the abilities and/or the will to employ it by terrorist [2]. Given typically limited resources, terrorists are very much dependent upon success. Wasting resources is not likely to benefit long-term goals of the terrorist groups. Terrorists may thus stick to known means and tactics, making them less innovative. If a target is regarded as too challenging, other targets may be chosen, while the tactics of the group remain the same. Terrorists, in particular, operate in contexts of enormous uncertainty and anxiety. To avoid fatal accidents, terrorists seek simple weapons that are easy to transport and assemble. This makes conventional weaponry still the weapons of choice for most groups [2].

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For terrorists, developing weapons of mass destruction capabilities may require great leaps in tactics, training, logistics – and above all, technical capacities. While these practical obstacles may be severe, strategic and even moral constrains against the use of weapons of mass destruction may also be prominent. Most terrorists do not regard themselves as crazy madmen but merely as "freedom-fighters" or martyrs [3]. Indiscriminate, large-scale killings may not comply with such personal perceptions, or with their supporters' attitudes. WMD terrorism certainly invites the risk of strong retaliatory actions, and this could threaten the very existence of the group. Moreover, the results of large-scale acts of violence, both in terms of actual physical damage and in terms of political "fallout", may be hard to assess.

Nevertheless, while the majority of terrorist groups are likely to stick with well-known activities, such as conventional bombings, some groups may be ready to take the step up to a new level of weaponry. Weapons of mass destruction may thus come to use outside the sphere of state military activities, as seen in the Tokyo metro sarin nerve agent attack in 1995. This was the first widely publicized large-scale attempt of using weapons of mass destruction for terrorism.[1] Similar or related actions cannot be ruled out even in the future as several interrelated developments have increased the risk that terrorists will use WMDs.

First of all, terrorist's motivations are changing. A new breed of terrorists appears more inclined than terrorists of the past to commit acts of extreme violence [5, 6, 7]. The set of new terrorists may include everything from ad hoc groups motivated by religious conviction or revenge, violent right-wing extremists, and apocalyptic cults. The increased violence is evidenced by trends in international terrorism over the last few decades. While the number of attacks has declined, the mortality rate and the number of indiscriminate killings are on the rise [8]. Secondly, weapons of mass destruction could be especially valuable to terrorists without traditional political goals, but rather seeking divine retribution, to display prowess, or just to perform large-scale killing [5].

Thirdly, terrorists will generally choose their technology to exploit the vulnerabilities of a particular society. Modern societies are particularly susceptible to weapons that are capable of killing many people at one time. Moreover, as governments implement more sophisticated security measure against terrorist attacks, terrorists may find weapons of mass destruction appealing, as a way to overcome such countermeasures [5]. Fourthly, with the brake-up of the Soviet Union, black markets may now offer unprecedented levels of weapons, components and know-how. Finally, advances in technology may have made terrorism with weapons of mass destruction easier to carry out. Looking at the technical history of nuclear devices, this becomes particularly evident. The first nuclear weapons, produced more than half a century ago, then represented state of the art technology and science. Today, the first generation nuclear weapons are not only old; they are also regarded primitive, with well-known designs from the scientific literature.[2]

3. DEFINING NUCLEAR TERRORISM

"Nuclear terrorism" is a widely used – and misused – term, suggesting the need for a stringent definition of the concept. For instance, some do not find it worthwhile to make clear

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[1] Sarin is an extremely toxic chemical warfare agent that is a powerful cholinesterase inhibitor also called GB. 12 people were killed and several thousand were inquired in the attack. Aum Shinrikyo's first large-scale attack using sarin, which went largely unnoticed internationally, occurred in Matsumoto, Japan, on June 24, 1994. Seven people were killed in the attack, and another 144 were seriously injured when cult-members used specially equipped vans to release sarin [4].

[2] This is further discussed in section 6.1, "Nuclear Weapon Production Knowledge".

distinctions between nuclear terrorism and radiological terrorism, despite being distinctly dissimilar in terms of technical approaches and damage potentials, see e.g. [9]. This is hardly the best point of departure for thorough threat assessments.

"*Nuclear terrorism*" can be defined as acts of violence and destruction where the means applied are *nuclear* devices, or threats of use of such means, or attacks on nuclear installations to create a condition of fear, to get attention or to blackmail to have wider effect on others than the directly targeted victim(s).

Similarly, "*radiological terrorism*" will be acts of violence involving the use of *radioactive* substances to accomplish specific goals beyond the targeted victim(s). As such, nuclear terrorism may be regarded as a more powerful subset of radiological terrorism. While recognizing that many of the *features* of nuclear and radiological terrorism (particularly with regards to public threat perception) are similar, a discussion of the latter will be outside the scope of this paper.

Note that with the definition above, even nuclear bomb *threats* should be regarded as "nuclear terrorism". This is due to the strong psychological aspect of any act of terrorism, where the targets or targeted area is likely to be instrumental to the terrorists' goal of reaching wider audiences. Given the potential consequences of nuclear detonations, such threats generally cannot be disregarded, and the government must react with appropriate countermeasures in credible cases[3].

A problem related to the nuclear bomb threats involves so-called "nuclear placebo-bombs", or powerful conventional bombs surrounded by radioactive material to give the impression of a small nuclear detonation. Such hoaxes will also fit the definition of nuclear terrorism given above. The targeted area would be contaminated and the conventional explosives would damage building structures etc. Such bombs could thus, prior to measurements revealing the absence of short-lived fission products, create significant fear, confusion, and what many terrorists seek– excessive attention.

Intended destruction of nuclear installations where the primary intention is to inflict economical, structural or military damage, and not to cause fear, should be regarded as "nuclear terrorism", but rather as "nuclear sabotage". Neither should acts of nuclear civilian disobedience be labeled "nuclear terrorism". Attacks against German trains carrying radioactive waste is one recent example. Transportation in the spring of 2001 have, again, evoked wrath and violence amongst demonstrators.[4]

4. INTEREST IN NUCLEAR TERRORISM

Nuclear weapons have been a state privilege for more than half a century, starting with the "Trinity"- test in the New Mexico desert in July 1945. No non-state actors have ever deployed

[3] For example, on 29 March 2000, a man called Vandenberg Air Force Base in California, USA, and reported the presence of a nuclear "briefcase" bomb near a small building on the base. Full security measures were taken to address the threat, and every building on the base was searched. US authorities eventually learned that the man had "a vision" of a bomb and that no real bomb existed.

[4] Some 20 000 police officers were on duty to control the transportation of radioactive waste out of Germany to France [10]. Other examples of nuclear civil disobedience are demonstrations at British nuclear submarine bases in the late 1990s.

or used a nuclear device, and the number of (publicly known) nuclear bomb treats has been limited and with little impact[5].

According to the Center for Nonproliferation Studies Weapons of Mass Destruction Terrorism Database, 16 radiological and nuclear related sub-national incidents occurred worldwide in the year 2000.[6] Of these, two nuclear bomb threats and seven other of the incidents were threats against nuclear facilities. The rest of the incidents involved radioactive materials. Half of the incidents took place in Russia and the Newly Independent States (NIS), four of which were threats against nuclear facilities. All in all, past incidents may only give limited reasons for concern when it comes to terrorist actively using nuclear devices or fissile materials. However, a disturbing interest in this type of macro-terrorism may be evolving. For example, on 1 March 2000, a Russian Defense Ministry official reported that Chechen rebels were using the "threat to use nuclear materials as a means of exerting psychological blackmail" [11].

A high-profiled terrorist group with obvious nuclear intentions is the Al- Qa'ida, the organization of Usama bin Laden. The current trail for the bombings of the US embassies in Nairobi, Kenya and Dar al-Salaam, Tanzania, August 1998, has shed new lights on bin Laden's and Al- Qa'ida's nuclear weapon intentions.[7] Dating back to 1993, the group tried on several occasions to acquire nuclear material – and apparently nuclear weapons – during the 1990s. Key aides of bin Laden were arrested and charged with trying to obtain nuclear material illegally. Apparently, the terrorist group seems to have a preference for smaller nuclear weapons, with tactical applications. This may be indicative for the intentions of these terrorists: To induce strong local impact rather than strategic consequences. It could, moreover, reflect disturbing preferences of applying nuclear technologies to well-known tactics of conventional terrorism.

The biological and chemical programs of the Japanese Aum Shinrikyo cult that culminated in the previously mentioned Tokyo metro attack have been highly publicized. Less well known is the nuclear weapon program of the group. Natural uranium was acquired from the sect's properties in Australia and markets were explored to purchase nuclear technology via front trading companies. Apparently the enrichment path, normally chosen by states with vast resources and well-developed nuclear infrastructure, turned out less than fruitful for Aum Shinrikyo[8].

Thus, despite the lack of clear-cut examples of nuclear terrorism involving nuclear devices, there is a disturbing interest among some groups in acquiring nuclear weapon capabilities. Technical hurdles to be overcome for such groups will be explored in the following, by looking at the potential access to nuclear material, the weaponization and deployment, and, finally, use of the devices. Barriers against theft or purchase of warheads or fully commissioned nuclear weapons will not be discussed[9].

[5] The risk of proliferating bomb threats makes authorities put a lid on such incidents and the level of public information is scarce.

[6] For more information on the database, see http://www.cns.miis.edu/dbinfo/index.htm .

[7] For an informative overview of these efforts and summary of testimonies from the trail, see [12].

[8] Why this arduous approach was chosen remains unclear. The cult's opportunistic path described in [13] may offer some explanations.

[9] This will also be outside the scope of this paper.

5. ACCESS TO NUCLEAR MATERIAL

The primary technical barrier against nuclear terrorism is access to highly enriched uranium (HEU) or plutonium, the essential components of any nuclear weapon.[10] State nuclear weapon programs will usually be supported by large and costly infrastructure for enrichment and/or reprocessing of fissile weapons material. Sub-national groups, however, are more likely to rely on externally acquired weapons-usable materials. Estimates of the quantities of fissile material needed for weapon production vary, depending on expected yield performance and technical sophistication. While the International Atomic Energy Agency's (IAEA's) "Significant Quantities" (SQ) are 25 kilo of HEU and eight kilo of plutonium, respectively, as low as one kilo of plutonium and 2.5 kilo of HEU has been suggested as sufficient with highly sophisticated weapon designs [14].

The vast production of fissile materials during the Cold War has today left the world with a staggering legacy of three million kilos of weapons-usable material. 2/3 of these materials are produced for military purposes [15]. The huge quantities of fissile materials and the reports of lax security and accountancy of nuclear materials raise concerns about the possibility of a successful diversion of significant quantities of weapons-usable materials, particularly in the former Soviet Union. While the potential proliferation threats and the consequences of such chilling scenarios are fairly easy to understand, the problems of fissile weapons-usable material management have proven anything but simple to solve [16]. Specialists from Russian law enforcement bodies have identified poor physical protection as the primary causes of nuclear thefts, along with the acute shortage of funds allocated for nuclear material protection, control and accounting (MPC&A) [17]. The ratio of prevented to successful thefts remains uncertain due to insufficient accounting of nuclear material at some facilities and the failure of some countries to carry out an overall national fissile material inventory exercise.

According to the United State Department of Energy (DOE), 603 metric tons of highly enriched uranium and plutonium — enough to produce almost 40 000 nuclear bombs — are at risk of nuclear material theft in Russia [18]. This material can be used directly in a nuclear weapon without further enrichment or reprocessing. The material is considered to be highly attractive to theft because it (1) is not very radioactive and therefore relatively safe to handle and (2) can easily be carried by one or two people in portable containers or as components from dismantled weapons. As of February 2001, after nearly a decade of cooperation, US assisted security upgrades were completed or partially completed at slightly less than 1/3 of the quantities of weapons-useable materials in Russia outside nuclear weapons. Internal US reviews indicate that the security systems already installed do not reduce the risk of theft of nuclear material at approximately one quarter of the sites [18].

Furthermore, recently declassified US documents reveals that a significant nuclear yield can be accomplished by utilizing reactor-grade plutonium. In 1962 an underground nuclear test using reactor-grade plutonium was carried out successfully [19]. Ever increasing stockpiles of separated civilian plutonium could thus be a reason for concern. Calls have been made for stringent protection of the material [20]. Generally, reactor-grade plutonium is significantly more radioactive than weapons-grade plutonium. This complicates the design, manufacture, and stockpiling of weapons. A high neutron-background in reactor-grade plutonium will increase the risk of pre-ignitions and "fizzle" yields. But, this also makes initiation of the nuclear chain reaction easier. Thus, the abundantly more available reactor-grade plutonium

[10] Lately, the possible proliferation potentials of neptunium and americium have been given increasingly more attention.

could become an appealing option to terrorists [21]. At the lowest level of sophistication, a potential proliferating state or sub-national group may build nuclear weapons from reactor-grade plutonium that would have an assured reliable yield of one or a few kilotons (and probable yield significantly higher than that) [22].

5.1. ILLICIT TRAFFICKING IN NUCLEAR MATERIAL

As indicated above, terrorists are likely to perform both practical and strategic assessments prior to any terrorist act. Increased access to fissile material, either from military or civilian stocks, could thus alter some of the practical considerations of terrorists. Indeed, the entries of Aum Shinrikyo and Al- Qa'ida into the nuclear arena were both of a highly opportunistic character [13]. The possible flow of material is therefore an important parameter.

In the beginning of 2001, the "Illicit Trafficking Database" of the International Atomic Energy Agency, contained 345 incidents confirmed by Member States involving either nuclear materials, radioactive sources or both. Almost half of the seizures is nuclear material (162 incidents), the rest being radioactive sources[11]. Less than 5% (14 incidents) of all the seizures involved plutonium or HEU. Thus, the fraction of seized fissile material remains low, but still on a quite significant level of incidents. Moreover, the low radiation levels makes detecting uranium and plutonium a challenging task, even when border guards are provided with the necessary equipment. The dark-figures may thus be high, and some "stockpiling" of material amongst terrorists cannot be excluded.

A close call apparently took place in December 1998, when the Russian Federal Security Services intercepted an attempt to divert 18.5 kg of "radioactive materials that might have been used in the production of nuclear weapons" [23, 24]. Russian officials, stating that the perpetrators "could have done serious damage to the Russian state" later confirmed this attempt, making it the first confirmed case that apparently involved a conspiracy to steal enough materials for bomb at a single stroke[12]. But, the extent to which a viable nuclear black-market exists is disputed. So far, law enforcement agencies, and most likely many potential sellers of nuclear material, have had a hard time identifying buyers, other than the aides of bin Laden.

6. WEAPONIZATION AND DEPLOYMENT OF TERRORIST NUCLEAR WEAPONS

Even if terrorists did succeed in acquiring significant quantities of fissile material, technical hurdles for crating a nuclear explosive remain. These hurdles should not, however, be regarded insurmountable. In fact, there is a good deal of misunderstanding about the ease with which a sub-national group could fabricate a nuclear explosive [25]. Often, and probably wrongfully, unsuccessful state nuclear programs, e.g. in Iraq, are cited to refute potential nuclear weapons capabilities of sub-national groups. As will be seen, this may be an overly simplified approach for trying to understand the threat of nuclear terrorism.

[11] 35% of the incidents with nuclear materials involved LEU.

[12] While the Russian government not has revealed the specific type of material involved, one can infer, based on the description of the material, the quantities involved and the sensitive facility where the diversion took place, that it was either HEU or plutonium. This makes this case the largest documented attempt to steal weapons-usable materials in the former Soviet Union [24].

For any actors attempting to weaponize nuclear material, two factors may be of particular importance. Firstly, the nuclear weapon production knowledge available and, secondly the set of "standards" the device is meant to meet.

6.1. NUCLEAR WEAPON PRODUCTION KNOWLEDGE

The rapid spread of technological knowledge can boost terrorists' weaponization attempts. The design and production of nuclear weapons today is a far simpler process than it was during the Manhattan Project [26]. Relevant nuclear weapons production information can be found in the technical literature [27, 28]. *The Los Alamos Primer. The First Lectures on How to Build an Atomic Bomb* was e.g. published 1992. The book originated as a series of five lectures, given to the physicists of the Manhattan Project at its commencement, outlining the theoretical foundations of the bomb-making [29]. Also within the information swamp on the Internet, potential nuclear weapon producers can find useful sites. While these are not likely to be "step-by-step" descriptions for nuclear weapon acquisition, parts of the openly available information is likely to assist and even guide potential bomb-makers in the process[13].

To highlight the proliferation dangers and the potential for clandestine nuclear bomb production, nuclear scientists have presented simple, technical outlines of crude nuclear weapons (25, 30). These weapons are allegedly capable of exploding with a yield equivalent to that of several hundred to a few thousand tons of TNT. As a comparison, the infamous "Earthquake bomb", also called the "Grand Slam", and the biggest conventional bomb ever exploded, had a yield several orders of magnitude lower.[14] Furthermore, there are lessons to be learnt from the now abandoned and dismantled South African nuclear weapon program. South Africa indigenously produced six nuclear devices based on the simple uranium gun-type weapon principle while under the constraints of an international embargo, and thus relying solely on its domestic resources.

6.2. THE DIFFERENT NUCLEAR WEAPON STANDARDS

First generation fission weapons of either the gun-type or implosion type are likely to be the weapon of choice for nuclear terrorists. Whether terrorists end up with an implosion-type or a gun-type weapon, may again depend the access, type and quantities of fissile material. It is considerably simpler to make a bomb using enriched uranium than to make one using plutonium, but the critical mass is larger[15].

The late Luis W. Alvarez, a prominent nuclear weapon scientist in the Manhattan Project, has emphasized the simplicity of constructing a nuclear explosive with highly enriched uranium [32]:

> *With modern weapons-grade uranium, the background neutron rate is so low that terrorists, if they have such materials, would have a good chance of setting of a high-yield explosion simply by dropping one half of the material onto the other half. Most people seem unaware that if separated HEU is at*

[13] One highly publicized site is e.g. http://www.milnet.com/milnet/nukeweap/Nfaq0.html .
[14] The yield equivalent of the conventional giant bomb was 10 000 tons of TNT.
[15] The fission cross-section and the average number of neutrons per fission are somewhat smaller for U-235 than they are for Pu-239, making the critical mass larger. However, with uranium there is essentially no problem of premature detonation due to neutrons from spontaneous fission, because of the lower spontaneous fission rates [31].

hand it's a trivial job to set off a nuclear explosion... even a high school kid could make a bomb in short order.

Under the right set of conditions, the required skills for making a crude nuclear weapon could therefore be limited. The Alvarez statement may also have eternalized the fundamental differences between a terrorist and a state nuclear weapon. While potential nuclear terrorists probably would go for an undefined "high yield explosion", military nuclear weapons must meet an array of requirements before fielded. The highly differing requirements for performance and delivery can make weapons designed to meet the "terrorist standard" less technically challenging than traditional state nuclear weapons. The differences are schematically presented in figure 1.

Firstly, a state would be at least as concerned with the nuclear device *not* going off during storage and transportation, as with optimizing the yield and detonation of the weapon. While safety is a must for states, such concerns could be given less consideration by terrorists, especially groups with strong affection to martyrdom.

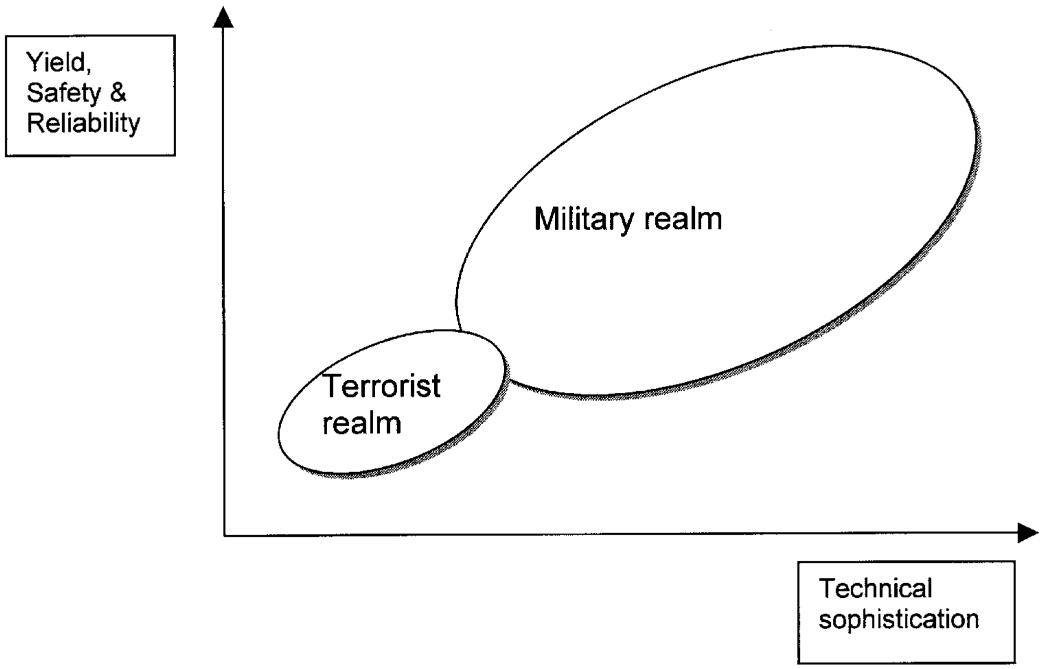

FIG. 1. Terrorist and state military weapons compared.

Secondly, the reliability concerns may be equivalently low amongst terrorists. While an ignition failure or a fizzle yield would be unfortunate from the viewpoint of terrorists, it could, potentially, have profound impact on the security of a state, e.g. in a nuclear offensive mode. Any explosion in the lower kiloton range represents an unprecedented terrorist yield (see below), and even pre-fragmented plutonium explosives may serve as radiological dispersion devices. States on the other hand, want fairly accurate and known yields to predict or calculate damages. Thirdly, weapons for military uses are normally needed in fairly large numbers, and they must be delivered by conventional military means (missiles, mortars etc.). The most important constraining factors for state nuclear weapon are the weight capacity of delivery vehicle and the space available to carry the weapon (e.g. the diameter and length of a nosecone or the length and width of a bomb bay). Development of reliable delivery systems and slender nuclear explosives are technically challenging and expensive. Crude terrorist nuclear weapons, however, will easily fit into a van, or even automobiles, for the subsequent detonation, possibly in densely populated areas [25]. Other non-military means of delivery could involve trucks, ships, or cargo in and around harbors.

Note that the two areas in figure 1 are slightly overlapping, indicating some common features between terrorist and state nuclear weapons. To have high confidence of the workability and yield of its (untested) nuclear stockpile, a proliferate state with limited access to sophisticated technology might well choose to simpler designs. South Africa and Pakistan are examples, and the Hiroshima-bomb was never tested prior to deployment. Moreover, some nuclear weapon modernization programs aim at producing smaller weapons with lower yields, making them more applicable at battlefield[16].

7. USE OF TERRORIST NUCLEAR WEAPONS

Depending on the intentions of the terrorist group, a wide range of strategic and tactical options and tools are available. In the following, the potential benefits of nuclear weapons from the perspective of terrorists will be explored.

7.1. EFFECTS OF TERRORIST NUCLEAR WEAPONS

At least two types of nuclear weapons can be built and fielded without any kind of yield test, and the possessors could have reasonable confidence in the performance of those weapons [26]. Thus, nuclear terrorists, with crude but reliable weapons design, may have a larger chance of setting of a nuclear explosion than anticipated. Moreover, even if pre-ignition of a simple nuclear device occurs at the worst possible moment (i.e. when the materials first become compressed enough to sustain a chain reaction), the explosive yield could be in the order of one to a few kilotons [34]. While this is referred to as a “fizzle yield”, a 1-kiloton bomb would still have a radius of destruction of roughly one-third that of the Hiroshima weapon, making it a potentially fearsome explosive.

Compared to other weapons of mass destruction, nuclear devices may be easier to deploy successfully[17]. While biological (and chemical) substances are difficult to disseminate and control and can potentially backfire on the attacker, the areas directly affected by single nuclear detonations will be fairly limited. Efficient deployment of infectious agents has been the challenge of biological weapons designers since the dawn of biological warfare. Biological weapons were used very infrequently in the past, most likely because they did not live up to their expectations or were very impractical weapons, producing relatively few casualties against armed forces [2]. Nuclear perpetrators could have a better opportunity to target the victims and control the aftermath of their actions. This may partly explain bin Laden’s interest in tactical nuclear devices. Moreover, the successful launching of nuclear terrorist attacks will not be affected by meteorological or environmental conditions, whereas biological and chemical agents are highly susceptible to such changes[18].

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[16] One example is the research the United States undertakes on a new generation of nuclear weapons, including low-yield, high-precision devices (with a yield of five kilotons or less) to be used e.g. against hardened targets.

[17] Within the category of WMD, biological agents have been given increasingly more attention (particularly in the U.S.). For a more extensive comparison of terrorists’ potential uses of nuclear and biological weapons, see [35].

[18] With some notable exceptions (e.g. the hardy anthrax spore) biological agents are affected by changes in temperature, and the efficiency of biological attacks depends strongly on stable and favorable wind directions, and particle (aerosol) distributions. The fact that many biological agents are killed by sunlight and moisture further complicates effective delivery and dissemination.

7.2. ATTENTION LIKELY GIVEN TO NUCLEAR TERRORISM

Terrorist incidents are high-profile events, and terrorism may be regarded as a way of communicating. To initiate change, terrorists must be able to draw attention to “the cause”. This is the reason why “most terrorists want showy attacks that produce a great deal of noise” [3]. Nuclear weapons could thus be of interest to terrorists because of their immense destructive power and their definitive “shock value”. The detonation of a nuclear device is definitely one option to create conditions of fear, to get attention, or to impose the right conditions for blackmail. This is likely to set a terrorist organization apart from any other group, and could compel governments to take them seriously [36]. The news media tend to focus on spectacular and negative events [37], and the world’s attention would be focused and immediate due to the manifest and unambiguous nature of the demonstration.

The public has greater fear of events and consequences that are confirmed, catastrophic, and not well understood [38]. The psychological impact of nuclear detonations is likely to be strong, with a radius of psychological damage exceeding that of injury and death [5]. Indeed, according to a document prepared by the US Joint Chiefs of Staff in 1946, atomic bombs might be used against industrial and population centers “with a view to forcing capitulation through terror and disintegration of national morale [39]. Past nuclear explosions and nuclear accidents, limited public understanding and knowledge of radiation, and the human inability to sense potential exposures may have cultivated (disproportionate) negative perceptions of radiation. Terrorists who capitalize on these factors are likely to have a strong impact.[19] In the aftermath of an explosion, governments may act vigorously to try to deal with the problem and call for actions that violate or severely limit civilian rights such as free speech and movement, and increase the surveillance of citizens.

Potentially, biological agents have the ability to inflict casualties in the same range as nuclear weapons. Such agents, being “silent killers” with incubation periods of days or weeks, may, however, lack the ability to cause immediate attention. In fact, the Aum Shinrikyo made nine attacks with biological and chemical weapons before and then two attempts after the major subway incident that finally attracted widespread attention [2]. Some of the chemical attacks were lethal, but none of the attempts initially were recognized as terror incidents by the media, the public or the law enforcement authorities. After being (unwittingly) exposed to biological agents, victims may go on to different areas, making causal relationships harder to identify. Epidemiological investigations are further complicated by the fact that nature itself produces lethal agents, and natural outbreaks of infectious diseases occur regularly. No such ambiguity will occur after a terrorist nuclear detonation[20].

8. CONCLUSION

Terrorist groups with aspiring weapons of mass destruction capabilities are facing strong practical and strategic constrains. These include everything from new requirements for training and operational practices, to possible stigmas damaging to any future political ambitions, and

[19] In this regard, the use of radiological weapons may also prove to be feasible for terrorist threats. Radioactive substances could be intentionally scattered e.g. by the use of conventional explosives (“dirty bombs”) to expose populations and the environment to radiation. The psychological reactions could potentially be strong.

[20] Of course, weapons of mass destruction terrorists could also take advantage of the resulting “vacuum of knowledge”, and add to the chaos and uncertainty by releasing threatening statements to the media, or to escape from the scene of the crime without leaving traces. However, the lack of “proof” may also undermine any biological terrorists’ intentions of e.g. extortion or blackmail, and could cause less psychological impact than confirmed acts of nuclear terrorism.

the threat of retaliatory extinction. Conventional means are thus likely to remain the weaponry of choice for most terrorists. However, there is a disturbing interest among some terrorist organizations in acquiring nuclear weapons, most likely for tactical purposes. Though remote, the risk of nuclear terrorism cannot and should not be ignored.

For decades, nuclear weapons have been a state privilege. However, using state nuclear weapon requirements as a basis when assessing the threat from terrorist weapons may be a dangerously simplified approach. All things considered, the technical hurdles for terrorists' nuclear weapon production are probably lower than for stringent military weapons. Even crude nuclear devices have the potential of introducing yields in the lower kiloton range. The use of crude nuclear weapons provides the opportunity of fairly reliable, distinct, prestigious, virginal, and highly visible acts of large-scale terrorism, without prior testing. Acquisition of fissile material is a prerequisite and probably the most formidable obstacle to the production of crude terrorist nuclear weapons. Preventing any extremist group from achieving their goals of large-scale nuclear violence could thus best be done by preventing the access to fissile materials through state compliances to rigorous standards of MPC&A.

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REFERENCES

[1] KAMP, K-H., "An Overrated Nightmare", *The Bulletin of the Atomic Scientists*, vol. 52, no. 4, July/August (1996).

[2] RAPOPORT, D., "Terrorism and Weapons of the Apocalypse", *National Security Studies Quarterly.* Summer 1999, volume V, issue 3 (1999).

[3] LAQUEUR, W., *The New Terrorism: Fanaticism and the Arms of Mass Destruction* (New York: Oxford University Press, 1999).

[4] BALLARD, T., PATE, J., ACKERMAN, G., McCauley, D., and LAWSON, S. "Chronology of Aum Shinrikyo's CBW Activities," Center for Nonproliferation Studies, CNS Reports. http://cns.miis.edu/pubs/reports/aum_chrn.htm .

[5] STERN, J., *The Ultimate Terrorist* (Cambridge: Harvard University Press, 1999).

[6] CAMPELL, J.K., "Excerpts from a Research Study: Weapons of Mass Destruction Terrorism – Proliferation by Non-State Actors", *Terrorism and Political Violence,* vol. 9, no. 2 (1997).

[7] HOFFMAN, B., "Holy Terror: The Implications of Terrorism Motivated by Religious Imperative", *RAND PAPER (P-7834)* (1993). http://nwcitizen.com/publicgood/reports/holywar3.htm .

[8] MAERLI, M.B., *Atomic Terrorism* (Oslo: Norwegian Institute of International Affairs, 1999) (in Norwegian).

[9] CAMERON, G., *Nuclear Terrorism: A Threat Assessment for the 21st Century* (New York: Palgrave, 1999).

[10] NTB, "New protests against German transports of radioactive waste", April 10, 2001 (in Norwegian).

[11] ITAR-TASS, "Russian General: Chechen Nuclear Waste Plant Under Control", 1 March, 2000 (in Russian).

[12] McCLOUD, K. and OSBORNE, M., “WMD Terrorism and Usama Bin Laden”, Center for Nonproliferation Studies, CNS Reports 2001. http://www.cns.miis.edu/pubs/reports/binladen.htm .
[13] CAMERON, G., “Multi-Track Microproliferation: Lessons from Aum Shinrikyo and Al Qaida”, *Studies in Conflict and Terrorism*, no. 22, October-December (1999).
[14] COCHRAN, T.B., and PAINE, C.E., *The Amount of Plutonium and Highly-Enriched Uranium Needed for Pure Fission Nuclear Weapons*. Nuclear Weapons Databook. Natural Resources Defense Council Inc. (1995).
[15] ALBRIGHT, D. and O'Neill, K. eds. *The Challenges of Fissile Material Control*. (Washington D.C.: Institute for Science and International Security, 1999).
[16] DAUGHTRY, E.E., and WEHLING, F., “Cooperative Efforts to Secure Fissile Materials in the NIS: Shortcomings, Successes, and Recommendations”, *The Nonproliferation Review*, Spring (2000).
[17] ORLOV, V.A., “Exports Control and Nuclear Smuggling in Russia”, in BERTSCH, G.K. and POTTER, W.C. eds. *Dangerous Weapons, Desperate States* (New York: Rouledge, 1999).
[18] UNITED STATES GENERAL ACCOUNTING OFFICE, “Security of Russia's Nuclear Material Improving; Further Enhancements Needed”, GAO-01-312, February 2001.
[19] DOE FACTS, “Additional Information Concerning Underground Nuclear Weapon Test of Reactor-grade Plutonium” (undated).
[20] GARWIN, R.L., “Reactor-Grade Plutonium Can be Used to Make Powerful and Reliable Nuclear Weapons: Separated plutonium in the fuel cycle must be protected as if it were nuclear weapons”, *Council on Foreign Relations*, New York. http://www.fas.org/rlg/980826-pu.htm .
[21] DOLLEY, S., “ Using Warhead Plutonium as Reactor Fuel Does Not Make it Unusable in Nuclear Bombs”, The Nuclear Control Institute, March 28 (1997) http://www.nci.org/ib32897c.htm .
[22] UNITED STATES DEPARTMENT OF ENERGY, Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives, report DoE/NN-0007, January (1997), quoted in [40].
[23] PARRISH, S. and ROBINSON, T., “Efforts to Strengthen the Export Controls and Combat Illicit Trafficking and Brain Drain” *Nonproliferation Review*, Spring (2000).
[24] MATTHEW, B., *The Next Wave: Urgently Needed Steps to Control Warheads and Fissile Materials*. Carnegie Endowment for International Peace, (2000).
[25] BARNABY, F., “Issues Surrounding Crude Nuclear Explosives”, In *Crude Nuclear Weapons. Proliferation and the Terrorist Threat*. International Physicians for the Prevention of Nuclear War. IPPNW Global Health Watch Report Number 1 (1996).
[26] MILITARY CRITICAL TECHNOLOGIES “Part II: Weapons of Mass Destruction Technologies (WMD)”, (1997, updated December 1999). http://www.dtic.mil/mctl/ .
[27] LOVINS, A.B., “Nuclear Weapons and Power-Reactor Plutonium”*, Nature* 28, 28. February (1980).
[28] Mark, C.J., “Explosive Properties of Reactor Grade Plutonium”, *Science and Global Security* 4, (1993).
[29] SERBER, R., *The Los Alamos Primer. The First Lectures on How to Build an Atomic Bomb* (Berkeley: University of California Press, 1992).
[30] BARNABY, F., *Instruments of terror* (London: Vision Paperback, satin Publication limited, 1996).
[31] BODANSKY, D. *Nuclear Energy: Principles, Practices and Prospects* (New York: Woodbury, 1996).
[32] ALVAREZ, L.W., *The Adventures of a Physicist* (New York: Basic Books Inc., 1987).

[33] THE PPNN Newsbrief, Fourth Quarter (2000).
[34] NATIONAL ACADEMY OF SCIENCES *Management and Disposition of Excess Weapons Plutonium*. Committee on International Security and Arms Control. (Washington D.C.:, National Academy Press, 1994).
[35] MAERLI, M.B., "Relearning the ABCs: Terrorists and "Weapons of Mass Destruction", *The Nonproliferation Review*, Summer (2000).
[36] CAMERON, G., "Nuclear Terrorism Reconsidered", *Current History*, April, (2000).
[37] GALTUNG, J. and Ruge, M.H., "The Structure of Foreign News", *The Journal of International Peace Research*, no. 1 (1965).
[38] SLOVIC, P., "Perception of Risk", *Science*, vol. 236, (1987).
[39] Declassified top secret memorandum for General Grooves, Summary of Target Committee Meetings on 10 and 11 May 1945, describing a meeting with Dr. Oppenheimer on May 10, 1945, National Archives, M1109, File 5 (D) (G), roll 1. Joint Chiefs of Staff, "Statement of Effects of Atomic Weapons on National Security and Military Organization," JCS 1477/5, Jan. 12, 1946 (declassified top secret), National Archives, RG 218, Box 222. Quoted in [5].
[40] von HIPPEL, F., "The FMCT and Cuts and Fissile Material Stockpiles", in "Fissile Materials: Scope, Stocks and Verification", *Disarmament Forum*, Two 1999, United Nations Institute for Disarmament Research (UNIDIR) http://www.unog.ch/unidir/E-DF2.HTM.

QUESTIONS AND ANSWERS

G. Bunn (USA): Is nuclear terrorism from subnational groups a greater danger than that from States?

M. Maerli (Norway): The threat stems from both States and subnational actors. Deterrence applied successfully during the past 50 years in a bipolar security world is no longer sufficient to deal with it.

J. Fechner (Germany): Whereas the probability of terrorists improvising nuclear weapons is rather low, is there not a much higher probability of their building radiological weapons using sources acquired through illicit trafficking?

M. Maerli: Yes. However, the potential physical damage is less for radiological terrorism than the damage that would be caused by nuclear terrorism, which is potentially so great that it cannot be neglected.

S. Erickson (USA): The Aum Shinriko example could be misleading. Could nuclear scientists really become involved with terrorists outside a religious cult?

M. Maerli: Given the range of motives among scientists, we could assume that economic incentives, for example, could also bring scientists into terrorist organizations.

THE IAEA PROGRAMME ACTIVITIES ADDRESSING ILLICIT TRAFFICKING IN NUCLEAR MATERIALS AND OTHER RADIOACTIVE SOURCES

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Presented by M. Soo Hoo

Abstract. The IAEA recognized the problems associated with illicit nuclear materials and uncontrolled radioactive sources soon after the first cases of smuggled nuclear material became known almost a decade ago. Since that time, the IAEA has continued the process of assisting Member States in their efforts to monitor, detect and identify nuclear and radioactive materials being illicitly trafficked. The IAEA programme is based on three pillars: Training, Technology and Information. The paper provides a review of the IAEA activities and future directions the programme will take to meet Member State requirements.

INTRODUCTION

In all probability, the first truly significant case involving the smuggling of nuclear material publicly surfaced in Germany in 1992. The number of incidents involving illicit nuclear material continued to increase during 1993, thereby effecting a high level of concern by IAEA Member States. In 1994, the General Conference passed a resolution on “Measures against Illicit Trafficking in Nuclear Material”. An important conclusion of the resolution was the confirmation of the responsibilities of the Member States in addressing the problem of illicit trafficking. Of equal importance was the invitation to the Director General to "intensify" the activities of the IAEA in areas related to illicit trafficking. Since that time, the IAEA has continually increased its overall level of assistance to Member States, assistance that addresses the numerous factors that may contribute to incidents of illicit trafficking. Existing programmes, such as support in the areas of national systems of accounting and control and the development of national infrastructure for export control procedures, were intensified. A database of illicit trafficking incidents was established by the IAEA in 1994 with voluntary participation by Member States. More recently, the IAEA acknowledged the specific assistance requirements of customs, border control and police agencies involved in monitoring, detecting, identifying and responding to incidents of illicit trafficking. Recognizing the global nature of the illicit trafficking problem and the need for international cooperation, the IAEA combined its resources and initiatives with those of the World Customs Organization (WCO) and the International Police Organization (INTERPOL). This paper provides a detailed look at the content of the IAEA’s Programme addressing Illicit Trafficking in Nuclear Materials and Other Radioactive Sources.

The past decade or so is witness to myriad changes in the world's political order and whilst most of these changes have benefited the world's population, a number of the changes have increased the threats to global stability and international health and safety. As is the case with many of mankind's inventions, the utility of nuclear material and radioactive devices have a dual nature. They provide society with many benefits while simultaneously they pose threats. On the high end of the threat scale is the possibility of nuclear proliferation including the possible use of nuclear devices by terrorist organizations. Lower on the scale is the threat to health and safety of the public posed by uncontrolled radioactive sources and the improper disposal of radioactive waste.

At this point, it might be useful to properly describe the characteristics of illicit trafficking[1] as well as identify other threats posed by uncontrolled radioactive sources. Illicit trafficking in nuclear materials is a direct proliferation threat. Illegal access to specific amounts of nuclear material, enough to build so much as a crude weapon, poses a grave threat to civilization. Illicit Trafficking should be thought of a series of acts, including illegal possession, theft, transportation and/or sale of nuclear materials. In short, illicit trafficking is composed of inter-connected acts with criminal intent. Illicit trafficking is a poly-crime and to be successful, it requires a seller, usually middlemen and an ultimate customer. These various criminal acts must be performed without detection by regulators or law enforcement agencies. However, it must be remembered that each of these illegal acts provides an opportunity for discover by regulators and law enforcement officials.

The illegal market for nuclear materials and radioactive sources, whether real or imagined by individuals, supplies the basis for the primary illegal act, the theft or illegal acquisition of the material. The anticipated reward, for criminals, would most likely be illegal monetary gain. For terrorists, other known rationales exist for their behavior[2]. Illicit trafficking can engender other crimes, from corruption to acts of violence.

Radioactive sources also provide opportunities for illicit trafficking. The inability of a terrorist group to acquire sufficient quantities of nuclear material might provide the initiative to acquire radioactive sources. Specifically, the goal would be to combine conventional explosives with a radioactive source in order to produce a weapon that possesses two distinct threats. The conventional explosive would render damage in proportion to the substance and quantity employed. The addition of a radioactive device would act as a force multiplier, especially if the radioactive material successfully contaminated the venue selected for the detonation. The damage, interpreted by the general public, would be both real (physical) and have a psychological impact.

So, I think it is accurate to say that thefts and illegal acquisition of nuclear material, and in some cases, radioactive sources, are the result of persons seeking illegal financial gains. Gains achieved through the ultimate sale of such materials to illegal end users. Additionally, the desire of members of terrorist groups to enhance the ability to threaten or actually employ such materials to achieve political aims drives the demand for such materials. Access to nuclear materials is facilitated through the use of insiders or persons employed at nuclear facilities and storage sites. Unfortunately, the vast amount of radioactive sources used in legitimate applications, such as industry and medical services, provides myriad opportunities for theft and illegal acquisition. Illicit trafficking is a result of the elementary supply and demand equation. As long as it is perceived that there is an illegal and lucrative market for nuclear material and radioactive sources, attempts at theft and illegal acquisitions will continue to occur.

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[1] Illicit Trafficking is the illegal "import, export, acquisition, sale, delivery, movement or transfer of nuclear materials and other radioactive sources from or across the territory of one State Party to that of another State Party". This definition is derived, in part, from the Revised draft Protocol against Illicit Manufacturing of and Trafficking in Firearms, Their Parts and Components and Ammunition, supplementing the United Nations Convention against Transnational Organized Crime.

[2] Motives for illegally acquiring nuclear materials, or any weapon of mass destruction, vary from pseudo-religious beliefs to nationalistic movements. Aum Shin Rikyo uses of nerve gas on the Tokyo mass transit to the placement of radioactive materials in a Moscow park allegedly by Chechen separatists to the attempted acquisition of nuclear materials by the agents of Osama bin laden.

THE IAEA PROGRAMME TO COMBAT ILLICIT TRAFFICKING

In essence, the programme is divided into some three specific, but related, areas of activity. The first area to be addressed is *TRAINING*. In cooperation with the WCO and INTERPOL, the IAEA has co-sponsored training initiatives based on a regional perspective. The goal is to increase the overall awareness of executives and managers to the problem of illicit trafficking in radioactive materials. Consisting of some 5 days of theoretical and practical instruction, the regional training seminars are designed for participation by officials from customs, border control, police and regulatory organizations. In numerous cases, these regional seminars also utilized the expertise and facilities of the Austrian Customs Administration and the Austrian Research Center, Seibersdorf. Another important objective of the seminars is to address the issues surrounding the health and safety of officers who might come into contact with radioactive materials, especially in public places.

As noted previously, a training objective was to increase the awareness of senior officials in law enforcement agencies to problems of illicit trafficking. This objective appears to have been achieved and is manifested by the numerous requests the IAEA continues to receive from Member States for specific training. The IAEA has responded by modifying and continually updating the curriculum of the regional seminar in order to address the training requirements of line officers and their immediate supervisors. Line officers are those personnel who will most likely come into direct contact with nuclear and other radioactive materials in the course of performing their daily tasks. The first of these "national level" courses was delivered in the last quarters of 2000. Attended by customs, police and regulators, the courses are a blend of theory, safety, practical exercises and response planning delivered within the scope of one week. The hosting Member States for the two national level courses delivered in 2000 deemed the courses a success. As a result, the IAEA continues to provide national level courses to requesting Member States in 2001 and is planning the courses for 2002.

Training is conducted in a vacuum; it is interactive and results in further activities. For example, during one particular national level course, the IAEA training team observed a high level of proficiency of a number of officers in carrying out laboratory exercises. Further inquiry by the IAEA team revealed that these officers had previously attended a month long intensive training course provided by a Member State. IAEA team members were also aware that the national course participants regularly requested more time be allocated for laboratory and especially practical exercises. Through the participant evaluations, many participants requested greater course duration due to the amount of material delivered. These observations, conversations and evaluations were the catalysts in the IAEA decision to further explore the availability of longer and more intensive courses of instruction. Obviously, a direct result of training is the establishment of a cadre of line officers who will immediately employ their newly acquired skills and knowledge. However, this will not institutionalize the skills and knowledge within an organization. As such, it was thought that a lengthier course with greater scope and depth could serve as the basis for institutionalizing the participating organizations' knowledge and practical experience acquired over the breadth of the training. In essence, a train-the-trainer objective was added to the goals and objectives of the proposed month long courses.

In December of 2000, IAEA personnel met with the Russian State Customs Committee in Moscow and the Director and staff of the Russian Customs Academy (RCA) in St. Petersburg. The objectives of staging month long courses at the RCA in St. Petersburg were discussed, including utilization of major segments of the RCA course curriculum and the

RCA professional staff of lecturers and experts. In a follow-on meeting in Vienna, RCA and IAEA representatives agreed upon the proposed combined curriculum. The intended participants for the month long course would be selected customs and law enforcement personnel and other organizations from the Newly Independent States (NIS) and Baltic States. In order to achieve a consensus on the plan of activities, a Seminar for the Heads of NIS Customs was planned for April 2001 in Pushkin, Russia. The April Seminar was fully attended by the NIS and Baltic representatives as well as specific Member States that provide additional support to the IAEA. The Seminar was effective in achieving unanimity for participation in the intensive Train-the Trainer Course. The NIS and Baltic States began the process of selecting and nominating their officers for participation in the courses to be held at the RCA in St. Petersburg in June and August 2001. The two intensive courses produced some 60 graduates for return to their respective organizations and to be utilized as instructors on national training initiatives.

In essence, the training has produced three tiers of trained personnel. The first being the managers and executives involved in the Regional Awareness courses. The second group consists of line officers that participated in the one-week course in detection, identification and response to incidents of illicit trafficking. The third group is comprised on the officers who successfully completed that intensive Train the Trainer courses and who will serve as instructors and training experts. The inclusion of a number of police, border guards, regulators and internal security personnel in the both the month long seminars as well as the national course has allowed for a wider base of involved agencies to benefit accordingly. The intentional inclusion of other disciplines in the three tiers of training has provided for increased levels of communication between the represented organizations as well as facilitating greater understanding of the roles and responsibilities of the organizations represented. "Thanks for bringing us together" was an unsolicited comment offered by a participant at the conclusion of a course.

The IAEA utilizes opportunities to present its role and responsibilities in the area of illicit trafficking through participation in various meetings and fora. The intention is to increase the overall awareness and understanding of the IAEA, its role and responsibilities and to seek opportunities to increase levels of cooperation and coordination.

A second pillar of the IAEA Programme to Combat Illicit Trafficking involves *TECHNOLOGY*. The ability to monitor, detect and identify the presence of radioactive materials is a function of the presence of capable technology combined with well-trained officers.

The capabilities as well as deficiencies in specific types of equipment/technology are documented in the report of the Illicit Trafficking Radiation Assessment Programme (ITRAP) issued in October 2000 and addressed in other papers provided in this International Conference. The results of the IRAP tests and evaluations are “in line” with the observations and evaluations produced by the training courses previously addressed. Specifically, participants are introduced to an array of currently available equipment during both classroom exercises as well as the practical exercises. Keeping in mind that the practical exercises seek to simulate a real life situation and environment, the observations of the training team include the participant use of the provided equipment. Participant teams are set up in such a manner as to employ all of the monitoring, detection and identification equipment available at the training venue. The IAEA relies upon the observations and reports of the training team members and, just as importantly, the evaluations of the participants. It is quite clear at this juncture that equipment that is characterized as hand held “detection and identification” poses the greatest challenges to the user community. Problems are apparent in the ability of the participant to properly master the use of the equipment during both classroom and practical exercises. Additionally, some overall design characteristics encumber users from effectively employing the instruments. Also, failures in field use were noted, such as short battery life, limited library and failure to properly identify the hidden sources used in the exercises. Here again, other papers provided during this International Conference provide more depth and technical explanations relative to the current capabilities of hand held detection and identification equipment. Suffice it to say that both the ITRAP Study and the experience of the IAEA in providing training allow for the overall evaluation of the various segments of the equipment market. The deficiencies are the basis for the following IAEA responses to the needs of Member States.

The IAEA is currently embarking on a number of action plans designed to address the current situation. One initiative is a Coordinated research Programme (CRP) dedicated to coordinating the research and development of the next level of technology in hand held instruments. The CRP will seek to assist in the overall process to increase the capabilities of these instruments while incorporating the stated needs of the users via a formal set of User Requirements. The CRP will benefit from the current IAEA effort to recruit a “cost free expert” (CFE) specifically dedicated to the work of the CRP as well as involvement in IAEA sponsored training initiatives. Two other initiatives deserve attention. The IAEA, under the auspices of Technical Cooperation Model Project RER/9/060, will sponsor to meetings to bring together the scientific and law enforcement communities to address radioanalysis. The fist meeting will occur before the end of 2001 and the larger second co-ordination meeting will be held in January 2002. The January meeting will include a diverse audience, all with a stated interest in hand held equipment. As such, national laboratories, the scientific and law enforcement communities as well as the developers and manufacturers will be invited to participate. In an effort to expand its level of international cooperation, the IAEA is also working with the Institute for Transuranium Elements (ITU) in the area of “nuclear forensics” for law enforcement officers. At this point, it is envisaged that two separate training courses will be conducted in the first half of 2002 at the ITU's facility in Karlsruhe, Germany.

In considering the depth and scope of the IAEA activities noted in the above paragraphs, it is apparent that the IAEA is embarking on a course of action to remedy the current shortcomings of specific equipment while fully incorporating the needs of the users. It is also envisioned that the IAEA will sponsor a "flash test" for specific types of equipment. The purpose is to test and evaluate specific types of equipment and to provide Member States with the authenticated results. Ultimately, the IAEA envisions the production of documentation of standards for equipment designed to detect and identify radionuclides. The IAEA goal is to provide Member States with standards, documentation and test results on equipment for evaluation and possible acquisition by the Member State.

The third pillar of the programme is, simply put, *INFORMATION*. There can be no understanding or grasp of the problem of illicit trafficking without access to reliable information. As noted earlier on, the IAEA established the Illicit Trafficking Database (ITDB) in 1994 to provide a reliable point of contact for reporting incidents and to access information. In the proceedings, there is a paper addressing the ITDB that articulates its attributes and methodology in much greater depth than is necessary in these paragraphs. However, information regarding all incidents involving radioactive materials is equally important to the IAEA and to the Member States. Information in the form of the contents of the ITDB is utilized in every training event. Participants are introduced to the ITDB and are provided detailed breakouts of the information that pertain to the host country, neighboring states and trafficking patterns. The CD-ROM version of the ITDB is essential for portraying as much of the total illicit trafficking environment that the IAEA has knowledge of. The breakout of the incidents into commodity, characteristics, date and location and other data allows for a fuller understanding by the participants of the overall number of incidents and what radioactive materials are most likely encountered. While the focus of the training module is to emphasize incidents that involve nuclear materials and strong sources, other perspectives are provided. An interesting example is the number of incidents that involve radioactive scrap metal shipments. Are these incidents merely failures to acquire the proper documentation or are they part of an organized criminal activity that illegally disposes of such hazardous materials on unsuspecting states? How often are these types of shipments discovered? Is there a pattern to the shipments, their point of origin and ultimate destination? The answers to these questions may assist Member States to develop pattern or trend analysis using the data found in the ITDB. Since there are source states, transit states and destination states, each Member State may have a different perspective on the available data. Information exchange greatly assists the IAEA and Member States to fully understand and address the problem of illicit trafficking. During training events, the IAEA team will solicit information about unconfirmed incidents and incidents that appear not to have been reported to the IAEA. In a number of cases, the interest generated in the ITDB has led to a number of states taking the initiative to join the ITDB and commence the process of reporting all incidents that occur.

Information is a key element in all efforts to combat illicit trafficking. Therefore, the IAEA continues to increase the capability of the ITDB, provide greater Member State access to the information and utilize the ITDB holdings to perform trend analysis. Additionally, the IAEA continues to seek the means to increase the level of data base interface with other international organizations while mutually respecting the confidentiality of the data and restrictions of the Member States.

In conclusion, the IAEA continues to expand the overall level of effort and involvement in the global response to incidents of illicit trafficking. In this paper, the objective was to provide the reader with an overview of the IAEA activities. References were made to other papers that are part of the Conference proceedings. Your interest is directed to these other papers in order to provide greater detail and information. I think it appropriate to point out that law enforcement agencies, such as customs, border control, police and internal security organizations are a "non-traditional" audience for the IAEA. Never the less, the IAEA continues to recognize the overall requirements of these organizations and continues its efforts to effectively address these needs via a multitude of initiatives. The final point of this paper is that no single programme designed to combat illicit trafficking that is able to stand-alone or is independent of other efforts. Training, technology development and information exchanges are interdependent upon one another but even collectively, do not comprise the whole. All other efforts and initiatives aimed at the first line of defense, the security of material as well as the ongoing effort to increase the level of safety and security of radioactive sources are essential responses to the threats posed by illicit trafficking.

In 2002 and beyond, new threats coupled with continued incidents of illicit trafficking will require the IAEA to continue to provide increasing levels of assistance to Member States. The IAEA is prepared to respond through greater involvement with other international organizations and through the continued provision of direct assistance to Member States.

QUESTIONS AND ANSWERS

A. Coker (Nigeria): Does the IAEA provide detection equipment for nations in need?

M. Soo Hoo (IAEA): It may assist Member States.
C. Schandorf (Ghana): Could you give some more details about the training programme to be hosted by Egypt?

M. Soo Hoo: Please contact Mr Bill Meehan.

S. Shakshooki (Libya): Training should include basic information about nuclear material as well as use of equipment.

M. Soo Hoo: Yes, it should be balanced.

P. Williams (USA): Does the IAEA database include follow-up material, which is typically less available in open source literature?

M. Soo Hoo: Not currently. However, in future it will.

M. Gregoric (Slovenia): Does the IAEA extend the TC training programme to countries with nuclear material or on a potential route for illicit trafficking.

M. Soo Hoo: Training — open to all Member States — has so far been conducted on request but future training should be more proactive.

ASSESSING THREATS AND EVALUATING VULNERABILITY

(Session 2)

Chairperson

J.B. FECHNER
Germany

Keynote Address

NUCLEAR REGULATORY MEASURES TO PREVENT ILLICIT USE OF NUCLEAR MATERIALS AND RADIOACTIVE SOURCES

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Abstract. The countries and international organizations are increasingly aware of the consequences that illicit use of nuclear materials and other radioactive sources might generate, being the most important one the risk and damage to persons. Therefore, these events have sparked off several initiatives, at a national and international level, in order to prevent their occurrence, and in the case of the event-taking place, to rapidly adopt the measures to recover these materials and mitigate the consequences. The existence of competent regulatory authorities that set up adequate control measures is an essential component to lower the probability of occurrence of illicit uses of nuclear materials. Moreover, the coordination by the nuclear regulatory authority of all relevant measures with other national organizations is seen as an important contribution to prevent these illegal uses. Internationally, the different forms of co-operation constitute important elements for the prevention of illegal movements of nuclear materials and radioactive sources between boundaries. This paper briefly describes the way in which the different nuclear regulatory measures and other measures contribute to the objective of preventing and responding to the illicit use of nuclear materials. It also includes a reference to the measures applicable to prevent illicit use of radioactive sources.

1. INTRODUCTION

Illicit uses of nuclear materials lead to several consequences, being the most important one the risk and damage to persons. These acts also generate concern regarding the area of criminal acts and proliferation of nuclear weapons. Hence, different national and international organizations involved in the control of such materials have decided to adopt or reinforce mechanisms that help decrease the probability of these illicit acts happening.

In some cases, the existence of illicit use and its increase have highlighted the need to strengthen the organizations entrusted with the regulation and control of nuclear activities. This is so because adequate legislation and national authorities that have the power, capacity and appropriate resources to track and control nuclear materials constitute the fundamental column to effectively prevent and react to this matter. These organizations should be also responsible for the co-ordination with the other institutions involved in the prevention and response of these illicit uses.

2. NUCLEAR REGULATORY MEASURES

As regards the regulatory infrastructure of the countries, one central topic refers to the design and enforcement of control measures assuring the continuity of knowledge about possession, use and movements of nuclear material as the primary element for the prevention of it illicit use. The lack of any of these measures would increase the probability of occurrence of illicit uses of nuclear material: the control system would thus result more vulnerable to these illicit acts.

In this regard, the existence of a regulatory authority empowered to establish effective physical protection and accountancy and control measures enhances the State's capability to prevent, intercept and respond to illicit use of nuclear materials. The goals of a regulatory system inter alia can be described as follows:

- To provide people with an appropriate level of protection against harmful effects of ionizing radiation.
- To ensure that nuclear materials are not diverted for unauthorized purposes and nuclear activities are performed in accordance with international commitments assumed by the State in the area of non-proliferation.
- To establish criteria and standards in order to prevent deliberate actions from being committed which may have severe radiological consequences or lead to the unauthorized removal of nuclear materials.

To achieve these goals, a regulatory authority system might include, among others, the following basic principles:

- Adopting standards and a licensing and registration system. Conducting regulatory inspections and audits to verify compliance with licenses and authorizations granted.

A set of well-defined standards and requirements contribute to the prevention of illicit uses of nuclear materials. Licensees should be well aware of them since the primary responsibility in keeping an adequate level of control rest on them. Inspections and enforcement actions performed by the Authority are intended to verify compliance with regulations and requirements by holders of nuclear materials. The application of sanctions in case of non-compliance that includes the suspension or withdrawal of the license also helps in preventing illicit uses of these materials.

- Carrying out studies and assessment for the licensing process and the verification of compliance of the licensee with relevant measures and requirements.

The regulatory authority should periodically evaluate the adequacy of physical protection and SSAC's[1]. Concerning physical protection of nuclear material, the assessment should include a systematic evaluation of the adequacy of the security measures adopted by the licensee to fulfill with physical protection standards. In this area, a vulnerability and threat analysis is an important task in evaluating the effectiveness of the control system implemented by the licensee. Regarding the SSAC, examples of these assessments are the evaluation of the precision and accuracy of the licensee's measurement system and the audit to its record and report scheme.

- Promoting scientific and technological development regarding safeguards and physical protection.

The continuous development of new technologies and methods to improve the effectiveness of the SSAC and physical protection measures at installation and at the regulatory level also facilitate preventing illicit uses of nuclear materials.

- Providing personnel training and education about safeguards and physical protection directed at the personnel responsible for the safety of the facilities and staff performing regulatory activities.

[1] State system of accounting and control of nuclear materials.

Knowledge is an essential element in preventing and responding to illicit uses of nuclear material. Nuclear regulatory authority staff should be highly qualified and skilled to perform effective control. It is equally important to train licensees and personnel of other relevant authorities in the field of safeguards, physical protection and prevention of illicit trafficking of nuclear material.

- Providing mechanisms to promote exchange of information with other relevant organizations (Customs, Boarder Guards, Police, Gendarmerie, import-export control authorities) and co-ordinate the required actions to prevent and respond to illicit use of nuclear materials. This includes:

  - To keep an active communication with relevant organizations.
  - To establish means to exchange information and coordinate actions with relevant authorities of neighbor countries in the region.
  - To promote the installation of radiation monitors at ports of entry.
  - To establish and coordinate contingency plans to promptly respond to illicit use.

2.1. CONTRIBUTION OF THE PHYSICAL PROTECTION SYSTEM TO PREVENT ILLICIT USE OF NUCLEAR MATERIAL

Physical Protection refers to the measures that States implement in order to protect nuclear material from theft, unauthorized diversion or sabotage. Setting up effective physical protection measures aimed at preventing the commission of illegal acts involving nuclear materials that can lead to severe radiological consequences is a major contribution to prevent illicit uses of nuclear material.

The design and implementation of a system of physical protection is the responsibility of the States. State systems must establish conditions which (a) minimize the possibilities of unauthorized removal of nuclear material or of sabotage, (b) provide rapid and comprehensive measures to locate and recover missing nuclear material, and (c) minimize the effects of sabotage. Important components of the system are:

- The independent evaluation of the effectiveness of physical protection measures at installations containing nuclear materials. Nuclear regulatory authorities should carry out periodic assessments of the physical protection systems at installations containing nuclear materials.
- A tool that helps to perform these periodic evaluations is the use of specific software to perform the analysis in an integrated and structured manner. The use of computing models which includes information about detection elements, delay elements and total delay, adversary's path and response time of security force and the corresponding non-detected access probability facilitates the assessment of the regulatory authority and permits to improve the system or to request corrective actions.
- The performance of audits and inspections to independently verify the adequacy of the system to prevent and respond to attempts of theft, unauthorized diversion and sabotage.
- Due to the appearance of illicit trafficking of nuclear materials, specific complementary measures to prevent these acts in the fields of prevention, legislation, response, training and exchange of information are required.

Prevention

This is the adoption of additional measures to prevent and detect the illicit handling or use of nuclear materials. The routine exchange of information with the Customs Authority and Security bodies should take place regularly. In addition, consideration should be given to the installation of radiation detectors to be located, for instance, at border control stations.

Response

The measures adopted by the State should be such that permit to react timely to the illicit act or to mitigate its consequences. It is important that nuclear regulatory authorities develop guidelines for border control authorities to detect and respond illicit movements of nuclear material.

Exchange of information

The periodic exchange of information with relevant organizations, directly or indirectly related with this matter, is fundamental for the prevention and detection of the illicit uses of nuclear materials.

Training

As said, training is an important tool to prevent the illicit use of nuclear materials. Thus, it is essential that a nuclear regulatory authority coordinates and carries out specific courses for holders of these materials and personnel of relevant organizations (in particular, organizations involved in control activities at entry points (e.g. Customs and Security forces). These courses should include topics such radiological protection, safe transport of radioactive materials, physical protection, prevention and detection of illicit trafficking of nuclear materials, emergency plans. Participation of relevant international organizations in these courses (e.g. IAEA, WCO, and INTERPOL) should be encouraged.

2.2. EXISTENCE OF A STATE SYSTEM OF ACCOUNTING AND CONTROL OF NUCLEAR MATERIALS

A complementary measure contributing to the prevention of illicit uses of nuclear materials is the establishment and maintenance of a competent SSAC. This system should comprise a set of requirements and procedures applicable to all nuclear materials to ensure, with a reasonable degree of certainty, that nuclear material is not diverted to unauthorized uses and that they are used in full compliance with a Country's non-proliferation commitments.

The SSAC has to be designed and enforced in a way that it:

- Ensures that the nuclear materials are imported, exported, produced, transferred, stored, used, or disposed of, only by authorized or licensed installations.
- Ensures that licensees and relevant organizations are well aware of their responsibilities and of applicable procedures and requirements.
- Keeps an updated system database of all nuclear material present in the country.

An effective SSAC should comprise procedures and requirements for the holders of nuclear materials. A pillar of this system is the accountancy of all nuclear materials and its

independent verification. One of the main requisites is to establish a system of records and reports for each installation showing nuclear materials inventories and their changes, including notification of transfers and receipts of nuclear materials. These inventories and their changes should be subject to control by the SSAC through audits and inspections.
To carry out its control, the competent authority has to be entitled to access to all nuclear installations and materials. It has also to be empowered with legal enforcement to require any measure that may be needed to resolve anomalies or request immediate corrective actions. The setting up of a central database containing the whole of the nuclear material inventory is also an important component of an effective control.

2.3. CONTRIBUTION OF AN EXPORT-IMPORT CONTROL SYSTEM TO PREVENT ILLICIT USE OF NUCLEAR MATERIAL

The existence of an export-import licensing system of sensitive materials is another measure that contributes to the prevention and detection of illicit uses of such materials. Therefore, it is important that countries set up such systems in a way that contributes -together with other measures- to this objective. The export-import authority should be integrated by all relevant organizations: well-defined roles and procedures should be in place, in particular, the nuclear regulatory authority and Customs. Conditions to authorize exports of nuclear materials so that the importing State provides certain level of physical protection and has in place an accountancy control system helps to achieve the above mentioned objective.

3. SAFETY OF RADIATION SOURCES AND SECURITY OF RADIOACTIVE MATERIALS

The International Atomic Energy Agency has taken several actions to promote the adoption by States of steps to ensure the existence of competent national systems of control for ensuring the safety of radiation sources and the security of radioactive materials. Within this framework, it has established an Action Plan that covers the following areas:

- Regulatory Infrastructures.
- Management of Disused Sources.
- Categorization of Sources.
- Response to Abnormal Events.
- Information Exchange.
- Education and Training, and
- International undertakings.

In this field, it is worthy to mention that within "Information Exchange"; an international conference of national regulatory authorities with competence in the safety of radiation sources and the security of radioactive materials took place in Buenos Aires (Argentina, December 2000). Concerning criminal activities the Conference concluded that measures to prevent the criminal misuse of radiation sources should be seen as complementary to measures to increase their safety and security. It was also concluded that events where there is a criminal intent of exposing people to harmful effects of radiation should be clearly distinguished from cases where individuals are exposed to radiation because of breaches in radiation sources safety and security. The prevention of criminal activities involving nuclear material or other radioactive materials requires border competence and a thorough understanding of the related-issues. A closer cooperation at the national and international level between nuclear regulatory authorities and law enforcement authorities is required.

CONCLUSIONS

- The existence of competent regulatory authorities empowered to set up adequate control measures (e.g. physical protection, national safeguards, and export-import control of sensitive materials) enhances the State's capability to prevent and respond to illicit use of nuclear materials, being the pillar to lower the probability of occurrence of illicit uses of nuclear materials.
- A coordination role of the nuclear regulatory authority of all relevant measures with other national organizations is seen as an important contribution to prevent these illegal uses.
- Responsibility for establishing and operating a comprehensive physical protection system for nuclear material and facilities within a State rests entirely with that State. Adequate physical protection measures against the theft or unauthorized diversion of nuclear material and against sabotage of nuclear facilities by individuals or groups need to be in place.
- The existence of a competent SSAC that recognizes the complementary nature of material accounting and control and physical protection measures contributes to prevent theft or unauthorized removal of nuclear material. Activities to verify nuclear material location and inventory are important components of the system.
- The establishment of an export-import control regime also helps preventing unauthorized movement of nuclear materials across borders. Adequate procedures and interaction with relevant authorities (nuclear regulatory authority, Foreign Affairs, Customs) are important elements for an effective control.
- The measures that have been described above have a complementary nature in the prevention of illicit uses of nuclear materials. The lack of any of them (physical protection, material control and accounting systems, export-import regimes) increases the probability of diversion or unauthorized removal of nuclear materials and thus, the control system would results more vulnerable to these illicit uses.
- The occurrence of illicit uses of nuclear material and other radioactive sources has an international dimension. Therefore, international cooperation plays an important role in preventing and responding to these illicit events.

REFERENCES

[1] SECURITY OF RADIOACTIVE SOURCES AND MATERIALS, Rodríguez C., D´Amato E, Fernández Moreno S. Autoridad Regulatoria Nuclear- International Conference "Safety of Radioactive Sources and Security of Radioactive Materials — Dijon- France — September 14-18, 1998.

[2] CONTROL OF THE SAFETY OF RADIATION SOURCES AND THE SECURITY OF RADIOACTIVE MATERIALS — Contributed report -International Conference of Regulatory Authorities with Competence in the Safety of Radiation Sources and and the Security of Radioactive Materials — Buenos Aires — December 11-15 2000.

QUESTIONS AND ANSWERS

I. Badawy (Egypt): You mentioned a nuclear regulatory authority for licensing, a safeguards accounting system, a physical protection system and an import–export authority. Do they work together, and how are they co-ordinated?

S. Fernandez-Moreno (Argentina): This can vary from State to State. In Argentina, the regulatory authority has a prominent role in co-ordinating all these activities.

N. Kravchenko (Russia): What role does the Argentinean customs service play in the import–export control system? Do customs officers take part in searches for nuclear and radioactive materials?

S. Fernandez-Moreno: In import–export control, the Argentinean customs authority has a major role in all sensitive areas, such as those relating to weapons, chemicals and nuclear materials. The nuclear regulatory authority helps customs and police to co-ordinate physical protection.

C. Schandorf (Ghana): How is legislation harmonized for physical protection, SSAC, import–export, safeguards, and illicit trafficking in nuclear materials?

S. Fernandez-Moreno: The Nuclear Act establishes that the Argentinean nuclear regulatory authority must control all these nuclear activities and is empowered to enforce adherence to the established standards. Collaboration and co-ordination with other relevant authorities (e.g. customs, police) can be achieved by, for example, setting up agreements, holding training courses for personnel and establishing border control procedures.

V. Lapshyn (Ukraine): You described a database for nuclear materials to be used by all authorities in the country. Can it be protected from illicit penetration?

S. Fernandez-Moreno: This database, a tool to verify that nuclear material in not diverted for unauthorized purposes, is only for the SSAC. Any sensitive data is protected.

ESTABILSHING DESIGN BASIS THREATS FOR THE PHYSICAL PROTECTION OF NUCLEAR MATERIALS AND FACILITIES

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Abstract. Support from the IAEA and donor countries has allowed Kazakhstan to create an ideology and a set of regulatory documents for physical protection of nuclear objects and an assessment for design threat at the international requirements level. Kazakhstan has carried out the initial assessment of threats to nuclear facilities and materials and the administration and response forces of nuclear facilities are guided by the materials of design threat for the development of physical protection measures. Requirements taking into account the necessity of design basis threat assessment have been developed in the framework of the licensing process. Comprehensive inspections have been carried out several nuclear facilities. Taking into account the initial investigations on local threats, a national level design threat is being complied. The Kazakhstan authorities are continuing to investigate all events which have negative influences and result in grave consequences.

In the area of nuclear energy utilization, the Republic of Kazakhstan follows international legislation standards. Since December 13, 1993 Kazakhstan has been a participant of the Nuclear Weapon Non-proliferation Treaty and does not have nuclear weapons. In the framework of this treaty, Kazakhstan provides measures to ensure the nonproliferation regime. The Republic signed the Agreement with IAEA on the guarantees that were ratified by a Presidential Decree in 1995. Now the Government is considering the Convention on Physical Protection of Nuclear Materials.

Kazakhstani legislation for nuclear energy utilization is represented by a set of laws; most importantly is the Law of the Republic of Kazakhstan "On the utilization of atomic energy", dated April 14, 1997 and other regulatory decrees.

According to this Law's requirements, the problems of physical protection are regulated by the Kazakhstan Atomic Energy Committee (KAEC) of the Ministry of Energy and Mineral Resources and by the other interdepartmental legislation documents.

Establishing the design basis threats for nuclear enterprises and institutes of Kazakhstan is an urgent problem because: 1) many important nuclear objects are located in Kazakhstan 2) dual use materials are being produced in Kazakhstan, 3) and the dangerous political situations in the neighboring region.

The basis for the investigation of design based threat in Kazakhstan was for the identification of the objects attractiveness for nuclear sabotage with radiological consequences for environment and population. Also the threat of nuclear sabotage and/or the theft of special nuclear material to create a critical mass and/or nuclear shell device.

Transparencies 1 and 2

Nuclear objects in Kazakhstan have the following characteristics:

- Ulba Metallurgical Plant, located in the eastern area of Kazakhstan, manufactures fuel pellets of uranium dioxide for heat release assemblies of RBMK and LWR reactor types. These pellets have an enrichment of U235 1.6-4.4%. Ulba also has a radioactive waste disposal storage site.

- A power plant for heat and power supply, and water desalination is based at the BN-350 fast breeder reactor. This reactor is located in Aktau city on the Caspian Sea. Since April 1999, the reactor has been in the process of being decommissioned. There is a lot of spent fuel with highly radioactive and toxic weapon plutonium there.
- There are also research reactors of National Nuclear Center, located in the north-eastern area of Kazakhstan, near Semipalatinsk city. These research reactors have nuclear materials of the first category, which are attractive to criminal groups:
  - IVG.1M — light-water heterogeneous reactor of vessel type on thermal neutrons, with light water moderator and coolant, maximum power is 35 MW;
  - IGR — impulse homogeneous graphite reactor on thermal neutrons, with graphite reflector;
  - RA — high temperature gas cooled reactor on thermal neutrons, 0.5 MW power;
  - There is also a research reactor site near Almaty city, with LWR-K — light-water reactor, with 10 MW power, uses highly enriched uranium (up to 36% of U-235);

Besides these specified objects, there are many objects from uranium mining and processing. The infrastructure of former Semipalatinsk and the other testing sites, and the Baykonur cosmodrome. All these are subject to illicit uses of radioactive materials and different types of radioactive waste.

The following activity was accomplished in the framework of physical security modernization for nuclear objects and nuclear materials for the period since 1994 till now under the support of International Atomic Energy Agency and international grants of donor countries.

- An estimation of existing physical protection measures and upgrades of such systems for all the nuclear facilities was performed. Important attention was paid to providing technical means of physical protection for the protection of 1-st category of nuclear materials, located in the nuclear facilities' storage sites.
- A set of expert reviews was performed with the support of Sweden and Germany to assess legislation documents and to organize physical protection of nuclear fuel manufacturing at Ulba Metallurgical Plant.
- A set of training seminars on physical protection organization, in a framework of IAEA recommendations (INFCIRC/225/Rev.3,4) was prepared and carried out. A practical seminar to assess the vulnerability of the physical protection system for the Nuclear Physics Institute with the participation of the US Department of Energy and Nuclear Regulatory Commission was also carried out.
- In May 1999 – Kazakhstan participated in a training seminar by Sandia National Laboratory for designing and assessment of physical protection systems at Brno, Czech Republic.
- In May 2000, with direct participation of the German Society of Nuclear Reactors and Facilities Security (GRS), a training seminar was held on establishing of design threat for hypothetical research reactors and the creation of physical protection conception.

This support from IAEA and donor countries has allowed Kazakhstan to create an ideology and a set of regulatory documents for physical protection of nuclear objects and an assessment for design threat at the international requirements level.
Now, relevant authorities of Kazakhstan investigate the issue of design threat. These are mostly done by the Committee of National Security jointly with the Committee of Atomic Energy and the administrations of nuclear facilities.

Taking into account the deficit of time and the necessity to develop adequate response to threats, the following work is being carried out:

1. The initial assessment examination of threats for nuclear facilities and materials at the local level was carried out. Now the administration and response forces of nuclear facilities are guided by the materials of design threat for the development of physical protection measures.
2. In a framework of the licensing process that was started in 1999 according to Kazakhstan legislation on physical protection of nuclear objects and materials, KAEC developed requirements taking into account the necessity of design threat assessment. Comprehensive inspections were carried out at several nuclear facilities in 2000. The recommendations for upgrading physical protection measures were issued according to the levels of local threats for each nuclear site.
3. Relevant authorities of Kazakhstan, together with KAEC, are continuing to investigate all the menacing events that may have negative influences and result in grave consequences.

   Transparency 3

   These events are the following:

   - The high mercantile interest in nuclear materials and radioactive substances. The attempts to purchase them were registered by law-enforcement authorities. For example, the theft of 149.8 kg of nuclear fuel pellets with U-235 enrichment up to 3,3% from Ulba Metallurgical Plant was discovered in Ust-Kamenogorsk in December 1999.
   - 4 cases of illicit use of nuclear materials with U-235 enrichment up to 4.4% were discovered and prevented in Almaty in the period between July 1999 and July 2000, (5 kg, 0,515 kg, 0,090 kg, 4 kg). It was determined that the goal of the procurement for commercial interests to resell the materials to interested southern countries.
   - Interest from international terrorist organizations to purchase nuclear materials for the creation of nuclear shells.
   - Military operations by terrorist troops in countries neighboring Kazakhstan in the spring-summer of 2000, and also available data on the probable beginning of military operations in spring of 2001.

4. Taking into account the initial investigations on local threats for every nuclear facility, the compiling of the government document on the design threat at national level is being carried out.

In the final stage in the research work for the determination of design basis threat with the participation and support of IAEA, there is a plan to organize a national workshop for the representatives of all Kazakhstan interested authorities. This will be held in October 2001 using IAEA methodology and utilization of international experience (USA, Germany, Great Britain, France).

It's our hope that the experienced received from this seminar will allow Kazakhstan to check the results of its work on assessment of design basis threat to nuclear facilities and materials, and to make necessary corrections in the methodology to investigate this problem.

UNDER ATOMIC ENERGY COMMITTE of REPUBLIC of KAZAKHSTAN
SUPERVISION NUCLEAR FACILITIES

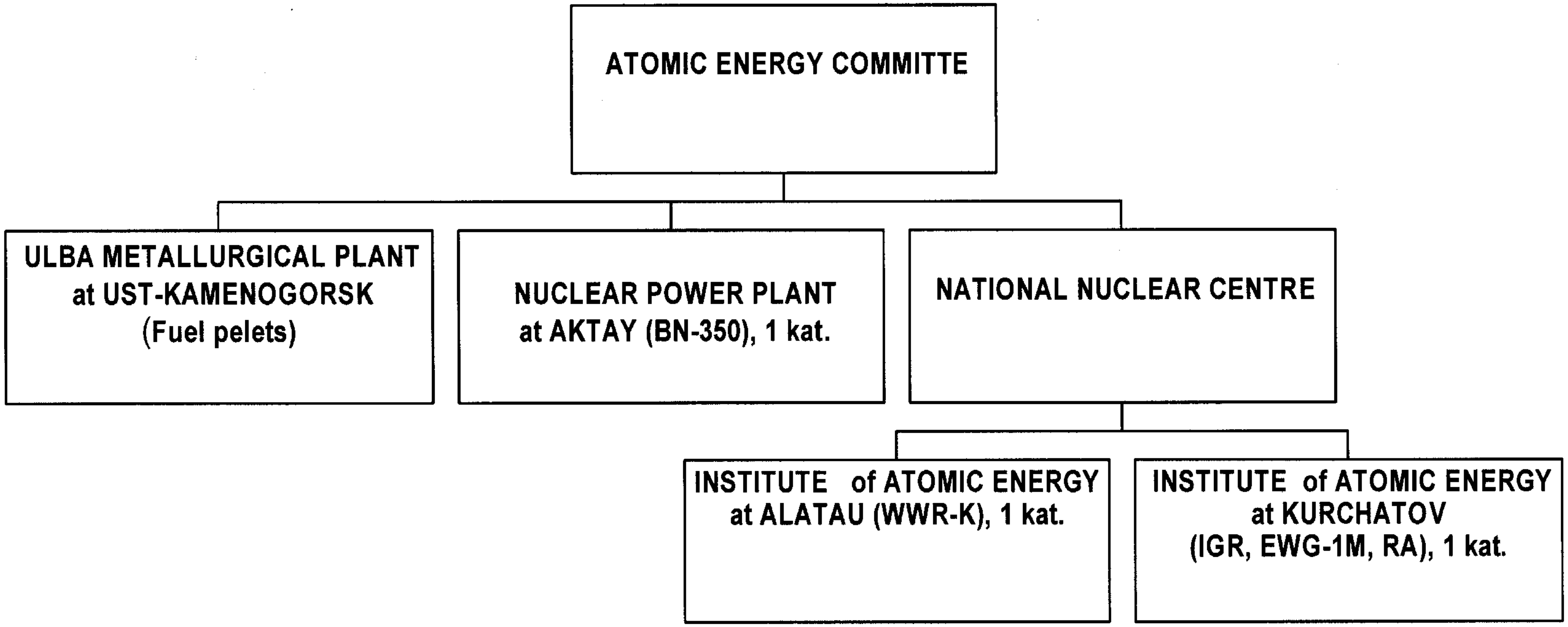

FIG. 1.

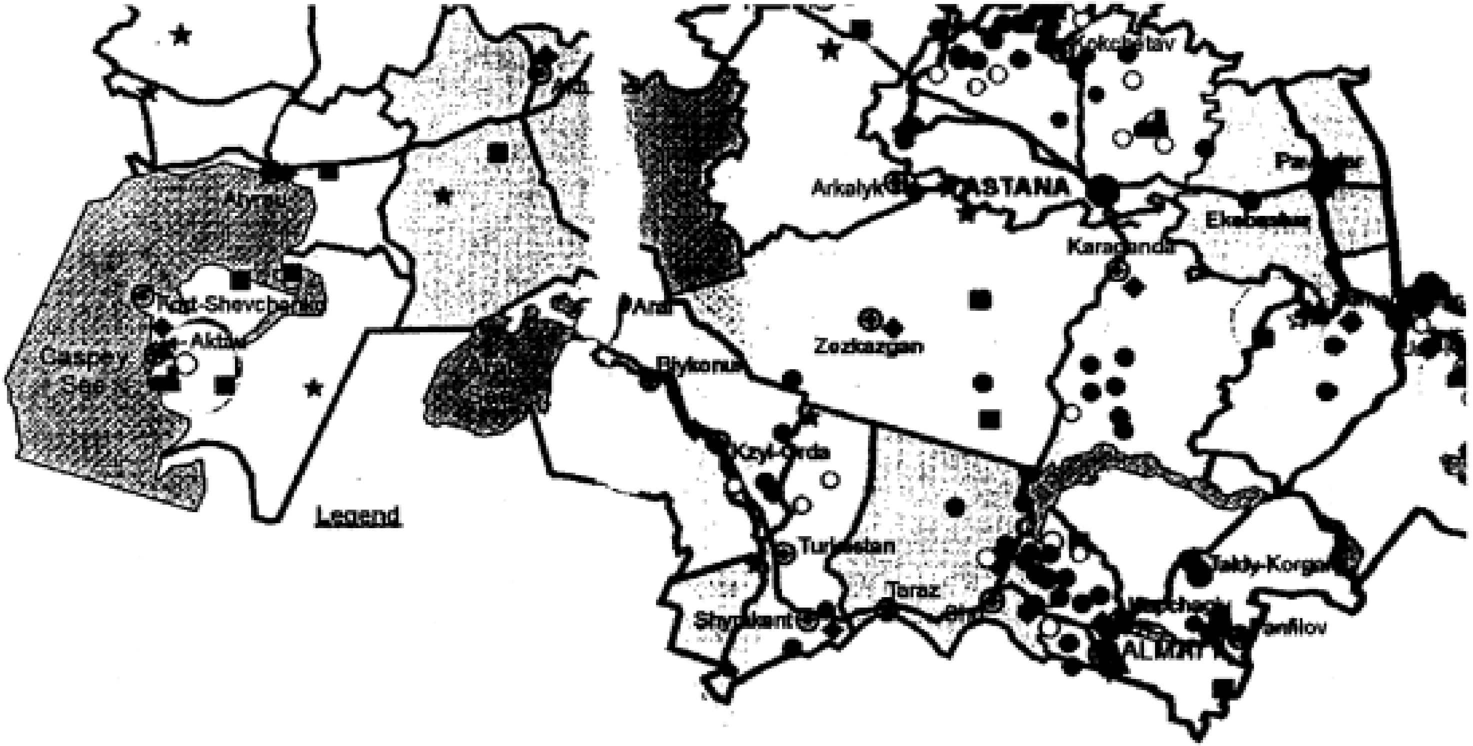

FIG.2. Location of radioactive dangerous object

Radioactive waste of ecological exploration, which characterized by O alpha- activity more than –7400 Bq/rkg and ambient dose rate (ADR) more the mkR/h.
Radioactive waste of uranium exploitation, which characterized by) alpha- activity more than 7400 Bqj/kg and ambient dose rate (ADR) more than 1 mkR/h
Radioactive waste of exploiting mineral resources, rare minerals, TM phosphorite, oil, coal, if
Radioactive waste on former nuclear test sites
Radioactive waste nuclear energetic and research facilities
Φ Sealed sources and radioisotopic fxoduction
gj/ Mining-metalurgical and chemical plant


R U S S I A N F E D E R A T I O N
Petropavlovsk
Kostanai
Kokshetau
Pavlodar
Uralsk
Aktiubinsk
Astana
Semipalatinsk
Atyrau
Zhezkazgan
Aktau
Kzyl-Orda
Almaty
Taraz
UZBE KISTAN
KYRGYZSTAN
TURKME NISTAN
C H I N A

FIG. 3.

QUESTIONS AND ANSWERS

J. Fechner (Germany): What is the role of police or military response forces in protecting nuclear facilities in Kazakhstan?

S. Chetvergov (Kazakhstan): The forces of the Ministry of the Interior, which co-operates with the Atomic Energy Committee, assist in protecting nuclear facilities.

THE CONCEPT OF RISK IN THE DESIGN BASIS THREAT: CAN COMPLEXITY THEORY HELP US UNDERSTAND IT?

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Abstract. Analysis of real data about non-nuclear security incidents suggests that the many factors involved may, under the non-equilibrium conditions required by complexity theory, be in a critical state. If so, managing risks means managing the simple power curves, not all the underlying factors. If this suggestion can be validated, it will add a theoretical base to the pragmatic case for the Design Basis Threat. It also suggests that concentrating only on threats and adverse consequences above an arbitrary threshold means that issues are only dealt with when they become critical. Complexity theory implies that the most effective protective security interventions will be before an issue becomes critical.

1. INTRODUCTION

Security, used in its English sense to mean protective measures, considers consequences that are attributable only to deliberate hostile action, including hostile action to reduce the effectiveness of safety measures. Although some of these consequences may be identical in kind to those arising from accidental failure, these particular occurrences would not arise in the absence of deliberate hostile activity. In a security context, in contrast to a safety context, the normative value of risk is zero. This is not a realistic or practicable value against which security measures can be assessed for effectiveness. Nor is it a realistic regulatory goal.

A number of numerical algorithms attempt to evaluate security risk either absolutely or for comparative purposes. However, in the absence of sufficient data to validate the algorithms, they require to make certain assumptions about which factors are important and how they interrelate. The complex interrelationships of the factors suggest that they are worth examining in terms of complexity theory.

2. METHOD AND RESULTS

A collation of some general (i.e. not involving nuclear facilities) terrorist incident data for the UK and the Republic of Ireland for the year 2000 was the basis for this study. Six categories were defined, each representing significantly different degrees of severity. A colleague was asked to allocate each incident to a category. The results are in Table I.

Table I. The frequency of some general terrorist incidents (none involved nuclear facilities) by intensity (6 is the most severe) in the UK and Republic of Ireland in the year 2000

Intended damage	1 least severe	2	3	4	5	6 most severe
Frequency (%)	62.5	22.0	10.0	3.7	1.4	0.4

It can be seen that the data is consistent with a power curve. Complexity theory suggests that this means the factors that give rise to incidents can enter a critical state. When this happens, the properties of a complex system can be described by power curves without having to take explicit account of all the component factors.

3. DISCUSSION

Table I needs to be interpreted with considerable caution. The data is limited, is almost certainly not comprehensive, or of uniform quality, and there are clear difficulties in scaling severity. The suggestion that complexity theory may apply to security threats remains tentative but is certainly worth further analysis. If complexity theory does apply, how might it increase understanding of the analysis of risk and, crucially, could it have implications for the way in which security is regulated and managed at nuclear facilities?

3.1. ANALYSING RISK

As noted in the introduction, there is no practicable "no risk" option. The intuitive "very low risk" option of denying anything and everything to real or potential opponents is very expensive. It is also, given that they are so widespread, irrelevant to nuclear materials.

There are a number of algorithms that focus on the need to give most protection to the most valuable assets. Low value assets under low threat receive reduced protection (at less cost) but still sufficient to achieve the same effective protection as other assets. No real risks are run. It is simply a way of avoiding deploying expensive security on low value assets. Table II illustrates such an algorithm.

Table II. A tabular algorithm for calculating risk

		Threat Level		
		HIGH (1)	*MEDIUM (1/2)*	*LOW (1/4)*
Asset Value	*HIGH (1)*	**HIGH (1)**	**MEDIUM (1/2)**	**LOW (1/4)**
	MEDIUM(1/2)	**MEDIUM (1/2)**	**LOW (1/4)**	**VERY LOW (1/8)**
	LOW (1/4)	**LOW (1/4)**	**VERY LOW (1/8)**	**INSIGNIFICANT**

Table II is a specific form of the general function:

$$\text{Risk} = f(P_T,V) \qquad \text{(Eqn. 1.)}$$

where P_T is the probability of a successful attack and V is the value of the asset to the holder. The value of P_T derives from the factors that go to make an attack successful and those factors that contribute to a successful defense. Aggression is a function of motivation, intention, capability and opportunity, but also of deterrence and the aggressor's view of the risk to himself. Defense is a function of vulnerability, and the strength and responsiveness of countermeasures. A true calculation of P_T would require considerable knowledge not only of the dimensions of each factor but how also they interact. Table I, therefore, is a very special case. It depends on P_T and V having dimensions and values that are of equivalent weight and it depends on the functional relationship being a simple product. Although conceptually useful, rarely is sufficient detail available to properly define a fully expanded equation. In the case of the threat to nuclear materials there is hardly any empirical data to use and the threat is qualitatively different from the asset.

If complexity theory can be applied to active threats, risk management means managing the power curve. If the system is in a critical state, it means that the factors that give rise to small incidents are exactly the same as those that give rise to large incidents. Managing to prevent small incidents becomes more important than managing big ones because preventing small incidents prevents both. A critical state also means that, for practical purposes, there are limits. There are small adverse consequences that can be accepted as being of no concern. There is also an effective maximum consequence.

3.2. RISK AND THE DESIGN BASIS THREAT

INFCIRC225/Rev4 recommends that states develop a Design Basis Threat (DBT) to provide the regulatory criteria against which to assess systems of physical protection. It can be seen, intuitively, to be risk-based because it focuses on local threats and requires judgments based on the severity of those threats. It is not unlike Table II. Protection is proportionate to the threat and the value of the asset. As noted above, Table II is, however, a very special case of the general equation. The DBT approach has, similarly, been criticised as not being about risk because it does not take into account all the risk factors that comprise the expansions of Equation 1. The DBT approach appears to ignore such risk factors as vulnerability, deterrence and physical protection. Is the DBT really any more about risk than Table II or is it just pragmatic?

Complexity theory suggests that ignorance of the detailed workings of a system in a critical state does not prevent some of its properties from being described in very simple terms. If the threat/protection system is critically unstable it can be adequately described without a detailed knowledge of its components. If risk management really is about managing the power curve, it can be seen that the DBT's focus on limited criteria may be appropriate. The DBT approach may be both pragmatic and theoretically justifiable. Furthermore, the existence of a theoretical maximum underlines the appropriateness of a regulatory process that can set upper limits to what need be of concern.

3.3. PRACTICAL SECURITY

Criticality arises only when complex systems are not in, or tending towards, equilibrium. The way to avoid security incidents altogether, therefore, may be to keep the system away from criticality. Overwhelming protection measures may achieve this: it may explain why there have been so few nuclear security incidents. Likewise, constantly allowing the release of small pressures for change prevents the build up of pressure. The power curve also implies that measures taken to prevent or counter small but significant adverse consequences will also prevent larger ones. The converse is not true. Measures taken only to counter large adverse consequences will probably be unable to prevent smaller adverse consequences. Concentrating solely on issues above an arbitrary threshold may allow lesser issues to develop to a critical state, increase the chance of them leading to a serious consequence, and could make the issues much less easy to counter than they would have been. This explains, also, why dealing with "insider" issues is so fundamentally important. Complexity theory may mean that we can know less than we might imagine we need to and still be able to make effective judgments about which threats to counter and how.

BIBLIOGRAPHY

BUCHANAN, M. Ubiquity, Weidenfeld & Nicholson' London (2000).

QUESTIONS AND ANSWERS

D. Flory (France): Physical protection systems are not designed to diminish frequency of malevolent activities, but may have a deterrent effect? Should your model allow for this?

J. Reynolds (UK): I agree with you. However, the problem is knowing what the deterrent effect is.

O. Johnson (USA): In developing a design basis threat (DBT), how is the notion of consequence included in the calculation?

J. Reynolds: Risk is the probability of malevolent activity leading to adverse consequence. It drives everything. Although I couldn't fully explore the idea in the time available, the table I showed is based on consequence.

J. Jalouneix (France): A comment: risk evaluation must take into account — (i) the severity of the threat itself and (ii) potential consequences: radiological releases into the environment (sabotage); diversion of nuclear material (theft).

J. Reynolds: I agree. However, relying only on the argument of consequences, we can be challenged that the consequences have never happened. We need substantial resources for protective security. I suggest that the real experience of lesser incidents indicates the potential for the more severe.

K. Hirano (Japan): Do your statistics categorize incidents according to frequency and severity in order to prevent more severe damage?

J. Reynolds: No. Authorities regard all such malevolent activities seriously. If the threshold is set too high, we might not treat lower level events as being a serious as they are.

J. Fechner (Germany): What changes to the UK DBT were triggered by your work?

J. Reynolds: The DBT takes account of all possible threats from all sources — not just the obvious ones.

A. Nilsson (IAEA): Please comment on the situation where a State does not recognize threat (DBT)?

J. Reynolds: Small incidents could indicate a real problem. A State can't know that it won't happen. Planning physical protection takes many years and we don't want to be too late. Therefore, very few countries would be in a position to assume no threat.

D. Ek (USA): You contend that risk cannot be approached mathematically because threat, primarily the frequency, cannot be accurately estimated? Does this refer to actual threat or DBT?

J. Reynolds: It would be unsafe to base the DBT only on actual occurrences. It should be based on experience combined with reasonable judgement.

R. Hibbs (USA): Even countries that do not believe there is a threat should have a minimal level of physical protection.

J. Reynolds: No comment.

D. Becker (Germany): Do you refer to a real or imagined risk? In future my office will consider the imagined risk, too.

J. Reynolds: Theoretically, there must be a real maximum risk. However, in the absence of evidence — and long may it remain so — we have to work with imagined risk while being wary of imagining unrealizable risk.

N. Kravchenko (Russia): Are there any recommendations, from a non-proliferation point of view, regarding the minimum amount of nuclear material guaranteed to be found at a border?

J. Reynolds: In producing the DBT, we take account of existing national protection systems (e.g. customs).

SECURITY STUDIES

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Abstract. The so called "Security Studies" constitute one of the major tools for evaluating the provisions implemented at facilities to protect and control nuclear material (NM) against unauthorized removal. Operators use security studies to demonstrate that they are complying with objectives set by the Competent Authority to counter internal or external acts aimed at unauthorized removal of nuclear material. The paper presents the context of security studies carried out in France.

1. INTRODUCTION

The national control system set up in France is designed in such a way that physical protection, control and accountancy of nuclear material complement each other and form a coherent whole. It is placed under the Authority of the Minister for the Industry as represented by the High Civil Servant for defense of this ministry (Competent Authority).

The French regulatory system lays down a performance-based approach rather than a compliance-based approach. It is oriented towards the detection and prevention of any loss, theft or diversion of nuclear material usable for the fabrication of a nuclear explosive device.
Emphasis has to be laid on the fact that prime responsibility for the security of nuclear material rests with the operator, holder of the relevant licence. To do so, the operator has to take all the necessary measures to guarantee the protection, control and accountancy of his nuclear material. In other words, he must define the principles of his protection, control and accounting systems and then put them into practice. He must also devise the procedures necessary for the satisfactory functioning of the various equipment of the systems. In particular, he exercises his responsibility over the maintenance of the equipment, periodic tests for checking its satisfactory functioning and the achievement of the required performance, the definition of operating procedures, the training of personnel, the execution of periodic exercises, etc. Moreover, the operator has to prove that his arrangements satisfy the objectives specified by the authority. Consequently, he has to produce various files and notably security studies.

The measures taken by the operator could be analysed in the frame of a "defense in depth" approach. This concept of defense in depth is organised around prevention, management of the event and mitigation as regards the unauthorized removal of nuclear material. It takes the form of several lines of defense including both administrative aspects (such as procedures, instructions, sanctions, access control rules, confidentiality rules, …) and technical aspects (multiple barriers fitted with detectors and delaying devices). Provisions taken in the field of material control and accountancy constitute one line of defense and provisions taken in the field of physical protection constitute an other one.

2. REGULATORY ASPECTS

The French Competent Authority requires, by ministerial instruction, that specific studies, known as security studies, be carried out to assess the effectiveness of the security arrangements taken for the most sensitive types of nuclear material. These studies can be divided into two types depending on their scope. The first covers the physical protection area and the second, the nuclear material control and accountancy area.

The security studies cover storages and facilities in which nuclear material are kept, produced or processed. They are used to assess the effectiveness and reliability of the control and protection provisions made to prevent internal or external action aimed at the theft of a significant quantity of nuclear material, and if necessary, to deal with such an event. They are focused on plutonium and high enriched uranium (HEU), stored in amounts higher than 2 and 5 kg respectively (these are the thresholds for Category 1).

On a practical point of view the process involves the following regulatory steps:

A study is performed by the operator concerned who is responsible for the security of nuclear material held in his installations.

- The study and its conclusions are assessed by the Institut de Protection et de Sûreté Nucléaire (IPSN) acting as technical support to the Competent Authority (CMN : Control of Nuclear Material, Ministry of Industry).
- The security study and its conclusions are submitted to the Competent Authority for approval.

After examination and on the basis of the assessment report produced by IPSN, the Competent Authority confirms by letter whether or not an authorization can be granted for holding, transferring and using nuclear material in the concerned facility. If need be, he can ask the operator to modify the existing arrangements or to make new ones, the implementation of which can then be verified during an inspection.

Of course security studies have to be carried out in compliance with the corresponding confidentiality rules. In addition, such studies have to be regularly updated, notably if significant modifications are made in the material control and accountancy or physical protection systems.

It is important that security studies are available in the facilities for competent personnel, as it gives the rationale behind control and protection of nuclear material. In particular, it could be used, in a performance-based approach, to support analysis reports or to illustrate that the required level of security has been reached.

Security studies have begun, in France, for more than fifteen years. Up to now more than fifty security studies are available in the field of physical protection and most of them have been revised at least once.

To go ahead preliminary security studies in the field of material control and accountancy have been performed by operators of two different types of facilities, the results of which are very encouraging. A more detailed security study was carried out for a nuclear manufacturing facility. It shows the relevance of the performance-based approach. At the same time a security study in the field of physical protection was carried out for the same facility. This work underlined the complementarity between these two types of studies.

3. HOW TO STEAL NUCLEAR MATERIAL

The potential unauthorized removal of nuclear material usually may take place in two stages. The first stage involves the sequence leading to handling of the nuclear material. It occurs inside the physical barriers of a facility and may include action involving the documents corresponding to material control and accounting systems. At this stage it is possible to limit the risk of unauthorized removal of nuclear material by means of detection capabilities of the material control and accounting systems. The second stage is more specific to theft and involves removing the nuclear material out of the physical barriers of a facility in which they are being held, notably by affecting the physical protection system.

4. SECURITY STUDIES

The philosophy of these studies is based on a postulated unauthorized removal of nuclear material and the study of the behaviour of the systems implemented to control and protect nuclear material in a facility. This postulated removal is laid down with reference to the design basis threat specified by the competent authority for the purpose of these studies. Both internal and external threats are taken in account. The external threat is more specific of the security studies in the field of physical protection.

Steal of small quantities of nuclear material without being discovered by one or more employee who usually have access to the nuclear material.

- Steal of a significant quantity of nuclear material all at once by one or more employee who may or may not have access to the nuclear material.
- Steal of a significant quantity of nuclear material by outsiders. Two assumptions are considered (1) a small team of attackers with limited resources, (2) a larger team of attackers with more sophisticated resources.

The operators have to study, from a quantity and time lapse point of view, the ability of the installed systems to detect unauthorized removal, as well as the possibility of tampering with the systems to mask unlawful operations. They have also to analyse the sequences during which nuclear material are accessed, removed from their containment and further removed from the facility in which they are stored. At each stage in the process, the probability of detection and the time taken to carry out the above actions have to be estimated. Of course, these two types of studies complement each other.

With more than fifty security studies in the field of physical protection, France has a large experience. Some of these studies have underlined the need to upgrade the physical protection system of particular facilities or nuclear sites. It was also underlined that the physical protection system could not be efficient enough to preclude the theft of small quantities of nuclear material. For this reason a new type of security study based on a control and accountancy approach has been developed. Up to now three security studies, already performed, underline the relevance of this approach. A fourth one is in course of preparation.

4.1. IN THE FIELD OF PHYSICAL PROTECTION

In the field of physical protection, security studies are based on an analysis of all the possible paths leading to nuclear material in compliance with the design basis threat. This may involve crossing zones or outwitting detection devices and overcoming obstacles implemented by operators at the facility for physical protection purposes. By following the paths mentioned above, the probability of undetected persons (or nuclear material) as they progress in the facility is evaluated. The moment at which this probability is sufficiently low as to be able to assume that the unauthorized removal has been detected, is determined. Then the time elapsing between positive detection of the action performed by the adversaries and the removal of the nuclear material from the facility is estimated. Critical paths are taken as being those along which nuclear material can be removed from the facility in the shortest time after detection. Special care is taken when analysing these paths.

A security study is performed for each facility housing sensitive nuclear material located on a nuclear site. In addition, for complex sites a specific security study is carried out for the whole of the site. The objective of this study is to evaluate the effectiveness and the consistency of the provisions taken at the site level to protect nuclear material. This site security study complements each facility security study, and focus on the physical protection of the central alarm station and the interaction between the inside and/or outside response forces. The site security study describes the actions of response forces since the detection of an alarm till the forces are in position to interrupt the adversary attack. The efficiency of this action is based on a quick location of the adversaries and the time required to deploy the response forces which has to be as short as possible. In this matter, the fences surrounding the site could be considered as a significant device to stop the adversaries and allow the recovery of the nuclear material.

The time required by the response forces (inside response forces and/or outside response forces) to counter each type of threat according to the scenarios previously identified are analysed namely:

- the procedures applied by the local security forces in the event of an alarm and the times and the means associated with these procedures,
- the resources available to the security forces,
- the physical protection and security of the means used to alert the authorities.

Finally potential upgrades are proposed by the operator to deal with the potential weak points identified by the security study, such as:

- delay devices could be increased by strengthening the physical barriers notably along the critical paths,
- new points of detection could be placed upstream to make delay more efficient for the response forces,
- physical protection of the nuclear material, its containment and the means of surveillance used could be strengthened,
- intrusion detection methods and personal checks could be improved,
- procedures followed in the event of alarms, resources of the inside response forces and how they are protected and, more particularly, the ways of alerting if necessary the outside response force could be updated,
- resources of the outside response forces, if applicable, could be redefined.

4.2. IN THE FIELD OF MATERIAL CONTROL AND ACCOUNTANCY

In the field of material control and accountancy, when unauthorized removal or dysfunction occurs, a discrepancy appears between the physical reality of nuclear material and the way in which it is represented in the material control and accountancy systems. This discrepancy remains latent until detected. Consideration is given to the scenario between creation of the discrepancy and its detection. It should be noted that possible detection of the discrepancy by the physical protection system is not covered by such studies, since this type of detection gives no information on either the effectiveness or the reliability of the material control and accountancy systems.

In other words, an assumption is made that such a discrepancy exists in compliance with a set of threats. Then, the purpose of the security study is to analyse the way in which the discrepancy is revealed in connection with a discovery threshold amount, if any. The duration of all possible scenarios is calculated and the possibilities of failure of the detection is taken into account in the study.

A critical scenario is defined as one which leads to discrepancies involving substantial amounts of material or for which the time periods before detection are long. Special care is taken when analysing these scenarios. The time elapsed before detection could be long if one or more point of control are bypassed or if nuclear material have been replaced by dummy material. Of course possible diversion of nuclear material held in waste or in scrap material need to be carefully studied notably if these material are without control for a long time. Careful examination is also necessary for scenarios in which detection depends on the presence of two persons (two persons rule criteria) or depends on organizations not directly concerned by measures taken by the operators to protect and control nuclear material (safety or radioprotection requirements for example).

Events which have enabled the discovery of the latent discrepancy are examined by studying the associated functions. A verification is made of the pertinence of the function for each of the situations or states that can arise in the facility (maintenance or emergency situations for example). A verification is also made to establish that the function in question is effectively a material control and accountancy matter. If not, and if detection strongly depends on this item, it will probably have to be integrated in the material control and accountancy systems. Thus the radioactivity detection system could produce alarms in case of unauthorized removal of nuclear material, but these alarms, which have to be taken into account by the staff in charge of radiological matters, could not be taken into account by the staff dealing with protection of nuclear material if there is no provision to do that.

Moreover if the function's reliability is deemed not sufficient, it should be disregarded as a detection capability. As an example the two persons rule could be not sufficient enough according to the cases to detect unauthorized removal of nuclear material.

For critical scenarios, a sensitivity analysis is performed to determine whether a quantity of material less than that considered for the purpose of the security study would have resulted in the same detection, possibly with a different time period. Care is, of course, taken to evaluate the quantity of material below which detection would probably not have taken place. The sensitivity analysis makes it possible to determine the threshold of detection of the discrepancy. This threshold may vary according to the nature of the measures performed (for example measure of weight, volume, concentration, radiation). The adjustment of the equipment used to make measures and its associated procedures have to be considered.

Possible improvements of the material control and accountancy systems are examined using the above approach when needed. Potential upgrades have to be proposed by the operator to deal with the potential weaknesses identified by the study. For example possible improvements could include:

- measures related to control (choice of measurement points, inventory methodology etc.),
- accountancy procedures,
- comparison of the actual situation of the nuclear material held in the facility with its representation in the material control and accountancy systems,
- independence between the material control system and the accountancy system,

- organization of the work of the staff in the different phases of the lifetime of the installation.

QUESTIONS AND ANSWERS

S. Fernandez Moreno (Argentina): Security studies of nuclear material apply different measures and objectives for physical protection (PP) and for accountancy and control (NMAC). How do you ensure the required expertise?

R. Venot (France): We have experts specialized in each area.

Anita Nilsson (IAEA): a) Where is the security study methodology documented? b) What benchmarks are used in the assessments?

R. Venot: a) The methodology is documented in an order of the French competent authority. b) There is a benchmark in two steps: (i) The studies are performed by the operators. (ii) They are evaluated independently by another body.

Y. Volodin (Russia): Has this methodology been applied to a real French facility? If so, what were the results in terms of upgrading NMAC or PP?

R. Venot: Yes, it has been applied where nuclear materials are produced, processed and stored. The studies are mandatory and focus on Pu and HEU. For PP, 50 studies have already been performed. For NMAC, three studies have been completed and a fourth is under way.

A. Hagemann (Germany): You carry out performance-oriented assessment of a whole system. What measures do you take to compensate for individual weak points?

R. Venot: Weak points can be dealt with by various measures for PP, NMAC, safety or radiation protection. However, it is important to evaluate the efficiency as a whole and, if necessary, to include certain safety or protection aspects.

ABOUT THE ROLE OF HUMAN FACTORS IN THE BUILDING OF PHYSICAL PROTECTION SYSTEM

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Abstract. Human factors have a special role in creating a strong, effective system of physical protection directed against theft or unauthorized movement of nuclear and other radioactive materials and against sabotage of nuclear facilities. To bring the physical protection of existing nuclear facilities up to present-day requirements, procedural measures are needed such as access controls and background checks on personnel with access. The state of security of nuclear facilities is completely dependent upon human actions, both those with criminal intentions and those standing in their path. Political, socio-economic, spiritual and other factors are outside of the operator's control. Threat assessment must rely on postulated scenarios for terrorist actions. The difficulty of both forecasting and defending against all possible threats is reflected in the fact that different countries take different approaches in protection of nuclear reactors. There is a need to obtain objective information on terrorist intentions and on the reality of threats.

ДОКЛАД

к выступлению на международной конференции по обеспечению
сохранности материала — меры предупреждения, пресечения и реагирования на незаконное использование ядерных материалов и радиоактивных источников на тему

"О роли человеческого фактора в построении системы физической защиты"

Сегодня уже всем очевидно, что незаконный оборот, включая наиболее опасные его формы: распространение ядерного оружия, контрабанда ядерных материалов, радиоактивных источников и оборудования, представляет серьезную угрозу мировому сообществу, является **преступлением против человечества**. Победить это **зло** можно лишь общими усилиями, создавая защиту от него на международном, национальном и объектовом уровнях.

Для успешного решения этих задач целесообразно создать на Международном уровне такой **режим**, который позволил бы ему различными средствами **заставить** государства придерживаться существующих международных соглашений, направленных на укрепление их позиций в области нераспространения ядерного оружия; обеспечить финансирование борьбы с незаконным оборотом, а также способствовал бы сотрудничеству в использовании Национальных и Международных Баз данных по нераспространению ядерного оружия, двухсторонним соглашениям между государственными органами и международными организациями о процедуре совместных расследований случаев незаконного оборота, а также определял бы комплекс требований и рекомендаций, которые должны выполнять Государства в целях эффективной борьбы с незаконным оборотом.

В центре деятельности **Международного режима** должны находиться **Национальные системы** борьбы с незаконным оборотом, включающие меры по **предотвращению, обнаружению и реагированию** на незаконный оборот на территории **конкретного государства** или через **его границы.** Причем, каждая попытка такого преступления или соучастия в нем должны пресекаться на **начальных** стадиях. В связи с чем все меры борьбы с незаконным оборотом должны быть **сфокусированы** на ядерные установки и другие места, где используются, хранятся или транспортируются ядерные и радиоактивные материалы.

С учетом этого, свой вклад в борьбу с незаконным оборотом мы видим — в обеспечении сохранности ядерного материала и радиоактивных источников, в создании **Мощных и высокоэффективных систем физической защиты,** направленных, в первую очередь, против хищения или несанкционированного перемещения ядерных и других радиоактивных материалов, а также против диверсий (саботажа) на ядерных установках.

Особая роль в создании Системы физической защиты (на всех уровнях) принадлежит **человеческому фактору.**

Сначала хотелось бы определить место этой темы в **системе общей безопасности.**

Основу **безопасности атомной отрасли**, как и многих других, составляют люди: разработчики, персонал, руководители различного уровня, принимающие ответственные решения; представители контролирующих, регулирующих и правоохранительных структур,- и поэтому роль **человеческого фактора** в целом можно считать, по крайней мере, — значительной.

Проанализировав даже в общих чертах состояние дел по повышению безопасности можно увидеть:

- **стадия проектирования и создания объектов** несмотря на ведущиеся работы по пуску блоков — уже практически завершена и рассчитывать на возможность внесения существенных изменений практически отсутствует. А они были бы полезны, ведь все разработано в 70-х годах и зачастую не соответствует сегодняшним требованиям физической защиты (ФЗ). Существовавшая в то время концепция нацеливала, в основном, на предотвращение хищения товарно-материальных ценностей, без учета наличия ядерного материала и ядерных установок, Об этом свидетельствует и организация охраны, и режима. А кроме этого, атомная энергетика создавалась по образу и подобию, в отличие от подхода в других странах, традиционной электроэнергетики, когда основным критерием была бесперебойная выработка электроэнергии. Жизнь показала, что атомная энергетика требует к себе более тонкого подхода, а основным критерием надежности эксплуатации следует считать недопущение возникновения ядерно- и радиационно- опасных ситуаций.

- следующий период — **эксплуатация объектов**, когда необходимо адаптироваться с имеющимися возможностями к требованиям сегодняшнего дня. При этом, как было указано выше, внести существенные изменения в компоновку помещений, расположение оборудования, изменить степень ее уязвимости от несанкционированных действий уже невозможно и остается с помощью процедур дотягивать до необходимого уровня. Процедуры включают: обустройство зон ограниченного доступа; ограничение до минимума числа лиц, имеющих доступ к ЯМ и ЯУ; требование предварительной проверки надежности всех лиц, которым разрешен регулярный доступ к ЯМ или на ЯУ. При этом, если взять за единицу необходимый уровень обеспечения безопасности, то чем несовершеннее техника, тем выше должна быть степень сознательности, компетентности, ответственности персонала или, другими словами, были **созданы условия, при которых человеческий фактор перекрывал бы техническую отсталость;**

- последний период — **выведение из эксплуатации**. Мы стоим на пороге этого процесса, но он не за горами и для других АЭС Украины. Учитывая, что ЧАЭС за весь период эксплуатации в соответствии с проектным решением хранит отработанное ядерное топливо в ХОЯТе на площадке, то понятно, что этот объект и после выгрузки топлива из реакторов и бассейнов выдержки будет представлять потенциальную опасность. Если взять во внимание еще и проблемы с **объектом "Укрытие"**, то понятно, что вывод из эксплуатации ЧАЭС только повысит остроту вопроса обеспечения ФЗ этого объекта.

Произошедшие в последние годы изменения могут характеризоваться радикальной переоценкой ценностей в обществе, в том числе и в понимании проблем безопасности. Что же в первую очередь влияет на формирование оперативной обстановки при обеспечении ФЗ?

Во-первых, **политические факторы**: изменение геополитической обстановки вследствие фундаментальных перемен во многих регионах мира и стран СНГ; становление государственности на основе принципов демократии, законности, информационной открытости; расширение международного сотрудничества при условии максимальной открытости сторон; низкий уровень политической, правовой и информационной культуры в обществе и др.;

Во-вторых, **социально-экономические факторы**: трудности переходного периода к рыночной экономике; падение жизненного уровня подавляющей части населения; рост явной и скрытой безработицы; дезинтеграция прежней социальной структуры; имущественная поляризация в обществе; эскалация преступности, наркомании, алкоголизма, криминализация общественных отношений;

В-третьих, **духовные факторы**: кризис государственной идеологии, деформация системы норм, установок, ценностей и др.

Кроме того, неожиданно высветилась проблема безопасности энергетического комплекса — **неконтролируемые процессы**, такие как неплатежи, задолженность по зарплате за несколько месяцев оказывают весьма пагубное влияние на уровень безопасности.

Понятно, что в этой сложной обстановке роль человека существенно возрастает. Действительно, когда нет денег на ремонт, топливо, наибольшая опасность скрывается в ситуациях, когда необходимо принять решение — остановить работу оборудования при наличии отклонений в его функционировании или продолжать работать несмотря на риск.

Незнание вышеуказанных факторов или их необъективный (неполный) учет является одной из основных причин непринятия своевременных мер по профилактике нарушений дисциплины, снижения уровня работоспособности специалистов, возникновения конфликтных ситуаций, проявления затрудненной адаптации к повышенным нагрузкам, психологической несовместимости персонала, что в конечном итоге может привести к отрицательным непоправимым последствиям.

Таким образом, содержание и степень безопасности общества в целом и каждого человека в отдельности находятся в прямой зависимости от функционирования всех структур общества, а прежде всего экономической, политической, социальной и правовой. **В результате система самой физической защиты приобретает сложную структуру.**

Приведенные данные очень важны при раскрытии понятия "физическая защита" — physical protection. Это понятие, как известно, предусматривает функции обеспечения безопасной эксплуатации с точки зрения устойчивости от саботажа, в том числе, и такую важнейшую функцию, как охрана, т.е. недопущение несанкционированного проникновения на охраняемую территорию и в помещения ядерной установки, предотвращение или сведение к минимуму возможного негативного воздействия, которое может прямо или косвенно создать опасность для окружающей среды, жизни или здоровья человека в результате воздействия радиации.

Таким образом, ни у кого не возникает сомнения в том, что состояние безопасности ядерных объектов всецело **зависит от деятельности человека,** как имеющего преступные намерения, так и стоящего на его пути.

Существует достаточно аргументов для утверждения, что обеспечение физической защиты с точки зрения человеческого фактора является основой для успешного решения проблемы безопасности в целом.

Основополагающие документы, регламентирующие основы нераспространения ядерных материалов: "Конвенция о физической защите ядерного материала", пересмотр которой сегодня осуществляется под эгидой МАГАТЭ, и Рекомендации МАГАТЭ INFCIRC/ 225/Rev.4 — являются своего рода мерилом уровня обеспечения ФЗ и распространяются на все ядерные установки и ядерные материалы.

Кроме того, Конвенция предлагает считать уголовными правонарушениями определенные действия по незаконному использованию или угрозы незаконного использования ядерных материалов с целью нанесения ущерба населению.

Этими же документами предусматривается разработка **национальной системы** ФЗ и **оценка государством угрозы** несанкционированного изъятия ядерных материалов. Государство должно **постоянно** анализировать угрозу и оценивать последствия любых изменений этой угрозы для уровней и методов ФЗ.

В отношении ядерных установок, которые могут стать объектом саботажа, должны быть осуществлены соответствующие меры ФЗ независимо от категории содержащихся в них ядерных материалов. Акт ядерного саботажа может создать радиологическую угрозу для населения.

Итак, мы видим, что Конвенция и Рекомендации МАГАТЭ придают большое значение именно человеческому фактору как основному носителю функций несанкционированных действий или деятельности по их предотвращению.

Учитывая то, что ядерный терроризм не имеет статистики, при рассмотрении того или иного варианта угроз исходят из предполагаемого сценария действий террористов. Вероятная ядерная мистификация, которая не может нанести реального вреда оборудованию, если хорошо преподнесена, может внести панику, нарушить нормальное функционирование предприятия или оказать другое негативное влияние.

Однако, имеющаяся открытая информация свидетельствует о том, что большинство террористических актов, включая и ядерное принуждение, являются воздействием на общественное мнение. Даже в случае умышленного саботажа результатом может быть неплановая, но штатная остановка реактора без всякой опасности оборудованию и окружающей среде, исключающая распространение радиоактивности.

Хотя действительный эффект от физического ущерба или разрушения может быть пренебрежительно мал или отсутствовать, психологический удар или воздействие на общественность или позицию правительства и мнение относительно АЭС может быть изменено в худшую сторону.

Такие факты, как нарушение защитного периметра, звонки с ядерными угрозами, стрельба по охране или оборудованию будет безусловно влиять на эксплуатацию. Но главной целью в этих случаях является пропаганда (например, выставить руководство станции и правительство неспособными обеспечить должную безопасность и таким образом разрушить надежды на лучшее мнение общества об АЭС), а не разрушение, захват или причинение кому-либо вреда. Такие "демонстрационные" нападения полностью никогда нельзя предотвратить, тем не менее, они также важны, угрожают безопасности и могут произвести немедленный драматический эффект..

Вместе с тем, имеющийся опыт показывает, что террористы, как и другие шантажисты, стараются не делать угроз. Внутренняя активность и решимость заставляет террористические группы совершенствовать тактику, наращивать насилие. Потенциальный вред могут представлять сценарии захвата террористами заложников, как это неоднократно бывает при шантаже с летательными аппаратами, причем большинство неудач возникает не из-за ошибок технических систем, а из-за ошибок людей; не потому, что не установлен порядок действий, а потому, что люди ему не следуют.

Ни одна организация не может работать без доверия людям на всех уровнях. Проводимые из соображений безопасности найм, охрана, контроль, регистрация людей могут стать настолько обременительны, что будут препятствовать нормальной эксплуатации оборудования. Полной безопасности добиться невозможно.

Чтобы всесторонне оценить значение терроризма, следует учесть политические, моральные и практические соображения. Трудности как предупреждения, так и защиты против весьма разнообразных угроз, которые понимаются под "ядерным терроризмом", подтверждаются различием подходов, используемых в разных странах для защиты АЭС. Однако из-за отсутствия возможности оценить угрозу принимается такой подход — "мы не знаем, является ли это угрозой, но лучше считать, что да". Поэтому при построении системы физической защиты во многих странах (Франция, Канада и др.) охрана даже не вооружена.

Однако, в последнее время при решении задач обеспечения физической защиты чаша весов склоняется к необходимости видеть, в первую очередь, конкретного человека, искать пути профилактики возможных проявлений, недопущения возникновения условий для негативных акций, а не делать ставку на силу, к которой необходимо прибегать как к крайней мере.

С учетом всего сказанного выше, нами была поставлена задача — насколько это возможно в современных условиях, получать объективную информацию о намерениях и реальности высказываемых угроз. С этой целью было решено в качестве носителя требуемой информации использовать речевой канал. Здесь же, как прикладная задача, должна быть обеспечена возможность оказания положительного воздействия на шантажиста с целью склонения его к отказу от преступных намерений. В этом плане у нас имеется положительный опыт.

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QUESTIONS AND ANSWERS

Y. Volodin (Russia): NPPs tend to be well protected but are dangerous from the viewpoint of risk of radiological consequences. How do you apply human factors in developing the DBT for an NPP, where the human error value is normally calculated as 50% for an operator and 100% for a terrorist?

P. Ivanov (Ukraine): There is no question that for the DBT, human error would be estimated at 100% for an NPP.

ASSESSMENT OF PHYSICAL PROTECTION SYSTEMS: EVA METHOD

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Abstract. "To detect then delay the progression of a potential adversary in order to have time for interception before he reaches his target" is a concept as old as the hills that is sometimes also called "defense in depth". While this physical protection principle is simple, the development of such systems sometimes is not. The analyst, who does not want to find out to his cost that his facility is vulnerable, then has to face the tricky problem of assessment. For this reason, CEA developed the EVA method, which allows demonstrating that "the adversary would actually be intercepted before reaching his target". With regard to the protection of nuclear materials, in 1995, the regulatory authority notified its approval for application of the EVA method in security surveys for CEA facilities.

1. INTRODUCTION

The CEA's missions, in such different activities as nuclear, defense, high technologies and associated regulatory requirements make it necessary to develop a strategy in the field of physical protection.

More specially, enterprises holding nuclear materials are governed by Law No. 80-572 from July 25, 1980 relating to the protection and control of nuclear materials. The holding permit delivered by the regulatory authority closely depends on their protection by the operator.

Decree No. 81-512 from May 12, 1981 relating to the protection and control of nuclear materials, defines their classification in accordance with their nature, weight, isotopic concentration, irradiation condition. With regard to category I materials, the nuclear operator has to demonstrate, via a security study, that potential adversaries could not steal them.

To meet this requirement, we developed methods for assessing the vulnerability of the physical protection system in our facilities.

EVA stands for "Evaluation de la Vulnérabilité des Accès" (Assessment of Access Vulnerability); this method allows handling theft scenarios with the adversaries conducting brutal actions resulting in an immediate intrusion detection.

2. AGGRESSION SCENARIOS CONSIDERED

The selected approach to control theft risk can be compared with those implemented to control other risks within CEA (chemical, biological, radiological, fire, etc.): the first step is to identify unwanted events, in this case theft of materials, and then the identification of the various targets.

The second step is to build up theft scenarios and then to make a selection among these scenarios: protection is not comprehensive but against a limited number of events. For example, the "apple stealer" should be intercepted, but not the "tank". The latter case would be handled by the Army, as this is a war action. The regulatory authority thus has to define the profiles of adversaries against whom industrial operators have the duty to protect the nuclear materials in order to have the right to hold them.

The third step is the analysis of these scenarios and, as the zero-risk does not exist, the facility should possibly be improved until the residual risk becomes acceptable.

This residual risk is managed: its level is maintained in time through the facility maintenance and we prepare to face the unwanted event via crisis drills.

The profiles of aggressors discussed herein are those whose purpose is to steal a large quantity of nuclear materials in a single action and then escape.

3. PHYSICAL PROTECTION SYSTEMS

From the above considerations, the following definition was established: a physical protection system is a set of provisions taken and systems implemented to protect a specified target with an acceptable vulnerability level with regard to well-defined threats in order to avoid unwanted events.

This definition is completed with protection objectives. In this case, the unwanted event is theft, the target consists of nuclear materials and the threats considered are both external and internal aggressors.

This results in a protection strategy: within CEA, the physical protection systems are based on the "defense in depth" principle and the purpose is to detect the aggressors and delay their progression to give time to the response force for interception.

Therefore, various physical barriers are provided between the outdoors of the Centers and nuclear materials: around Centers, a first fence usually determines the "Normal Protection Area", around critical facilities, another stronger fence determines the "Enhanced Protection Area" and inside buildings, the materials are warehoused in stores.

At each physical barrier, accesses are protected and controlled so as to obtain a consistent protection level.

In case of guard alarm, the security agents rapidly respond. Typically, they apply a rising strategy from reconnaissance to check for actual intrusion alarm or false alarm, up to calling for the dog-handling unit while expecting the Gendarme Force in rural areas or the Police in urban areas.

4. ASSESSMENT OF PHYSICAL PROTECTION SYSTEMS WITH THE EVA METHOD

Assessing physical protection systems designed to prevent theft of nuclear materials through a brief and brutal action, consists in determining whether the response force will have time to intercept the aggressors before they can escape.

CEA developed the EVA method for this purpose.

4.1. EVA PRINCIPLE

Its principle may be illustrated by the following scenario (figure 1):

- at time T0 (random selected), an aggressor starts his action,

- at time T4, he is considered as out of reach for the response force.

During his progression,

- at time T1, he triggers an alarm; this alarm is assessed at the Central Alarm Station to check whether this is a real alarm and to match the “response”,
- at time T2, the “response” is initiated,
- at time T3, the response force is in interception position.

Interception is effective if, from detection time T1, the response time T3-T1 is shorter than the time required by the intruder to reach his target T4-T1.

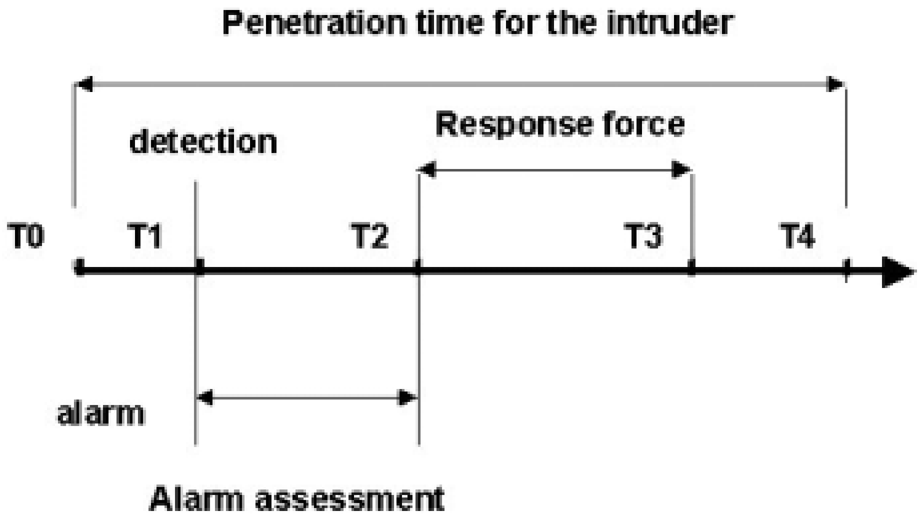

FIG. 1. EVA Method Principle

4.2. EVA MODELING

To perform this assessment, the facility and aggression scenarios are modeled.

The first step is to identify the protection layers representing the various protection barriers around the target.
For example, in current situations, the first protection layer represents the “fence” area, the second layer represents the building surrounding wall, the third protection layer represents the room partitions (walls, floor, ceiling), and the fourth protection layer represents the partition of the cabinet housing the target.

The second step is the inventory of protection elements representing the ways through that aggressors might follow to overcome the protection barriers.

For example, doors, windows, roof tiles, ventilation ducts, technical galleries under facilities are current protection elements.

The third step is the selection of the type of attack conducted by the aggressors to overcome the ways through. It depends on their strategy, which can be either forced way through if they want to privilege time T4 – T1, or clandestine way through if they can delay the detection time T1. It also depends on the status of intrusion sensors and thus on the time of the day and presence of the facility personnel or not.

Practically, several scenarios have to be drafted to incorporate these various aspects.

When this scriptwriter task is completed, the fourth step is to quantify the protection elements to convert them into “mathematical entities” representing the five parameters to be incorporated:

- the delay before detection, which corresponds to the time required for the aggressors to force an obstacle before the alarm is triggered;
- the detection probability, which depends on the type of sensor and mainly, on the operating conditions;
- the delay after detection, which is the time required for the aggressors to reach the next obstacle;
- the response time, which is typically of some minutes;
- the number of the next protection layer, to determine the various possible paths for the aggressors.

The fifth step is the calculation of the protection level indicators for the facility under survey. Results are presented as a classification of the various paths providing access to the target, in decreasing vulnerability order. Each path or scenario is more specially characterized by:

- the aggressor interception probability;
- the margin or delay of the response force.

Other indicators provide additional information, namely:

- the aggressor detection probability;
- the critical detection point.

The critical detection point is the last protection element before detecting the adversary way along a given path to enable interception.

5. ASSESSMENT OF THE PHYSICAL PROTECTION SYSTEM COMPONENTS

In our own Physical Protection Laboratory, tests are conducted to measure the parameters of the protection elements:

- the time to overcome the protection barriers; this time more specially depends on the characteristics of the obstacle (structure, material) and aggressor’s tools;
- the detection probability corresponding to the various intrusion sensors and their operating condition.

The laboratory is committed to determine the performances of the physical protection systems in order to demonstrate that the systems implemented meet the regulations. As an expertise tool and information relay for the experience feedback in this area, it enables to advise and assist the operators for drafting technical documents and selecting the protection systems specific to their requirements.

To conduct the tests, the laboratory uses a field of approximately 2.5 ha for outdoor detection systems, and a 250 m^2 hall for indoor detection systems.

Tests are also conducted at CEA, in facilities to be destructed.

Through a cooperation with the Air Force, overcoming tests are conducted by expert commandos.

At present, more than 200 tests (figure 2) have been conducted. The results are capitalized in a computer database.

FIG. 2. Overcoming Test: Attack of a standard door consisting of 2 metal sheets (3 mm thick) Adversary: one aggressor. Techniques: drilling of a manhole (40 cm x 40 cm). Tool: soldering gun. Measured result: time to overcome.

They concern the various standard (fences, doors, windows, walls, …) or specific (special glass, composite-material wall, glove boxes, …) obstacles, and the various intrusion sensors (video detection, UHF barriers, infrared barriers, sensing fences, indoor motion sensors, …) used in the facilities.

The type of overcome (drilling a manhole, climbing, …), the number of intruders, the type of tools characteristic of robbers (soldering guns, crowbars, bolt cutters, fireman hatch, mason hammer, thermal saw, …) or military commandos (high-performance explosives, …) are the currently incorporated parameters.

Outdoors, nearly all the systems available were tested. Their performances are assessed considering environmental nuisances (climate, animal life, flora, and human activities).

Indoor, nuisances are not the same as outdoors (ventilation, heating, operating requirements). The assessment is more specially focused to the deception possibility with regard to the threats defined in the regulations.

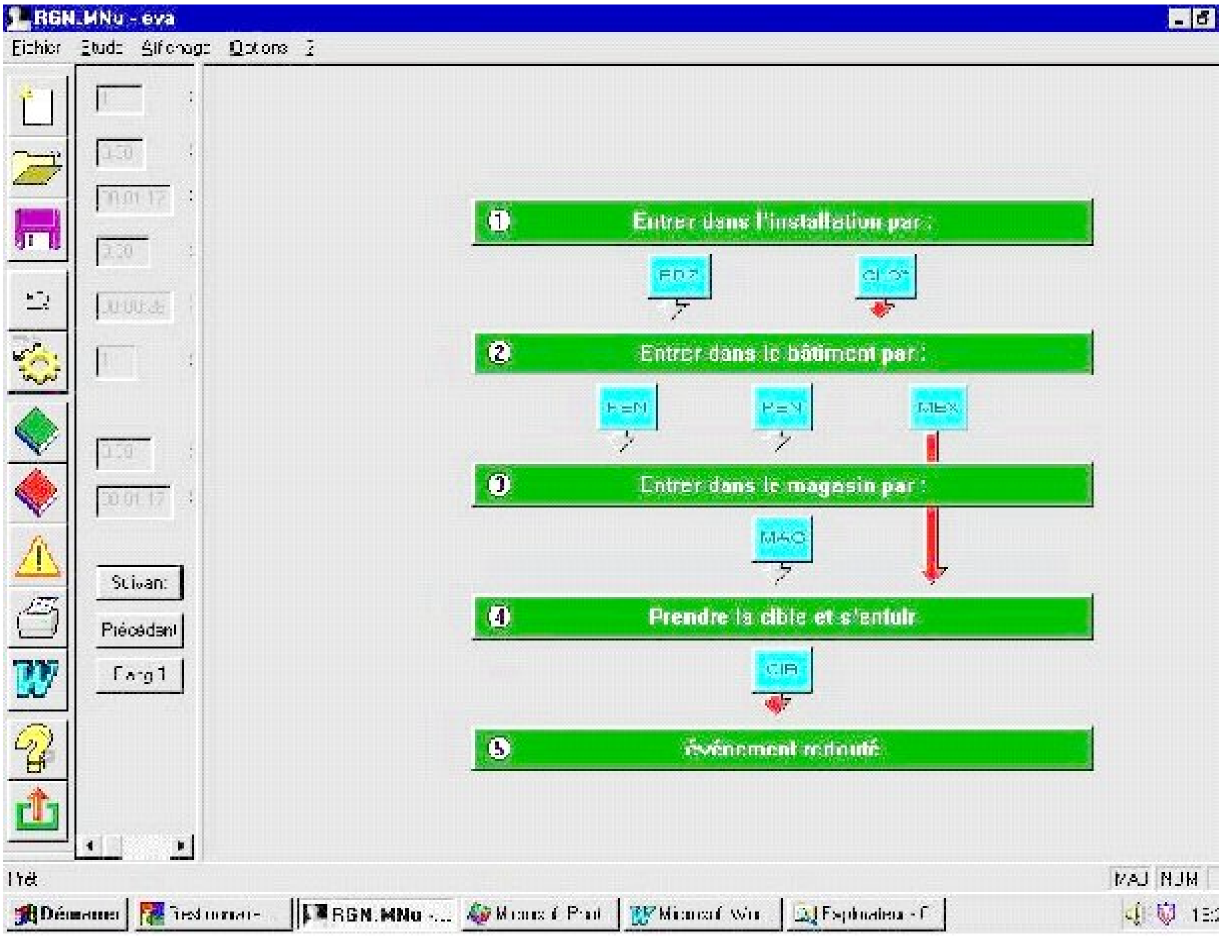

FIG. 3. EVA Software : Modeling a fictitious facility: different paths to reach the target. Aggressor interception probability, margin and delay of the response force, Intrusion detection probability, critical detection point, most vulnerable path.

6. EVA SOFTWARE

CEA developed a software associated with the EVA method (figure 3).

It allows viewing the modeling of the facility under survey and calculating the above mentioned indicators for its physical protection level: interception probability, margin and delay of response, adversary detection probability, and critical detection point.

It automatically classifies the different paths providing access to the target, in decreasing vulnerability order.

It is therefore possible to survey sophisticated facilities leading to several hundreds of different paths to reach the target and the weak points of the protection system are quickly highlighted.

It allows simulating the effect of a possible enhancement of protections in order to optimize the cost-efficiency ratio or the effect of a system degradation and checking the effect of conservation measures.

Running on Windows, on a standard desktop computer, this software is quite user-friendly and highly appreciated for its easy operation and teaching quality for which the indissociable roles of detection, intruder delay by obstacles, response time are clearly viewed.

7. CASE STUDY

To illustrate the use of the EVA method, the survey of vulnerability of a facility holding nuclear materials is described below.

For confidentiality reasons with regard to the information relating to this type of survey, the topology of the premises and le numerical values of physical barrier overcoming times and intrusion detection probability stated in this paragraph are deliberately fictitious.

7.1. DEFINITION OF THE SCENARIO

When assessing the efficiency of a physical protection system, it is essential to know what is to be protected and against which threat.
So, for this simulation,

- **the target** consists of the nuclear materials held in the facility store;
- **the unwanted event** is the theft of these nuclear materials;
- **the threat** is defined by three aggressors, external to the enterprise, equipped with explosives, conventional robbery tools, and possessing information with regard to the operating status of the systems and access procedures.

7.2. DESCRIPTION OF THE PHYSICAL PROTECTION SYSTEM

The various components of the physical protection system or subsystems are accurately inventoried. The systematically include agents, procedures, systems:

- protection barriers (fence, wall, closed doors, ...): the nuclear materials are warehoused in the store backing one of the building outer walls. The building is surrounded by a dual fence separated by a no man's land (figure 4). The walls are made of 20 cm thick solid blocks, …
- intrusion detection: IR. barrier, sensors (door opening, volumetric, broken glass, seismic,...),
- access control,
- local security unit: the guard team ensures a 6 min. response time.

(Selected sample scenario)

During off duty hours (HNO), nobody is present in the facility. The nuclear materials are warehoused in the store.

Three aggressors, external to the enterprise, equipped with explosives, conventional robbery tools, and possessing information with regard to the operating status of the systems and access procedures, reach the fence without being detected and try to penetrate the facility.

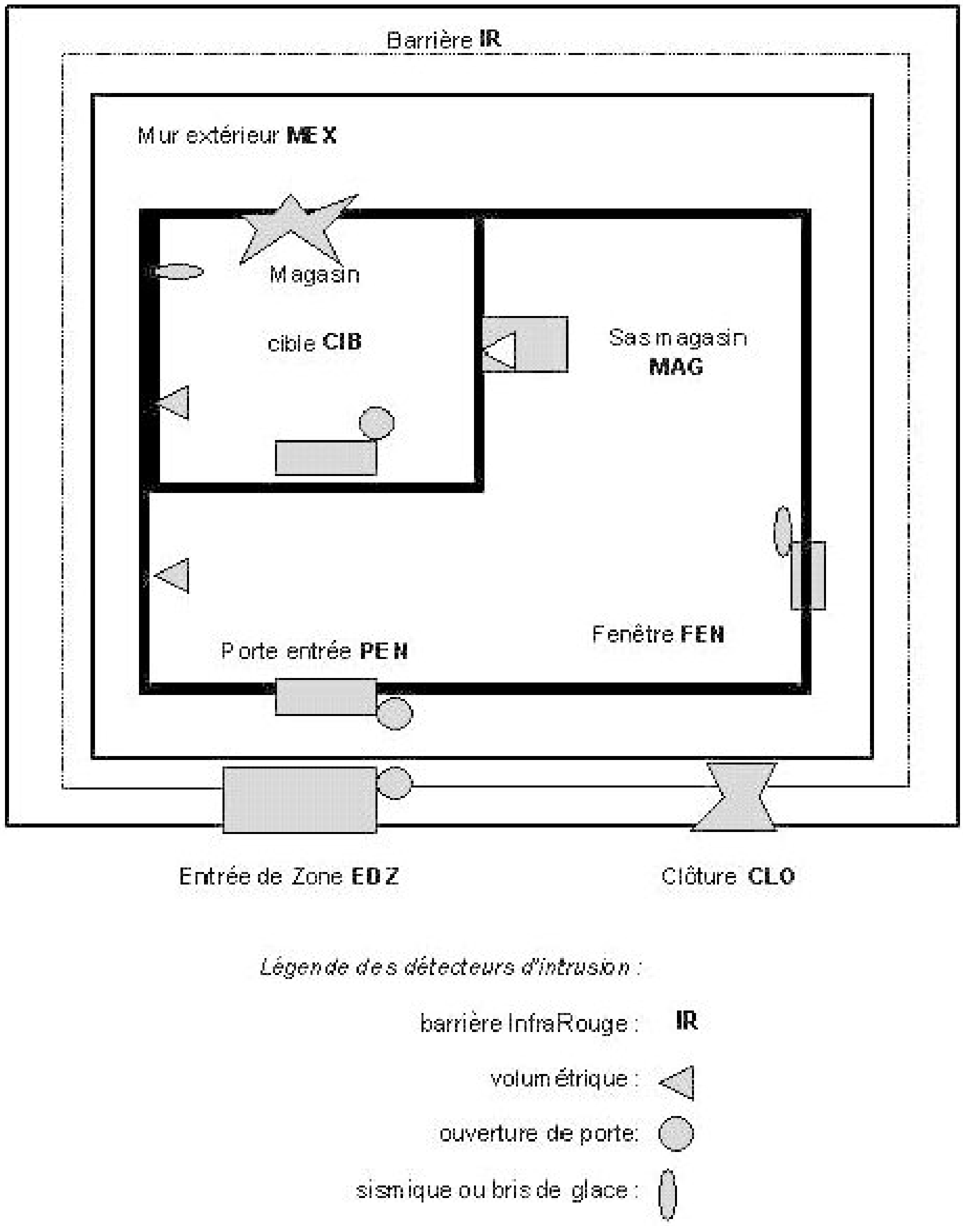

FIG. 4. Diagram of the studied facility.

7.3. PLANT AND ATTACK SCENARIO MODELING

The response time of the Local Security Force is 6 min (measures during drills).

1 – Entering the facility through:

EDZ: the area entrance. Ejection of key nozzle, opening sensor, go to the building, (time before detection: 15 sec., detection probability: 0.9, time after detection: 30 sec., next layer: 2).

CLO: the fence. Climbing the fence and cutting concertinas, infrared barrier, go to the building, (time before detection: 15 sec., detection probability : 0.5, time after detection: 45 sec., next layer: 2).

2 – Entering the building through:

FEN: the window. Cutting the protection grid and breaking the glass, broken glass sensor, go to the store airlock, (time before detection: 1 min 30 sec., detection probability : 0.5, time after detection: 10 sec., next layer: 3).

PEN: the entrance door. Ejection of key nozzle, opening sensor, go to the store airlock, (time before detection: 25 sec., detection probability : 0.5, time after detection: 1 min 55 sec., next layer: 3).

MEX: the outer wall. Installation of the explosive, firing, clearing a way through, seismic sensor, go to the cabinet housing the target (time before detection: 1 min, detection probability: 0.99, time after detection: 1 min 30 sec., next layer: 4).

3 – Entering the store through:

MAG: the store airlock. Forcing the airlock first door, then the second door, volumetric sensor inside the airlock, go to the housing the target (time before detection: 30 sec., detection probability: 0.99, time after detection: 2 min, next layer: 4).

4 – Take the target and escape

CIB: the target. Penetrating the store and cutting the door of the cabinet housing the target, with an electrical saw, opening detector, escape (time before detection: 2 sec., detection probability: 0.8, time after detection: 4 min).

5 – unwanted event – End of action

7.4. CALCULATION OF THE FACILITY VULNERABILITY LEVEL WITH THE EVA SOFTWARE
(for the selected sample scenario)

Name of scenario: RGN, Name of target: Mnu, 03/01/2001 at 13:31:01

ANALYSIS RESULT

The path with rank 1 in the vulnerability classification goes through:
1/CLO2/MEX 3/[s] 4/CIB

The intruder interception probability along this path is	: 0.50
The time margin for intercepting the intruder is	: 1 min 17 s
The probability for intruder not being detected is	: 0.00
The response delay in case of non-interception is	: 28 s
The PDC is on layer	: 1
The PDC probability is	: 0.50
The PDC margin is	: 1 min 17 s

The path with rank 2 in the vulnerability classification goes through:
1/EDZ 2/MEX 3/[s] 4/CIB

The intruder interception probability along this path is	: 0.90
The time margin for intercepting the intruder is	: 1 min 2 s
The probability for intruder not being detected is	: 0.00
The response delay in case of non-interception is	: 28 s
The PDC is on layer	: 1
The PDC probability is	: 0.90
The PDC margin is	: 1 min 2 s

The path with rank 3 in the vulnerability classification goes through:
1/CLO 2/FEN 3/MAG 4/CIB

The intruder interception probability along this path is	: 1.00
The time margin for intercepting the intruder is	: 1 min 39 s
The probability for intruder not being detected is	: 0.00
The response delay in case of non-interception is	: 2 min
The PDC is on layer	: 3
The PDC probability is	: 0.25
The PDC margin is	: 2 s

The path with rank 4 in the vulnerability classification goes through:
1/CLO 2/PEN 3/MAG 4/CIB

The intruder interception probability along this path is	: 1.00
The time margin for intercepting the intruder is	: 2 min 26 s
The probability for intruder not being detected is	: 0.00
The response delay in case of non-interception is	: 2 min
The PDC is on layer	: 3
The PDC probability is	: 0.25
The PDC margin is	: 2 s

The path with rank 5 in the vulnerability classification goes through:
1/EDZ 2/FEN 3/MAG 4/CIB

The intruder interception probability along this path is	: 1.00
The time margin for intercepting the intruder is	: 2 min 28 s
The probability for intruder not being detected is	: 0.00
The response delay in case of non-interception is	: 2 min
The PDC is on layer	: 3
The PDC probability is	: 0.05
The PDC margin is	: 2 s

The path with rank 6 in the vulnerability classification goes through:
1/EDZ 2/PEN 3/MAG 4/CIB

The intruder interception probability along this path is	: 1.00
The time margin for intercepting the intruder is	: 3 min 9 s
The probability for intruder not being detected is	: 0.00
The response delay in case of non-interception is	: 2 min
The PDC is on layer	: 3
The PDC probability is	: 0.05
The PDC margin is	: 2 s

7.5. CONCLUSION
(for the selected sample scenario)

During HNO, the vulnerability level of the facility corresponds to an aggressor detection probability of 50% with a margin for the response force equal to 1 min 17 s along the most vulnerable path going through the fence, the outer wall shared by the facility and the store.

Improvement decisions are usually made jointly by the various actors of the protection system representing the facility operators, the technical departments, the security agents, to incorporate the various requirements that may result.

8. CONCLUSION

The regulation concerning the various malicious acts, and more especially the protection and confinement of nuclear materials, since 1980, generated an increasing requirement for security expertise.

The use of assessment methods for the Physical Protection Systems of the facilities, worked out in this context, generated the development of tools allowing a consistent handling of facility security and reducing the subjective aspect of assessments.

Today, the EVA software gives a new dimension to the survey of physical protection systems, through the simulation principle and provides a decisional aid resource for designers, operators and analysts, which allows maximizing the defense efficiency at the lowest cost.

In addition to the satisfaction of legal obligations, using the analysis methods recommended for CEA, allows a quality assurance approach with regard to physical protection of facilities and hence an ongoing benefit with the experience feedback on the various sites.

Their implementation closely involves the operator in the analysis process. Indeed, the support by site operators, members of the Center Management and Operational Management, maintenance agents, Security agents, all of them well aware, is essential to obtain correct results.

Standardization of the concepts and models on which such methods are based, incites the operators of the various enterprise facilities, concerned by these analyses, to speak the same language and have the same viewpoint on these questions, in short, to acquire a consistent security culture.

QUESTIONS AND ANSWERS

N. Kravchenko (Russia): a) In assessing the effectiveness of a physical protection (PP) system, does EVA take account of possible false alarms in monitoring systems? b) Does EVA enable assessment of the effectiveness of a PP system in a case of two simultaneous attacks on a facility?

J. Bernard (France): a) No, EVA assumes that a plant’s monitoring equipment is working well.

A. Jorda (France): b) The EVA method studies all penetration paths and takes the efficiency of different barriers into account. In France, we can make assessments for two simultaneous malevolent operations.

K. Wager (UK): Could I have a copy of the EVA software?

J. Bernard: Yes, after the presetation we can meet and discuss collaboration.

PHYSICAL PROTECTION AGAINST SABOTAGE

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Abstract. INFCIRC 225 Rev. 4 has put more emphasis on physical protection of nuclear material and nuclear facilities against sabotage and has introduced the Design Basis Threat, DBT, as key element of the states physical protection system. By using the DBT the level of physical protection of nuclear material during use, storage, transport and of nuclear facilities is determined. More than the physical protection against unauthorised removal the physical protection against sabotage has interfaces with the nuclear safety field, particularly the physical protection of nuclear facilities. In order to reach the intended level of physical protection a common understanding of DBT, of its role in the regulatory system, the threat behind and its intention, a consensus among all parties involved in the field of physical protection is essential.

1. INTRODUCTION

Following INFCIRC 225 Rev.4 [1] the design basis threat is developed from an evaluation by the State of the threat of unauthorised removal of nuclear material and of sabotage of nuclear material and nuclear facilities. Even though many of the credible threats are global the DBT is a specific development of that State. Caused by the differences in States perceived design basis threats, culture, legal systems and history, there are variations in physical protection practices between different States which are reasonable and necessary.

It is a common responsibility of all States to care for a sufficient protection of citizens and environment against the potential hazards involved with the use, storage and transport of nuclear material and the operation of nuclear facilities. In order to discharge this responsibility before granting a license States have not only to prove that the defined demands on safety and on physical protection have been met. The State has also to provide suitable conditions for a safe and secured use, storage and transport of nuclear material as well as for the operation of nuclear facilities. Both the demands on physical protection and the condition are results respectively influencing factors of DBT. The DBT can be used as a tool to organise the tasks of different bodies and organisations and can also be used as a tool to delegate functions and responsibilities in the physical protection. The DBT is the more than a table giving the number, tools and explosives of potential aggressors developed from the states threat assessment.

The physical protection against sabotage is used as an example to demonstrate different possible views on DBT and its application.

2. ROLE OF DESIGN BASIS THREAT IN GERMANY

Most of the nuclear activities in Germany are undertaken by private enterprises. Only the federal storage for nuclear material is and a future final disposal facility will be operated by a federal authority which is the Federal Office of Radiation Protection. The German State Authorities provide conditions for a safe and secure use, storage, transport and operation of nuclear material respectively nuclear facilities but no onsite physical protection. The licensee is required to provide physical protection measures in order to control the situation during a potential attempt of unauthorised removal of nuclear material or of sabotage in a way that enables the response forces adequately.

The response on a malevolent act is provided in Germany by the Police which has committed itself to be onsite 30 minutes after being alarmed to take over the responsibility of adequate response to any attack. The DBT document [2] and the existing guidelines e.g. [3] are the basis for the licensees to work out physical protection plans and design the physical protection measures which will provide the required situation for the responding Police forces. The required suitable situation for the Police resulted in the requirement that within the response time potential intruders have not intruded in a building which has to be protected because of the equipment or the material inside.

The DBT is used as a tool to define the sharing of responsibilities for physical protection between State bodies and the license holder respectively the operator. The “necessary physical protection” which is required in the German Atomic Energy Act [4] as a prerequisite in the licensing procedure is ensured if the defined DBT is defeated by these measures.

The German DBT document [2] is a document concerning the technical physical protection measures and is used to qualify measures as appropriate to meet the requirements. There is no way of balancing between the measures to compensate e.g. a low detection probability by a better delay. A low detection probability cannot be compensated by a better delay because detection is needed in order to limit the methods used in an intrusion attempt. A good detection quality cannot compensate a low quality of delay measures because the response time of the Police forces from offsite will not be changed.

The guard service is an supplementary element in the system of physical protection the licensee/operator has to provide. Both elements provide the preventive basic security.

A practical example how the distribution of responsibilities works is given by the demonstrations on the occasion recently when after a break of several years the first waste transport started from France to the interim storage in Gorleben. Under normal conditions the physical protection of a transport like this would follow the line given by requirements of the transport guideline [5]. In this case not only the number of demonstrators in total, also the number of violent demonstrators was far beyond any number given in the DBT document. Facing the extraordinary number the Police took over the responsibility to ensure the enforcement of a licensed safe and secured transport. The costs for this action were tremendous and were one of the declared objectives of the demonstrators. These costs are not charged to the carrier.

3. APPLICATION OF DBT IN THE PHYSICAL PROTECTION OF SABOTAGE

3.1. DEFINITION OF A DBT

In defining the DBT concerning the protection against unauthorised removal of nuclear material it will be much easier to achieve the necessary consensus among the parties involved than in the field of sabotage protection. An attempt of unauthorised removal commonly called theft has a very clear goal: to take possession of the material. If the attractiveness of a certain material is high enough the threat has sound credibility e.g. underlined by a number of illicit trafficking cases in the past and the international concern about the risk proliferation.

Concerning the physical protection against sabotage the DBT is a more sophisticated definition. There has been no serious act of sabotage nor an attempt of sabotage in the past. The attack of the Hamun sect in the underground station in Japan and the acts of terror supported respectively initiated by people around Ben Laden gave a some lessons what threat might be credible and might be considered in a DBT. The accident in NPP Chernobyl demonstrated dramatically the potential consequences if nuclear power runs out of control. Revision 4 of INFCIRC 225 expresses the grown international concern about the potential consequences of sabotage. INFCIRC 225/Rev.4 gives a definition of "sabotage" and shows a way to elaborate physical protection against sabotage in general. Concerning the protection against unauthorised removal of material the categorisation table provides a basis to set a level of protection. Concerning the protection against sabotage there is no comparable categorisation. It is said that "safety specialists, in close cooperation with physical protection specialists, should evaluate the consequences of malevolent acts, considered in the context of the State's design basis threat, to identify nuclear material, or the minimum complement of equipment, systems or devices to be protected against sabotage".

3.2. COMPLIANCE BASED APPROACH IN GERMANY

The German physical protection System has been developed since the increasing terrorist activities in the 1970ies. From the beginning the protection against Sabotage played an important role in the German system of Physical Protection because most of the facilities are nuclear power plants, NPP. In the beginning the requirements for both, the physical protection against unauthorised removal and against sabotage were defined by "Security Categories". This method of categorisation took into account the attractiveness of the nuclear material for unauthorised removal, which was similar to the categorisation table in INFCIRC 225.

It took also into account the potential radiological consequences of an act of sabotage against the material directly or against a nuclear facility where the material is used or processed. The result of this was that nuclear material of category I was assigned to the same so called security category I as e.g. nuclear power plants while the fresh fuel is in category III of the table in INFCIRC 225. For every facility an evaluation of the possibilities and the potential consequences of a potential release or potential exposure to radiation has been performed in order to assign it to one of the four security categories.

The basis for this evaluation was the material itself and the form of the material, the design of the facility concerned, the perceived threat and the effect on human health in a short-term and a long-term prospect. The idea behind was to assign every "security category" a booklet of demanded measures and features as a design basis in order to have a balanced physical protection for nuclear material and facilities all over in Germany. There was e.g. a booklet for access control, for detection at the perimeter, vehicle barrier etc. The basis of these booklets was a combination of potential consequences respectively the attractiveness of the nuclear material concerned, the attributes and characteristics of potential adversaries (DBT) and considering the state of the art of security technology. The whole set of papers was called the catalogue of security measures.

The application of the catalogue in the physical protection of a NPP was in general as follows: A facility e.g. a NPP was assigned to a security category (here Cat I), safety relevant systems and equipment to an inner area protected by a mechanical barrier providing delay, the information to design an appropriate barrier, with doors and hatches etc, was taken from the barrier booklet for security category I.

One of the advantages of the security measure catalogue was that only the information about the required measures had to be given to the designers and facility operators and not the confidential DBT information which was behind those requirements. There have been several good reasons to change this approach. One was to avoid mixing up the categories in the table contained in the Convention on Physical Protection of Nuclear Material from October 1979 (CPPNM) and the security categories. Another reason was that the system of catalogues turned out to be inflexible and was more and more used as a list for a compliance check, loosing the appropriate relation to the physical protection objectives considering the individual situation of a facility.

3.3. APPROACH BASED ON SPECIFIC PROTECTION OBJECTIVES

The above described security categories are not used anymore. Concerning the physical protection against unauthorised removal the categorisation table of the CPPNM is the basis for the existing guidelines. Concerning the protection against sabotage a calculation of the potential release or the potential exposure to radiation caused by a malevolent act is the basis for the requirements on physical protection.

If the result of that calculation is below a certain threshold value the assigned category corresponding to the table of the CPPNM is the leading factor for the design of the necessary physical protection. This threshold value is given by the radiation protection ordinance [6]. In the case that the result of the calculation is beyond that limit but within a certain bandwidth a balance of the efforts to protect against potential sabotage and the resulting reduction of a calculated release is the basis for required measures. The DBT is of course one of the assumptions of the calculation and so the practice of keeping a balance in a acceptable bandwidth of threshold value is in accordance with the philosophy behind the development of the DBT. Also here the Competent Authority is in the position to decide which remaining risk is an acceptable risk.

For a nuclear power plant with light water reactors the value of a potential release is far beyond the threshold. The highest level of physical protection against sabotage also in this approach is required and covers the risk of an unauthorised removal.

Based on the experiences with the application of the security measure catalogue a guideline e.g. for the physical protection of NPP's with light water reactors [3] was developed during the erection period of the last generation of NPP's in Germany. The idea behind this guideline was to give more explanation in order to achieve broader consensus by a deeper understanding of what is meant by the expression "necessary physical protection" in the Atomic Energy Act [4]. Starting with the general objectives which are similar to those in INFCIRC 225/Rev.4 and the distribution of responsibilities in the system of physical protection between the operator and the Police as the offsite response force specific objectives for the NPP's with the two different reactor types in Germany are defined.

This was done through the identification of certain operation conditions which have to be prevented during a malevolent act by physical protection measures of the operator. In order to achieve this specific objective and to provide the required suitable conditions for the off site response force a vulnerability analysis identified a number of buildings are identified have to be protected against intrusion attempts of aggressors from outside. Concerning the protection against malevolent acts from inside by a person with authorised access a number of systems has been identified.

In the second part a set of required measures is formulated in a general way that makes clear the purpose of the required measure and leaves enough freedom to find an individual solution to meet the requirement. The DBT document give additional information for the design and the assessment of technical measures. Concerning guard service as a supplementary element in the system of physical measures information about number, equipment, organisation and education is given in a separate guideline [7]. This guideline also contains requirements on weapons and the obligation to use weapons in certain situations.

These measures provide a basic physical protection against attempts of an unauthorised removal and sabotage for normal situation. In the case of situations of increased danger an outline emergency plan [8] defines certain situations and the measures correlated. The principle is that with increasing threat the police will give more support to the physical protection measures of the operator in order to improve the response to a malevolent act and to shorten the response time.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY; The Physical Protection of Nuclear Material and Nuclear Facilities, INFCIRC 225/Rev.4(corrected), IAEA, Vienna (1999).

[2] DBT: Auslegungsgrundlagen für ortsfeste Einrichtungen der Sicherungskategorie I gegen Störmaßnahmen oder sonstige Einwirkungen Dritter (SEWD), 09. September 1997, VS-Vertr.

[3] Guideline for the Physical Protection of NPP: Richtlinie für den Schutz von Kernkraftwerken mit Leichtwasserreaktoren gegen Störmaßnahmen oder sonstige Einwirkungen Dritter, BMU RS I 3 – 13151-6/14, VS-NfD, 06. December 1995.

[4] Atomic Energy Act: Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren, 23. December 1959, last modification 03. Mai 2000.

[5] Transport guideline: Richtlinie für den Schutz von radioaktiven Stoffen gegen Störmaßnahmen oder sonstige Einwirkungen Dritter bei der Beförderung, BMU RS I 3 – 13 151 – 2/4, 28. Mai 1991.

[6] Radiation Protection Ordinance: Verordnung über den Schutz vor Schäden durch ionisierende Strahlen, 30. June 1989, last modification 18. August 1997.

[7] Guard Service Guideline: Anforderungen an den Objeksicherungsdienst und an Objektsicherungsbeauftragte in kerntechnischen Anlagen der Sicherungskategorie I, BMI 08. April 1986.

[8] Outline Emergency Plan: Rahmenplan "Sicherung und Schutz kerntechnischer Einrichtungen bei verschärfter Gefahrenlage und konkreter Gefahr", BMU RS I 3 – 13 143/20.2 VS-NfD.

QUESTIONS AND ANSWERS

D. Flory (France): In using the DBT criteria, do you make a sensitivity analysis, possibly extending the threshold, or do you limit your evaluation to the strict DBT values.

A. Hagemann (Germany): The DBT values are the basis for evaluation used for the design of technical measures. In the light of the evaluation results and also of the potential consequences of the threat, the operator may be prepared to invest more effort and capital to extend the DBT threshold.

Y. Volodin (Russia): How often and for what reasons is the operator required to revise the DBT?

A. Hagemann: There is no schedule to revise the DBT but the appearance of new threats would lead to the competent authorities considering response and how to reflect this in the DBT.

G. Bunn (USA): Do you have the same DBT for sabotage of ordinary nuclear reactors as you do for facilities storing weapon usable Category I nuclear material?

A. Hagemann: There is one DBT for all facilities, set at Category I, the highest level. However, the measures and detailed planning may be different.

R. Warren (USA): Is the DBT for transportation different from that for fixed sites?

A. Hagemann: Yes. The differences are compensated by response capabilities (e.g. off-site police).

PHYSICAL PROTECTION

(Session 3)

Chairperson

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Keynote Address

STRENGTHENING GLOBAL PHYSICAL PROTECTION PRACTICES: GAINING BETTER INFORMATION ON NATIONAL PRACTICES FOR PROTECTION OF NUCLEAR MATERIAL

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Abstract. There are no international requirements for protecting nuclear material in domestic use, storage or transport. Experts from many countries meeting in Vienna are considering establishing such international requirements. Meanwhile, the foundation for international norms of physical protection is IAEA INFCIRC 225/Rev.4, consensus recommendations for protection systems. In addition to establishing international requirements, practices of physical protection can be strengthened by exchanges of information, for example, comparing recommended standards with the actual practices of states. The more system operators can learn about the threats other states have faced and the successful practices others have used to defend against these threats, the more physical protection is likely to be improved. Research comparing practices shows wide variation from state to state. Better means are needed to systematize exchanges of information on state standards and practices. Conferences such as this one are useful to that end, but they may be too infrequent and too technical for policy makers and others responsible for funding physical protection systems. As a review of two past physical protection conferences has shown, they often do not produce sufficient data in the same subject areas to produce detailed comparisons between very many states. Training is another way to improve physical protection practices. Existing physical protection courses and workshops are very useful, but they do not reach all the audiences that need training. Some regions of the world and some specialized audiences have been left out. For example, one-day seminars that teach basics may be useful for policy makers. More lengthy courses are appropriate for those that design and operate protection systems. Indeed, physical protection practices can be improved by strengthening training for all of those responsible for physical protection, as the experts meeting in Vienna have recommended.

STRENGTHENING THE INTERNATIONAL REGIME FOR SECURITY OF NUCLEAR MATERIALS

There are no international requirements for protecting weapon-usable nuclear material in domestic use, storage or transport. The Convention on Physical Protection of Nuclear Materials sets international requirements for security of nuclear materials in international transport, but not for those within a country that are not in international transport. Moreover, unlike Non-Proliferation Treaty safeguards, the Convention, even in the case of international transport, does not require that parties provide information to the IAEA on how they protect materials from theft or sabotage. It does, however, call on parties to “cooperate and consult as appropriate with each other directly or through international organizations” with respect to the “design, maintenance or improvement” of their physical protection systems for international transport (Art.5.3).

As IAEA Director General ElBaradei has said, “it is not a matter of indifference to other States whether and to what extent [physical protection] responsibility is fulfilled” by any state using, storing or transporting nuclear materials (IAEA INFCIRC/225, Revision 4, Corr., 1999, preface). Since 1999, major efforts have been made by experts from many countries to find an acceptable way to amend the Convention on Physical Protection so that it will apply to the domestic use, storage and transport of nuclear material -- so that all states will be better protected. We are advised that progress has been made in Vienna toward achieving a consensus that the Convention should be amended to establish treaty standards for nuclear material in domestic use, storage and transport.

Today, the foundation for domestic physical protection norms is IAEA INFCIRC/225, Rev. 4. Like the Convention, it calls for states to "cooperate and consult" and "exchange information" on "physical protection techniques and practices, either directly or through international organizations" (INFCIRC/225, Rev.4, para. 1.3). But its norms are only recommendations -- recommendations that are not always followed.

Though both INFCIRC/225 and the Convention ask states to "cooperate and consult" on their physical protection practices, establishing a specific reporting *requirement* appears unattainable in the current negotiations for revision of the Convention. Yet, the more system operators can learn about the protection practices of other operators that have proved successful, the more likely they are to improve their physical protection practices where those practices are weak. The reasons for refusing to provide detailed information are of course that its release could benefit terrorists, thieves or hostile states desiring to steal or sabotage the protected nuclear material. The first purpose of this paper is to examine to what extent information on a state's physical protection practices is sensitive in this sense. What information can be shared and what cannot be?. The unquantifiable but essential trade-off is between the enhanced international security that would come from effective, universally applied standards and the effect they should have to deter terrorists and thieves, on the one hand, and, on the other, the reduced security that could result from making descriptions of the details of protective systems public and thus available to terrorists or thieves.

INFCIRC/225, Rev. 4 suggests that the most sensitive information is that "addressing possible vulnerabilities in physical protection systems as it could indicate means of successfully removing nuclear material or of carrying out sabotage" (para. 4.3.2). Are there other kinds of information that are not so sensitive, that could be shared in some manner?

PROVIDING INFORMATION THAT MAY NOT BE SENSITIVE

There are already some bilateral and multilateral exchanges of information on security practices. Many bilateral agreements suggest that INFCIRC/225 should be followed for physical protection. A Nuclear Suppliers Guidelines' annex suggests that INCIRC/225 (no reference to which revision) is a "useful basis for guiding recipient States in designing a system of physical protection measures and procedures" [1]. Some suppliers also ask recipients to provide information on what the recipients do to provide protection. Some go further. For example, the USA often asks for periodic inspections of the security measures used to protect nuclear material or facilities it has supplied. At physical protection training courses, information on actual physical protection practices is often shared.

In the IAEA's International Physical Protection Advisory Service (IPPAS), experts from several countries visit facilities that request their support for evaluating existing protection and provide advice on possible improvements. Other IAEA technical assistance and peer review programs, as well as bilateral nuclear assistance efforts, often result in similar disclosures of information. This is not generally available to the public — only to the experts and IAEA employees who participate. The information appears to be treated as "safeguards confidential" by the IAEA.

International conferences like this one and national conferences like those conducted by the US Institute of Nuclear Materials Management provide a great deal of information to participants on how particular states protect their nuclear materials. Experts give the information voluntarily.

At Stanford University, we have a project to examine in more detail what kinds of information on physical protection might be provided on either a limited confidential or a public basis. In 1999, we published a comparison of physical protection practices based upon information from the proceedings of two 1997 conferences on physical protection, one at Stanford, and one at the IAEA. [2, 3, 4] In the Stanford conference, we asked experts from other countries to describe their physical protection policies and practices. The degree of disclosure varied from country to country. At the later IAEA conference on physical protection, there was greater variation in the subject matter and amount of disclosure, in part because the subjects on which information was requested were more varied and general. While the amount of information provided from both conferences varied from country to country, some useful information was available from each of 19 important countries.

The Stanford review contains, for example, some data on the human side of physical protection, one of the subjects for discussion at this conference. For example, Japan said that, in planning its security for nuclear material, it did not include any insider threat. In addition, Japan was one of two countries that did not require some clearance check or vetting for its personnel that handle weapon-usable nuclear material. The Japanese believed that employees in Japan almost always remained in a job for a lifetime and that employer experience and neighborhood registrations would reveal any problems. The Japanese practice may have changed since the adoption of Revision 4 of INFCIRC/225. Revision 4, which now calls for "predetermination of the trustworthiness of all individuals permitted unescorted access to nuclear material or facilities" (para 6.1.2). The point here is that the Japanese experts were quite prepared to explain and justify their unusual practice to other experts.

In the Stanford survey, the nature of vetting in other countries varied from checks of criminal files and previous employer records to that plus background investigations including interviews of neighbors and associates. There is no international standard for vetting. We are not urging one. However, does the willingness to provide information on this subject to Stanford and IAEA meetings suggest that periodic reporting by Convention parties on clearance procedures may be feasible?

Another variation identified in the review was the information provided on outsider threats. Only 5 of the 19 countries mentioned sabotage as a threat. Ten listed terrorism and five listed demonstrations by the general public. Eight did not provide information on any threat. Given the importance now given to "design basis threats" by Revision 4 of INFCIRC/225, more international exchange of information on threat perceptions would seem to be useful. The subject of "design basis threats" is on the agenda of this conference. We concur with those who drafted the agenda that this subject could be discussed successfully without revealing sensitive information.

Threats are, of course, not uniform across the globe. There may now be less variation than suggested by the limited information we received from our sample of 19 countries. After our data was collected, INFCIRC/225 was amended by consensus to emphasize design basis threats and to deal with sabotage to nuclear reactors or nuclear material. Is there now a broader consensus that sabotage is a threat to more than few countries? From our sample's 5 out of 19 response, one might assume that sabotage was not perceived as a problem in 1997 to many countries with nuclear reactors or material. Given the changes in INFCIRC/225, would it be useful to have some regularized way of exchanging information on design basis threats?

Given the major increase in truck bomb attacks, is protection against them in order for nuclear reactors, spent fuel storage pools, and nuclear material storage sites? High-explosive bombs in a truck, car or boat were used in recent terrorist attacks on US facilities: an international trade center in New York City, a government building in Oklahoma City, two US embassies in Africa, a US troop residence in Saudi Arabia; and a US naval vessel in a port in Yemen. (There has been at least one truck attack on a US nuclear reactor but it was by a deranged person, not a terrorist.) Other countries are presumably not immune to truck bomb attacks. But Bulgaria and Japan were the only countries in our limited survey that mentioned the need for protection from truck bomb threats.

The absence of information from other countries does not mean they had done nothing to deal with this threat. But it would be useful to have some way of exchanging information more regularly on threats. Obviously conferences like this one are important for information exchange. But conferences on physical protection are expensive and are not held frequently. Since physical protection practices are supposed to be directly related to identified threats, would not a regular exchange of information on threats be useful, perhaps submitted to the IAEA? Would revealing information on threats perceived by a country compromise that country's security for its nuclear material? In what cases could perceived threats be reported to the IAEA on a "safeguards confidential" basis and be summarized by the IAEA region by region without naming which states perceived which kinds of threats?

Another area where exchanging information could be useful is on regulatory systems: laws, regulations and facility licensing practices that relate to physical protection. Like "human factors" and "design basis threats", "legal and regulatory infrastructures" are on the list of topics for this conference. This is appropriate because regulatory structures and laws are not only an important element of physical protection but they are usually public.

The Convention requires each party to apply specific levels of protection for international transport "within the framework of its national law" (Art. 4.4). It also says that a party "shall inform the depositary [the IAEA] of its laws and regulations which give effect to this Convention" (Art. 14.1). Since the Convention does not now apply to domestic physical protection, reports on domestic regulatory systems do not appear to be called for by this language. Apparently the reports that states have submitted have dealt with adoption of the specific criminal statutes called for by the Convention (Arts. 7 and 8), not with statutes or regulations on physical protection practices. A majority of parties to the Convention have not yet filed reports on their adoption of the required criminal legislation. Would an IAEA questionnaire asking for reports on legislation and regulations be feasible for parties to the Convention if the questionnaire were prepared on a consensus basis by a group of country experts?

Given the lack of any international inspections for physical protection, national inspections of facilities are clearly important to achieving effective security in fact. Revision 4 of INFCIRC/225 says states should take responsibility for verifying compliance with their physical protection regulatory requirements "through periodic inspections." (para 4.3.3.1) It does not recommend whether the inspecting authority should be independent of the operator of the facility, or whether the inspections may be announced beforehand giving the facility operators time to prepare for the inspection. These seem relevant questions the answer to which may or may not appear in legislation and regulations.

Ten of the nineteen countries in our Stanford survey reported national inspections, but only two mentioned unannounced inspections. Inspection requirements and other national regulations and legislation on physical protection would seem to be another area where cooperative reporting should be possible without breaching security sensitivities. Indeed, when International Physical Protection Advisory Service experts go to a country to provide assistance in improving physical protection, the IAEA often sends a lawyer to help draft national legislation or regulations establishing physical protection standards for adoption by the government.

To see whether it is possible to obtain better information from other countries on physical protection practices, the Stanford project developed a questionnaire based on INFCIRC/225, Revision 4 standards. In addition, we prepared a confidentiality agreement promising not to make the information public without the permission of the providers of the information. We hoped we could eventually publish some of the information in summarized form, but without disclosing what country it came from, a method sometimes used by the IAEA.

So far, several countries have joined us by signing the confidentiality agreement but very few have filled out the questionnaire. Would the results be the same if the IAEA sent out a questionnaire, one based upon consensus drafting? Our questionnaire may be too long and too intrusive. Perhaps a shorter trial questionnaire could be limited, for example, to protection against sabotage to reactors and spent fuel. Information on this may be less sensitive than information on facilities using or storing weapon-usable material. The dangers of truck-bomb or even helicopter terrorism against reactors and spent fuel are probably increasing. Some at the IAEA believe that protection of reactors and spent fuel in relation to the risk of attack tends to be less adequate than that given to facilities where weapon-usable material is used or stored. Cooperative efforts to improve physical protection could be significantly assisted by disclosures of information on what existing concerns and practices actually are. As noted above, INFCIRC/225, Rev.4 calls on parties to cooperate and to exchange information on physical protection techniques and practices. Conferences and workshops are not the only way to do that.

TRAINING AND DEMONSTRATION TECHNOLOGY FOR TRAINING

A key element in strengthening the international physical protection regime is the training of those groups that are involved in providing physical security. Training for these groups is essential if facilities are to be designed, built and operated adequately to deal with the particular threats they face. These groups include the scientists and engineers who design and build the protection facilities as well as the operators who run them. They include the facility managers and the guards, the security forces available to respond to threats, the regulators and even the policy makers responsible for overall management or funding.

The IAEA already helps to organize many different kinds of physical protection courses, including the International Training Course at Albuquerque, New Mexico. It has organized regional training courses in three regions of the world so far. It has been responsible for specialized workshops, for example, on design-basis threats, in several countries. To date, the majority of the specialized workshops have been in Eastern Europe and Central Asia. In addition to the IAEA-organized courses, there are physical training courses at institutes in Russia.

More training is needed. Improving physical protection practices requires more than new computers and buildings, better sensors and stronger fences. IAEA estimates suggest that, of all the funds spent by the IAEA for assistance in physical protection, training has been given only five percent. (The IAEA total does not include the much larger funding level provided in bilateral programs to improve Russian material, protection, accounting and control). Moreover, there are some regional disparities: Much more IAEA assistance and training has gone to Eastern Europe and Central Asia than to the Middle East, Africa, South Asia and the Far East.

With more funds for training, courses could be better tailored to the needs of particular audiences, including audiences not now served. The scientific-technical content of the training could be more focused on the specific requirements of the specific group of trainees already described. For example, high level managers and officials need less "how-to-do-it," information, and guards need not learn how to design a facility.

In cooperation with other academic institutions, Stanford hopes to explore some of the training possibilities for groups that do not already have courses — for example, policy makers responsible for managing or funding physical protection. The experts meeting in Vienna to consider revising the Physical Protection Convention concluded that policy makers needed a course directed at their needs. They would not have to learn how to design a physical protection system, or even how to operate one. But they should know what the threats are and what sort of facilities and practices are needed to meet those threats. They should also review their own national laws and regulations, as well as the international norms, INFCIRC/225, Rev.4 and the Convention on Physical Protection. To propose such a course, Stanford hopes to cooperate with two academic institutions now helping to teach physical protection in Russia, the Monterey Institute of International Studies and the University of Georgia, as well as with two US national labs that work on physical protection, Sandia National Laboratories and the Lawrence Livermore National Laboratory.

A focus of our future effort will be three areas related to training:

(a) *Training assessment questionnaires.* Our first effort to produce a questionnaire based upon INFCIRC/225, Revision 4 has already been described. For training purposes, we propose to draft a new questionnaire that asks questions about a generic threat to a generic nuclear facility. An example would be a questionnaire asking how spent fuel should be protected against a suicidal truck bomber using high explosives in an attempt to spread radioactive materials over the surrounding territory. If a questionnaire of this kind were supplied to the students and an outline of possible countermeasures were provided to the teacher, could teaching be improved? We have found that potential students seem to have more interest in understanding INFCIRC/225 when a specific question is put to them than when they are simply asked to read it. Questionnaires of this type can be prepared for weapon-usable material storage sites, for research or power reactors, or for storage sites for fresh fuel for fast-breeder reactors.

(b) *National case studies.* If case studies were written for generic facilities similar to those that exist in different countries, they could be useful for training. The International Training School in Albuquerque sometimes uses generic nuclear facilities to teach how to apply design-basis threat methodology. We plan a generic case study by US and Russian experts of two comparable facilities in Russia and the USA. If this showed, for example, the protection given a typical power reactor in each country, the information shared between the two countries could be instructive if used in training courses.

(c) *Demonstration computer models.* Visualization of threats and counteractions is an important tool in facilitating understanding of abstract concepts, such as "compliance" based versus "performance" based approaches to physical protection. Several software tools have been developed in the past for evaluation and/or demonstration of physical protection (e.g. EASI, SAVI, ASSESS, ACE-IT, RIST, CMSAC, JTS, JCATS). Many of these computer tools are available to physical protection experts though access to some is limited. Critics of one or more of these tools have said they are too simplistic or are not sufficiently user friendly. More importantly, if, as is usually the case, the tool's focus is to evaluate a particular facility's security in some detail, it may need to incorporate more sensitive data than is needed for a training tool.

We envisage a training tool along the lines of a modern computer game. For a demonstration-teaching device for students, generic data is sufficient. It does not require all the detailed data that is usually used to evaluate a real facility. With help from two US national laboratories, we have begun research to design such a device.

REFERENCES

[1] NUCLEAR SUPPLIERS GROUP GUIDELINES, ANNEX C, reproduce in CARLTON E. THORNE, A GUIDE TO NUCLEAR EXPORT CONTROLS, 1999-2000, p. NSG Part 1-50.

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Physical Protection of Nuclear Materials: Experience in Regulation, Implementation and Operations, Proceedings of an International Conference, Vienna, 10-14 November 1997 (published 1998).

[3] CENTER FOR INTERNATIONAL SECURITY AND ARMS CONTROL, STANFORD UNIVERSITY; CENTER FOR GLOBAL RESEARCH, LAWRENCE LIVERMORE NATIONAL LABORATORY; AND CENTER FOR NONPROLIERATION STUDIES, MONTEREY INSTITUTE OF INTERNATIONAL STUDIES, A Comparative Approach to the Protection of Fissile Materials, Proceedings of the Workshop at Stanford University, July 28-30, 1997 (published 1998).

[4] HARRINGTON K.J., Physical Protection of Civilian Fissile Material: National Comparisons, Sandia National Laboratories and Stanford Center for International Security and Cooperation, (1999).

QUESTIONS AND ANSWERS

D Flory (France): What is your view on promoting a "security culture" as a motto, a logo?

G. Bunn (USA): It is a good idea — a logo would remind people to focus on PP.

A. Coker (Nigeria): Notwithstanding the need for information exchange, how can sensitive information be safeguarded against abuse by terrorists or rogue States?

G. Bunn: We must learn what can be safely shared, such as information on PP legislation and regulations, methods of screening employees, and estimates of threats.

ROLE AND PLACE OF THE OPERATING BODY (UTILITY) IN THE SYSTEM OF MEASURES TO COMBAT ILLICIT TRAFFICKING OF RADIOACTIVE MATERIALS INCLUDING NUCLEAR MATERIALS

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Abstract. The National Nuclear Energy Generating Company (ENERGOATOM) is responsible for ensuring the physical protection of nuclear materials and nuclear installations in Ukraine. It has established a system of measures aimed at preventing nuclear terrorism and unauthorized withdrawal of nuclear materials. ENERGOATOM, together with the central and local law-enforcement authorities and the Nuclear Regulatory Authority, takes organizational and technical measures to increase the safety, physical protection and security of NPPs. Modernization work involves turning to in-depth defence of protected and particularly important areas of the plants using modern automated systems of technical aids. Currently, all Ukrainian NPPs are carrying out modernization work with funding and assistance from foreign companies and organizations including US DOE.

National Nuclear Energy Generating Company ENERGOATOM is the largest operating body (utility) in Ukraine, which comprises five nuclear power plants. NNEGC ENERGOATOM is an authorized legal person. The personnel of NNEGC ENERGOATOM carries out work in the field of utilization, storage and transportation of radioactive and nuclear materials.

In accordance with the legislative and normative acts applicable in Ukraine as well as in compliance with Ukraine's international commitments NNEGC ENERGOATOM is responsible for ensuring physical protection of nuclear materials and nuclear installations. ENERGOATOM's facilities have an established and functioning system of physical protection measures. This system is aimed at prevention of nuclear terrorism and unauthorized withdrawal of nuclear materials which are the constituents of the state adopted measures to combat illicit trafficking of radioactive materials.

According to the IAEA's assessments the main fields of the state's activity regarding setting up of the measures to combat the illicit trafficking of radioactive materials cover three levels of protection: prevention, detection and response measures.

According to these assessments, physical protection measures taken at Ukraininan NPPs and other nuclear facilities belong to the first protection level, i.e. prevention.

Among the main activities of the Company's administration and NPP's physical protection services is improvement of NPP physical protection system aimed at its better compliance with legislative and normative acts applicable in Ukraine as well as with the international commitments of Ukraine in this field.

With this regard ENERGOATOM together with the central and local law-enforcement authorities and Nuclear Regulatory Authority take organizational and technical measures to increase NPP's safety, physical protection and security.

In 1994 NRA issued 'Rules on Physical Protection of Nuclear Materials and Nuclear Installations, which were then re-published in 1999. According to these rules a utility should turn from the obsolete design solutions on NPP security's organization to in-depth defense of protected and particularly important areas of the plants using modern technical aids (Slide 4).

This work is carried out by the Company together with the NPP's security (regime) services in the framework of implementation of the 'State Program for Establishing and Implementing of the Automated System of Technical Aids of Ukraininan NPPs' Physical Protection against the Threat of Nuclear Terrorism and Unauthorized Withdrawal of Nuclear Materials'.

Currently, all Ukrainian NPPs carry out modernization work. Under conditions of financial difficulties in the power industry NNEGC ENERGOATOM bends its every effort to attract foreign companies and organizations to funding the State Program [for Establishing and Implementing of the Automated System of Technical Aids of Ukraininan NPPs' Physical Protection against the Threat of Nuclear Terrorism and Unauthorized Withdrawal of Nuclear Materials]. This year we assume to have such assistance on the safety improvement programs from the US DOE, European Commission (in the framework of TACIS Program), EBRD.

The life dictates that the problem of rehabilitation of the engineering and technical aids of the NPP physical protection be resolved as soon as possible since it would strengthen the measures aimed at prevention of nuclear terrorism and unauthorized withdrawal of nuclear materials.

For the last two years there were some events at Ukraine's nuclear power plants which can be classified as unauthorized activities towards nuclear installations.

For instance, on December 1, 1999 there was an attempt of penetration by car into the South Ukraine NPP's territory. The intruder was detained by the guards who had to use arms. Later it was found out that the intruder was a mentally sick person and his actions were triggered by the acute condition of his sickness. At the same time, this event allowed to verify in the real conditions how prepared the security and the guards are to act under abnormal conditions. It was also an opportunity to test the impact resistance of the check point gates.

At the same South Ukraine NPP on December 27, 1999 a case of intended damage of the communication cable of electrical supply system of Unit 1 turbine generators resulting in temporary loss of power of this unit took place.

In the course of investigation of this event circumstances in which the law-enforcement bodies participated it was established that this cable was cut by the two workers of South Ukraine NPP electrical department who were in agreement to steal the cable. These workers had access to semi-floor cable facilities and used to perform maintenance work on these facilities. During this crime preparation the intruders preliminary planned to steal a part of the de-energized stand-by cable which was not employed by the unit's power supply system. However, on the day of the theft the criminals made a mistake. Instead of the stand-by cable they intended to steal they cut the nearby communication cable in the turbine generator power supply system that resulted in switching off Unit 1 and significant material damage for the NPP and utility.

In view of extraordinary danger of these unauthorized activities regarding nuclear installations, administration of NNEGC ENERGOATOM and NPPs took cardinal measures to eliminate deficiencies in organization of work with personnel and to follow strictly the requirements of the 'Rules of Physical Protection of Nuclear Materials and Nuclear Installations'. Amendments regarding the necessary minimization of the number of persons allowed to work in the restricted areas and at vulnerable places were integrated in the administrative documents.

Protection against unauthorized access to the process facilities of NPP power units has been improved. After the car intrusion attempt at South Ukraine NPP all NPPs strengthened engineering protection against ramming.

Currently, supported by the Company's administration as well as by the international organizations, NPPs became more active in development and implementation of automated system of technical aids of NPP physical protection against the threat of nuclear terrorism and unauthorized withdrawal of nuclear material.

For instance, owing to the financial support of the US DOE, in 2000 a state-of-the-art system of engineering and technical aids of physical protection was installed and commissioned at Khmelnitsky NPP Unit 1 within several months' period.

Activities on upgrading of technical means of access control system at Unit 3 and Shelter Object are carried out at Chornobyl NPP in the framework of safety improvement programs funded by the EBRD.

NNEGC ENERGOATOM funds similar work at South Ukraine and Zaporizhzhya NPP. The first stage of design works has been completed, equipment is being delivered and technical aids of physical protection are being installed for two units under construction at Khmelnitsky and Rivne NPP (Program Kh2-R4).

In 2000 a joint exercise with law-enforcement authorities was held. The results proved that the Company, NPPs and law enforcement authorities take adequate measures to eliminate deficiencies in physical protection and security of NPPs.

It should be noted that based on the normative and legislative acts recently adopted in Ukraine, the main office of ENERGOATOM, all NPPs and law-enforcement authorities introduced a new procedure of documents' preparation for issuing personnel access permits to specific work. This all can be treated as a definite contribution to establishing in Ukraine of the State system of measures to combat illicit trafficking of radioactive materials.

The practical benefit is that in the course of document preparation for issuing personnel access permits to specific works, the security services can reveal the persons with the criminal background, and drug addicts.

For instance, 5 persons taking drugs were fired in 2000 at Zaporizhzhya NPP.

The above data prove that system of measures taken by NNEGC ENERGOATOM regarding assurance of NPP physical protection is continuously improved and aimed at better compliance with the modern safety requirements as well as with the operating situation on-site and in its surroundings.

Again, I wish to emphasize that ENERGOATOM carries out all NPP physical protection related activities in close cooperation with central and local law-enforcement authorities, and with nuclear regulatory authority, that is the fundamental condition for successful implementation by the state of the measures against illicit trafficking of radioactive materials.

Let me express the confidence that by joint effort we will be able to solve the most complicated problems both in assuring physical protection of our facilities and with setting up of the harmonious state system of measures to combat illicit trafficking of radioactive materials.

QUESTIONS AND ANSWERS

U. Mirsaidov (Tajikistan): a) Does the existence of a national infrastructure enable you to meet your obligations in radiation protection and safety? What are your particular responsibilities? b) Is the legislative basis adequate? c) What are the regulatory organs in the safety area?

I. Kokhan (Ukraine): a) We co-operate with the responsible authorities between the border and the facility, and have implemented prophylactic PP measures at the facility. b) In 1994, Ukraine adapted its PP regulations according to INFCIRC 225. Our latest PP legislation was passed in 2000. c) Officials from the Ministry of the Interior, the customs service and the national intelligence service all co-operate in PP, with the assistance of the army.

JOINT US–RUSSIAN CO-OPERATION TO ENHANCE PROTECTION OF WEAPONS USABLE NUCLEAR MATERIAL IN THE RUSSIAN FEDERATION

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Abstract. In 1995, the US Department of Energy (DOE) was assigned formal responsibility within the US government for directing the Material Protection, Control and Accounting (MPC&A) program under the Office of Nonproliferation and National Security. Improving the protection of nuclear material became the mutual goal of the United States and Russian Federation. Under the MPC&A program, assurances are required to provide evidence to the US Executive and Legislative personnel, oversight personnel, DOE, and the public that the program is cost-effective and meeting proliferation risk reduction goals. By building mutual trust and confidence with our Russian counterparts, progress has been made toward gaining access/assurances at a number of Ministry of the Russian Federation for Atomic Energy (MinAtom) sites. This progress has provided the required assurances at a large number of sites, primarily in the civilian sector of the Russian nuclear complex. However, the issue of access/assurances at a few sites, primarily in the weapons sector of the MinAtom complex, is still tentative.

1. BACKGROUND

In the aftermath of the cold war, the possibility that weapons usable nuclear materials could be stolen or diverted became an international concern. The loss of small amounts of these materials could enable organizations or individuals to build a nuclear weapon. The worldwide proliferation of weapons of mass destruction materialized as one of the most serious risks confronting the United States.

The decline of nuclear material security in Russia, the Newly Independent States (NIS), and the Baltics was corroborated by visits of US personnel to nuclear facilities and official government reports. Russian officials reported several incidents of theft and attempted theft of nuclear related items. US officials also substantiated smuggling incidences involving small amounts of weapons usable nuclear material.

On May 10, 1995, President Clinton and President Yeltsin signed a Joint Statement on Nonproliferation confirming US and Russian obligations to strengthen national and international control, accounting and physical protection of nuclear materials. A Joint Statement was signed by former US Secretary of Energy, Hazel O'Leary, and the Russian Atomic Energy Minister, Viktor Mikhailov, initiating MPC&A upgrades at five key sites within Russia. During this time, the DOE and Gosatomnadzor (the Russian equivalent of the US Nuclear Regulatory Agency) signed an agreement for collaboration that created a national system for safeguarding nuclear material and providing MPC&A upgrades at six additional sites in Russia. The signing of these documents energized the MPC&A program. In September 1995, President Clinton issued a Presidential Decision Directive on "US Policy on Improving Nuclear Material Security in Russia and the Other Newly Independent States" (PDD/NSC-41). This mandate authenticated cooperation with Russia, the NIS and the Baltic States to improve the security of nuclear materials. DOE was assigned responsibility within the US government for directing the MPC&A program. The US national laboratories were tasked by DOE to work directly with the Russian Federation's nuclear institutes to improve MPC&A.

As the program matured, original assumptions and future plans were modified. The original estimate of some 300–400 metric tons of proliferation attractive material in Russia changed significantly.

MPC&A priorities were directed toward reducing the threat to US national security posed by unsecured Russian weapons-usable nuclear material; expanding security upgrades work at sensitive sites; installing physical security and accountancy upgrades appropriate for the level of material attractiveness and the threat of theft; consolidating material into fewer buildings and at fewer sites; converting excess highly enriched uranium (HEU) to low enriched uranium; and encouraging the development of Russian capabilities to operate and sustain security improvements.

In 1998, Russia experienced an economic crisis. As a result of the major political changes within Russia, the goals of the MPC&A program were altered, and it became necessary to prioritize system enhancements for both the short and long-term. United States' project teams began employing a process in which material identification, site description, upgrade design criteria, risk assessment, and threat definition were confronted. Upgrades were developed jointly with Russian site personnel and significance was placed on activities that would reduce both insider and outsider threat.

In October 1999, the MPC&A Agreement between the United States and the Russian Federation was signed. Under this Agreement, both parties agreed to cooperate in the further development of existing MPC&A programs, improve various systems of MPC&A, including transportation of nuclear materials, furnishing appropriate equipment and instruments to facilities within Russia where direct-use nuclear materials are situated, and to prevent illicit movement of nuclear materials. A Joint Coordinating Committee was established to develop Joint Action Plans, implement provisions of the Agreement to resolve outstanding issues, and to make recommendations concerning amendments to the Agreement.

2. EFFECTIVE MPC&A SYSTEM OPERATIONS AND INFRASTRUCTURE SUPPORT

During the economic crisis in Russia, DOE's MPC&A program concluded that protection of nuclear material had to include the proper use of MPC&A equipment and tried to determine to what degree the sites were operating their systems. DOE recognized the need to implement a more extensive effort to address effective operations to achieve long-term sustainability.

An initiative was begun to address the site's ability to operate and sustain its MPC&A systems over the long-term. This initiative was designed to support and aid Russian Federation sites in the operations of US funded MPC&A upgrades/systems by establishing a program wide strategic approach to sustainability. The strategy was to champion joint US/Russian sponsored MPC&A systems, advancing the capability of Russian nuclear sites to operate and maintain their systems. The fundamental objective was to entrust ownership and operations of the MPC&A systems to the Russian nuclear sites. Project teams began to focus on the ability and motivation of personnel operating and maintaining MPC&A equipment. As a result, training and vendor support was earmarked as an important sustainability issue. Ensuring that the sites have an effective cadre of trained operations, maintenance, and response personnel became a high priority.

An effort to support the US project team's decision in selecting equipment also became a priority. The MPC&A program began an equipment assessment and evaluation project to provide US project teams with qualitative and quantitative information on MPC&A equipment. This information, although not dictatorial in nature, provides the necessary tools for US and Russian team members to choose the most suitable, commercially available equipment for the sites. Providing the US and Russian team members the opportunity to select the most suitable equipment contributes to the overall effectiveness of the MPC&A systems operations.

The MPC&A program also assists the Russian Federation in establishing and implementing national and other infrastructure components to support an effective MPC&A system that protects special nuclear material from the threats of nuclear proliferation and nuclear terrorism. This mission is carried out through coordination with other US program elements, such as compliance assurance, regional training and education, secure transportation of nuclear material, and national accounting.

3. ESTABLISHMENT OF NATIONAL NUCLEAR SECURITY ADMINISTRATION

In March 2000, the Secretary of Energy, Bill Richardson, established the National Nuclear Security Administration (NNSA). NNSA was created in response to legislation that required DOE to establish an organization that would fulfill DOE's national security mission. A new Under Secretary and Administrator for NNSA was selected. DOE's Nonproliferation and National Security, Defense Programs, Fissile Materials Disposition, and Naval Reactors were placed within NNSA. Nonproliferation and National Security joined Fissile Materials to form the Office of Defense Nuclear Nonproliferation.

4. MINATOM WEAPONS COMPLEX DIVISION

The MinAtom Weapons Complex Division, Office of International Material Protection and Emergency Cooperation, NN-50, falls under the jurisdiction of the Office of Defense Nuclear Nonproliferation, NNSA. The Division is responsible for MPC&A upgrades at 11 sites, including 4 weapons production enterprises of the Russian Federation nuclear weapons complex. These sites account for more than 500 metric tons of the most highly attractive weapons-usable nuclear material in Russia and involve: processing and storage of nuclear weapons material; weapons research and development; storage of nuclear weapons components; and processing of HEU for commercial applications.

The Division contributes to US national security by improving MPC&A capabilities within the Russian Federation MinAtom weapons complex. Greatest priority is placed on protecting highly attractive material and focusing on areas where there is a large throughput of material because of handling or processing operations.

The Division's main objectives are to continue to expand the relationships between NNSA and MinAtom requiring the Division to implement NNSA MPC&A guidelines and other related NNSA policies and directives at Russian nuclear facilities as a means of assuring the proper categorization of nuclear materials at sites; obtain accurate site descriptions; identify when and where MPC&A upgrades are required; establish appropriate MPC&A upgrade designs to reduce nuclear proliferation; and assure that MPC&A upgrade designs are effectively installed and operated.

5. DOE ISSUED MPC&A ACCESS/ASSURANCE GUIDANCE

In January 2000, DOE issued MPC&A Access/Assurances Guidance stating that assurances are required to provide evidence to the President, Congress, DOE, and the public that improvements are cost-effective and are meeting United States national security goals. Assurances are needed to verify that NNSA/DOE contracted work is properly performed at key stages, and systems and agreed upon procedures are made operational.

Assurances are required for the entire life cycle (from the selection of the equipment, through its installation and finally after it has been operational for a period of time) of MPC&A equipment provided at a site. Implementation of the assurance process is site specific. Each site will most likely require different procedures when implementing the assurance process.

Assurance preparation embodies three parts: (1) US site team briefs Russian site personnel on implementing the assurance process, (2) selection of specific building or facility at site as candidate for MPC&A upgrades, and (3) site personnel must understand the assurance process in order to properly select the specific building or facility within the site where the assurance process will be implemented.

The NNSA/DOE assurance process is comprised of Material Characterization Assurances (to determine if the protected material category justifies the expenditure of MPC&A funds to protect the material); Site Characterization Assurances (establish a baseline protection level for a building or area where material is located and establish parameters upon which MPC&A upgrades will be based); Installation Assurances (to provide proper performance of MPC&A equipment upon arrival, and during set-up, calibration, and preliminary operation at the site); Operational Assurances (provide assurances during the operation of the MPC&A equipment for a negotiated period of time after the equipment has been commissioned and/or operational at each site).

The four NNSA/DOE assurance processes do not have to be addressed serially. They can be developed in parallel. However, all four Assurance process areas must be approved by NNSA/DOE and MinAtom before contracting for MPC&A upgrades can be initiated. Once

all four assurance process areas have been defined for a specific building and have been approved by NNSA/DOE and MinAtom, the preparation of contracts for design and implementation of the MPC&A work for that building can be initiated.

6. FORMATION OF JOINT WORKING GROUP ON ASSURANCES

Secretary Richardson and Minister Adamov established a Task Force on “Access” co-chaired by Ambassador Eileen Malloy and Vladimir Limonayev, Chief of Department of Information, MinAtom in March 2000. The Task Force led to the establishment of a Joint Working Group on Assurances whose members include NNSA/DOE, MinAtom, the All Russian Scientific Research Institute of Experimental Physics (VNIIEF), and the All Russian Scientific Research Institute of Technical Physics (VNIITF) sites.

In June 2000, US and Russian MPC&A teams met at VNIIEF and VNIITF to discuss pilot sites for meeting new NNSA/DOE assurance guidance and to clarify the specific details of NNSA and MinAtom requirements which could impact implementation.

In September 2000, contracts to develop assurance procedures for the pilot sites were signed by US national laboratories, VNIIEF and VNIITF. The Joint Working Group on Assurances agreed to minimize the time required for completion of the pilot contracts. MinAtom was supportive of the joint approach to the assurance issue.

7. PATH FORWARD

Given the sensitivity of the MinAtom sites, NNSA/DOE has made good progress toward enhancing the MPC&A mission by working collaboratively with MinAtom and the Russian facilities on access/assurances and sustainability.

MinAtom is aware of the importance the USA places on the MPC&A program and ensuring MinAtom's long-term ability to operate their systems effectively using their own resources. MinAtom knows that future funding for MPC&A cooperation depends on the successful implementation of the NNSA/DOE MPC&A policies. NNSA/DOE will continue to expand the relationships between NNSA and MinAtom by implementing NNSA MPC&A guidelines and other related NNSA/DOE policies and directives at all Russian nuclear facilities.

8. SUMMARY

NNSA/DOE is optimistic about its future endeavors to continue security upgrades on weapons usable nuclear material at the Russian Federation MinAtom weapons complex, and establish a comprehensive program to foster Russia's ability to operate and sustain installed security upgrades at the site level.

Many productive discussions have been conducted with Russian colleagues on improving nuclear material protection, control and accounting. NNSA/DOE recognizes that it must continue to work in a creative and cooperative manner to move forward on MPC&A negotiations and that a balance must be struck between United States requirements and Russian national security laws.

Based on the past successes, NNSA/DOE believes it is possible to arrive at mutually acceptable approaches to MPC&A and to continue our partnership with the Russian government in implementing security systems and methods that employ modern technology and strict material control and accounting principles.

QUESTIONS AND ANSWERS

M. Maerli (Norway): US–Russian MPC&A upgrades have been hampered by severe access limitations, especially in facilities within the Russian weapon complex. How do you confront these access problems and what is the status of associated negotiations?

P. Cahalane (USA): Access, where permitted, is the preferred means of assurance that the MPC&A equipment systems are cost effective, properly designed and installed and operationally effective. Other forms of assurance are being considered by the US Department of Energy.

R. Steinhäusler (Austria): a) When warranties and service contracts expire, Russian facility operators will have difficulties in sustaining the upgrades. How will the USA address this problem? b) There has been much criticism of the questionable cost effectiveness of having facility upgrades done by US instead of local contractors. What is being done about this?

P. Cahalane: a) The USA is working closely with Russians on sustainability. b) The MPC&A programme includes the use of Russian equipment and labour whenever possible.

A. Hagemann (Germany): What is the basis for Department of Energy's assessment of installed equipment in Russian facilities?

P. Cahalane: US MPC&A experts work closely with site personnel, developing their own technical assessments to determine what equipment/upgrades are appropriate at a given site, assisted — where allowed — by actual walkthroughs with Russian technicians.

Y. Volodin (Russia): Would you elaborate on the financial resources already allocated to Russian nuclear weapon related complexes and on what is expected in the future?

P. Cahalane: Personally, I believe that the future looks good at the sensitive sites. There is good support in Washington for the MPC&A programme, there are good results at key sites and we are committed to co-operation.

THE UK NATIONAL RESPONSE PLAN — AN "ALL RISKS" APPROACH

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Abstract. Under UK law, no single law enforcement body is empowered to address all the issues of illicit trafficking in radioactive substances. The UK Interpol Environmental Crime (Radioactive Substances) Sub-Group ("the sub-group") exists to enable an integrated multi-disciplinary approach to policy development on this problem. It comprises representatives of all relevant UK government departments and agencies, as well as representatives of the UK metals industries, and port associations. The sub-group aims to co-ordinate the policy interests, powers and duties of all the organisations represented by its membership through the development of national response arrangements. The sub-group takes the view that this is not solely a radiation protection problem, and so a wider risk management approach is taken, recognising :

- radiation risks (deterministic and stochastic),
- environmental risk,
- security risks,
- socio-economic risks; and,
- risks to the organisations that are part of the plan (such as reputation).

Introduction

The UK has been using and regulating radioactive materials for many years. The law and the regulatory systems to implement it have developed over that time, to meet the perceived need. Regulators competent in the safety and security of radioactive materials, and police and customs and other government bodies with an interest in these matters have all acquired their own statutory powers and duties which generally meet their operational needs.

More recently, the threat of inadvertent movements of, and illicit trafficking in radioactive materials has emerged in the UK, as in other countries. It has also become apparent that, under the provisions of current legislation, a single law enforcement body cannot meet this relatively new challenge. In recognition of this, the Environment Agency of England and Wales convened the UK Interpol Environmental Crime (Radioactive Substances) Sub-Group ("the sub-group"). The purpose of the sub-group is to enable an integrated multi-disciplinary approach to this problem.

The sub-group now comprises representatives of all relevant UK government departments and agencies, as well as representatives of the UK metals industries, and port associations.

The sub-group has developed an intelligence-led national response plan that will be deployed in response to discoveries of suspected cases illicit trafficking. The plan is to be piloted in 2001.

It is hoped that this paper will provide some useful information for other Member States who may also be considering the establishment of a plan of this type. Experience from the operation of the plan will be reported at the first appropriate opportunity.

The UK Response Plan

When deployed, the UK Response Plan will establish arrangements under which intelligence is shared between member organisations of the sub-group about potential cases of illicit trafficking. Such intelligence will then be used to try to intercept specific suspect consignments at the point of entry, or more strategically, to target resources to high risk ports shown to be likely to receive imports from high risk countries.

The consensus of the sub-group is that it is essential to co-ordinate the interests, powers and duties of all the organisations represented by its membership if there is to be a realistic probability of combating the problem. The approach taken is based on risk management.

It is important to recognise that the risks being managed by the UK arrangements are:

- radiation risks (deterministic and stochastic),
- environmental risk,
- security risks,
- socio-economic risks; and,
- risks to the organisations that are part of the plan (such as reputation).

If the plan was designed to manage only radiation risk, the synergistic advantages of being able to call on the resources of all the organisations represented in the sub-group would be lost. In addition, with the approach described there is an expectation that the statutory interests of all the regulators and other law enforcement bodies will be better protected.

The UK Response Plan has two alternative start points:

- illicitly trafficked radioactive material is discovered by customs, police or other law enforcement body; or,
- information is received alerting customs, police or another law enforcement body to a specific risk that radioactive materials are being illicitly trafficked.

In the first case, if radioactive material has been discovered, it is not initially known whether it comprises nuclear material, or other radioactive material. An initial response will require a radio-analytical assessment. If illicit nuclear material is suspected, customs and police have statutory powers to act appropriately.

However, at the operational level, they do not have radio-analytical services and radiation protection support immediately available, as the frequency of occurrence of such incidents is extremely low. The pilot plan will provide prompt access to these services when they are required.

Equally, experience has been that illicitly trafficked nuclear materials have sometimes been discovered by staff of the regulatory bodies, away from points of entry into the UK. There is clearly benefit in such regulatory staff being aware of the interests of police, customs and other government bodies. As subscribers to the plan, they will know what action to take as well as having insight into the forensic features of the scene of discovery that must be protected pending investigation by police and other government bodies.

However, the typical case is an inadvertent movement. These usually involve orphaned sources, where police and customs do not have a statutory locus. In such cases, it is the UK environment agencies that take the lead (as regulators of radioactive substances), together with the Health and Safety Executive (HSE), as regulator of radiation safety. However, they do not have all the statutory powers needed to intervene.

In these circumstances, the UK Response Plan is intended to provide co-ordination in such a way that the relevant powers and resources that customs and police do have, can be used in support of the environment agencies and the HSE. Clearly such support must have a clear legal basis. The plan clarifies these powers and resources as they are currently understood, and the pilot will provide an opportunity to identify areas where improvements would be beneficial.

It should be noted that the UK National Response Plan is designed to "dovetail" in to other relevant emergency plans, not to replace them. For example, it does not address the incident management issues that would result from a large-scale contamination incident. These are dealt with by existing emergency plans that are owned and maintained by local government authorities. However, the UK National Response Plan is intended to ensure that the interests of the law enforcement bodies that subscribe to it, are included in the decision making processes required for such a major incident.

Piloting the UK Response Plan — Step 1

The draft plan went through two iterations following consultation with the organisations represented on the sub-group. It is clear that there are gaps in the requirements for such a plan, and that at least some of these gaps will persist unless there are changes made to primary legislation. The sub-group is of the view that we cannot wait for such changes in legislation to be enacted before taking action to combat illicit trafficking and inadvertent movements of radioactive materials. The plan will therefore be implemented whilst it is still under development. There are risks in this approach, and these will be actively managed. The approach adopted is described in the next section.

A sub-set of five from the sub-group has developed a table-top exercise ("EXERCISE JOINT RESPONSE") that will test the arrangements in a safe environment. The exercise is designed to challenge operational staff and policy makers in the organisations represented in the plan to develop solutions to problems as they are encountered. A team of facilitators will discourage (and hopefully prevent) participants from retreating to the safety of "that is not my problem". The hope is that solutions will be identified that encourage manageable risks to be taken in the safety of the exercise. This process will be structured in such a way as to provide an initial Risk Assessment of the arrangements as they are drafted.

With the benefit of the Risk Assessment, the plan will be refined further, and any areas of excess unmitigated risk (for example, risks of litigation or risk to reputation of any of the participants), will be identified.

Piloting the UK Response Plan — Step 2

The second stage of the pilot is still in development. The aspiration is to deploy the plan at a single UK location, for a trial period. To achieve this, a Research and Development Project is being set-up. It is hoped that the plan will be operated at the pilot level for six months. Part of the project will be to analyse the issues encountered with the aim of identifying further improvements to the arrangements. In addition, the Risk Assessment of the arrangements themselves will be improved.

The intention is that following the rigorous Risk Assessment and pilot project, the National Response Plan will then be in a condition in which it can be deployed across all parts of the UK.

This is seen as the best way to manage an effective response to the challenge of illicit trafficking in, or inadvertent movements of, radioactive materials, given that UK legislation cannot at present provide all the necessary powers.

Conclusion

In the UK, the powers and duties of the regulatory bodies competent in the safety and security of radioactive materials do not currently provide for all the circumstances that may be met during incidents involving inadvertent movements of, or illicit trafficking in, radioactive materials. In this sense, if the UK addresses only the radiological protection risks, there will remain gaps in the national arrangements through which such radioactive materials will have an unobstructed route into the country.

If the powers and duties of other law enforcement bodies are co-ordinated with those of the regulators of radioactive materials, synergies are obtained which reduce all the risks associated with "illicit trafficking". In addition, with the approach described above there is an expectation that the statutory interests of all the regulators and other law enforcement bodies will be better protected.

Whilst it is recognised that the arrangements will never be 100 per cent effective, this "all risks" approach is seen as the only viable response in the UK to inadvertent movements of, or illicit trafficking in, radioactive materials.

QUESTIONS AND ANSWERS

I. Ray (EC): A theoretical approach is OK but what about practical cases? Unforeseen problems can arise.

C. Englefield (UK): The point of my presentation is that we first test the plan using a safe "theoretical" approach to enable rigorous risk assessment. We expect unforeseen problems to arise but we shall be better prepared to deal with them than we should be without a plan.

OVERVIEW OF THE ACTIVITIES ON PREVENTION AND COMBATING ILLICIT TRAFFICKING IN NUCLEAR MATERIALS AND UPGRADING OF PHYSICAL PROTECTION SYSTEMS IN THE CZECH REPUBLIC

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Abstract. The paper describes the effort and co-ordination role of the State Office for Nuclear Safety in prevention and combating of illicit trafficking in nuclear materials in the Czech Republic. There are given details on the activities to strengthening the national regulatory programme. The scheme to response the incident of illicit trafficking is covered. Basic information on R&D programme on the development of analytical methods suitable for forensic analysis of nuclear materials of unknown origin as well as close co-operation with the Institute for Transuranium Elements (Karlsruhe, Germany) are describes. The basic information on illicit trafficking in nuclear materials occurred in the Czech Republic are summarize. The second part of the paper comprehensively describes the upgrading of the physical protection systems at the different types of the nuclear installations (research reactors, storage of nuclear material including spent fuel, power reactors — WWER 440 and WWER 1000) to fulfill the more strict requirements of the new Atomic Law No. 18/1997 Coll. and Regulation No. 144/1997 Coll., on physical protection of nuclear materials and nuclear facilities which entered into force in 1997. The follow up actions in connection with IAAEA IPPAS mission carried out in 1998 are given. Basic information on physical protection of NPP Temelin in connection with start of the operation of the first unit in 2000 and continuos construction of the second unit will be given.

1. INTRODUCTION

The new phenomenon “Illicit Trafficking” in nuclear materials has been observed in 90´s. Following the increase in reporting of the illicit trafficking incidents it has been adopted resolution on “Measures against illicit trafficking in nuclear material” (GC(XXXVIII)/RES/15) on 23 September 1994 during the ninth IAEA General Conference. This resolution accelerate the IAEA´s activities as are described in the document “Measures against illicit trafficking in nuclear materials and other radioactive sources”, IAEA, GOV/2773 dated 24 November 1994 followed by up-dated series of this document, last one adopted by Board of Governors and General Conference as GOV/2000/40-GC(44)/15 dated August 17, 2000. The international support in this matter has been also expressed in “Moscow Nuclear Safety and Security Summit Declaration” (Moscow, 20 April 1996) as stated in IAEA information circular INFCIRC/509 dated 4 June 1996.

This new phenomenon “illicit trafficking” in nuclear materials has been observed also in the Czech Republic. Referring to the IAEA Secretariat´s circular letter N4.11.42 Circ. dated 2 August 1995 also the Czech Republic decided to participate in IAEA Illicit Trafficking Database Programme. The State Office for Nuclear Safety (SUJB) represents the governmental “Point of Contact” with regard to the Convention on the Physical Protection of Nuclear Material [1] and Illicit Trafficking Data Base Programme. The SONS also play a crucial role in establishing of the co-operation of different national authorities involved in this matter. From the first incident in the December 1994 until now the 10 events involving nuclear material and 3 events involving radioactive sources have been observed (see figure 1 and 2). From these incidents only 3 one deals with the nuclear materials having non-proliferation significance. The others are connected with depleted and natural uranium in small quantities (theft, unauthorised use and/or possession) mostly shielding containers or chemicals in laboratories.

The physical protection of nuclear facilities and nuclear materials in the Czech Republic is considered to be an integral part of nuclear safety. There is no difference in the damage to the environment by the release of radioactivity whether it is due to failure of technological systems or to radiological sabotage.

The ultimate objective of the physical protection system (PPS) is to prevent the accomplishment of unauthorized overt or covert actions to nuclear facilities and nuclear materials. When a physical protection system is applied to a nuclear facility or to nuclear materials, its objective is to prevent radiological sabotage of facilities and theft of nuclear materials. Thus an effective system of physical protection plays an important role in preventing illicit trafficking of nuclear materials.

2. PREVENTION

2.1. IMPROVING THE STATE SYSTEM OF ACCOUNTING FOR AND CONTROL OF NUCLEAR MATERIAL

The aspect of the “prevention” of the illicit trafficking in nuclear material is namely realised through the improving the state system of accountancy for and control of nuclear material.

Focusing on the strengthening the national regulatory programme, a new comprehensive Atomic Law [2] was approved by the Parliament of the Czech Republic on 24 January 1997 and the new Atomic Law came into force on 1 July 1997. The Atomic Law also defines basic provisions for accountancy for and control of nuclear materials and export/import of nuclear materials. To follow these provisions of the Atomic Law the new national regulation Decree No. 145/1997, Coll. [3], was prepared and issued on 19 June 1997.

It has been established in the Czech Republic a very effective SSAC supporting by extensive IAEA inspections [4] as well as national control provided by SUJB´s inspectors. For these purposes SUJB co-ordinated and sponsored technical projects. The projects in the field of non-destructive analysis (NDA) of nuclear materials using portable gamma-spectrometric system and in developing destructive methods of nuclear materials analysis were carried out by the Faculty of Nuclear Science and Physical Engineering of the Czech Technical University, Prague and Nuclear Research Institute Řež, Ltd. (NRI).

2.2. STRENGTHENING THE STATE SYSTEM OF THE PHYSICAL PROTECTION

Very effectively the “prevention” of illicit trafficking in nuclear materials can be also established by strengthening the state system of physical protection of the nuclear materials.

Following the requirements on physical protection of nuclear materials and nuclear facilities as given in Atomic Law [2] the new basic national regulation Decree No. 144/1997 [5] was prepared and issued on 19 June 1997. Increase in reliability and complexity of this physical protection system effectively reduce the potential of “illicit trafficking” in nuclear materials under jurisdiction of the Czech Republic.

At nuclear installations in the Czech Republic there are very strictly followed the provisions to ensure the physical protections of nuclear materials in accordance with INFICIRC 225/Rev.4 [6]. In addition the national Regulation [5] requires protecting all nuclear material of Category I, II and III by using technical alarming systems. Still there are potential to seized namely depleted and natural uranium and small samples of enriched uranium and plutonium in the quantities lower than the limit for Category III as given in Table: Categorisation of Nuclear Material [6]. For these nuclear materials there are no strictly defined measures for their physical protection (only in accordance with prudent management practices).

There is recommendation of the necessity to provide the proper measures on the physical protection of the seized nuclear materials in course of investigation. The material should be protected according to the level of nuclear material categorisation. In the Czech Republic, there are suitable facilities in NRI to handle and store nuclear material even of Category I.

2.3. STRENGTHENING THE NATIONAL REGULATORY PROGRAMME

Strengthening of the national regulatory programme has been established by a new comprehensive Atomic Law [1]. The proposal of the Atomic Law constitutes the legal basis for the physical protection of nuclear facilities, nuclear materials and transportation of nuclear materials (paras 4, 9, 13, 18, 20 39 and 44). To follow the basic requirements of the Atomic Law the new basic national regulation Decree No. 144 on Physical Protection of Nuclear Materials and Nuclear Facilities and on its Inclusion into Particular Category was prepared [5]. The new regulation very clearly describes technical and administrative measures to ensure physical protection of nuclear facilities and materials, as well as nuclear materials during transport, categorisation of nuclear materials, parts of nuclear installations and licensing of physical protection. The provisions of the Decree follow the basic IAEA recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Rev.4, (Corrected)) and provisions of the Convention on the Physical Protection of Nuclear Material (INFCIRC/274/Rev.1).

The specific physical protection measures, which are applied to a particular facility, are determined by the State. That determination is based on factors specific including the State, threat perception, economics, political infrastructure and culture.

According to the Atomic Law [1] the licensee bears the responsibility of physical protection of his facility and nuclear material. The licensee has to submit to SUJB for approval a safety report the contents of which are described in the Appendix of the Atomic Law and in para 18 of the Decree No. 144/1997 Coll.; the safety report has to show how the requirements to ensure physical protection are fulfilled.

All systems of physical protection of nuclear materials and nuclear installations have to follow updated requirements set by Decree No. 144/1997, Coll., not later than five years after entry into force of the Atomic Law (June 1, 2002). These additional requirements determine general aspects, detailed requirements concerning the design of the technical system including its maintenance and communication means, requirements concerning the provisions of guarding as well as the demands of dealing with confidential information. A detailed description of the contents of the above mentioned chapters is given in para 18 of Decree No. 144/1997, Coll. [5].

2.4. NUCLEAR INSTALLATIONS IN THE CZECH REPUBLIC

In the Czech Republic, only the following steps of the nuclear fuel cycle are covered:

- exploration, mining and milling of uranium ore;
- storage of uranium concentrate (yellow cake);
- operation of nuclear reactors;
- storage of highly enriched uranium (HEU) and other nuclear materials;
- interim storage of spent fuel (away from reactor);
- storage of high level radioactive wastes;
- disposal of low and medium radioactive wastes;
- transportation of nuclear materials.

The principal nuclear facilities are briefly described as follows.

Nuclear power plants

- NPP Dukovany: four units, WWER-440/type 213, low enriched uranium (LEU), category I;
- NPP Temelín: two unit, WWER-1000, LEU, under construction, category I, storage of fresh fuel in operation from 1997, loading of fresh fuel to 1st unit on July 5, 2000.

Research reactors

- Nuclear Research Institute Řež: reactor LWR-15 (HEU) and reactor LR-0 (LEU), category II;
- Czech Technical University, Prague: reactor VR-1P (HEU), category II.

Interim storage of spent fuel (away from reactor)

- NPP Dukovany site dry type using cask CASTOR-440/84, capacity 60 casks, category I.

Other facilities

- Storage of fresh fuel (HEU): Nuclear Research Institute Řež , category I;
- ŠKODA, Institute of Nuclear Fuel, Prague, D, N, LEU, category III;
- Storage of uranium concentrate: DIAMO, s.p. Straž pod Ralskem and GEAM, o.z. Dolní Rožínka, N, category III;
- Storage of high level radioactive wastes: Nuclear Research Institute Rež, irradiated HEU and LEU, radioactive wastes, category II;
- Regional repository of low level radioactive wastes at NPP Dukovany, category III;
- Repository of radioactive wastes Richard (near city Litoměřice), SURAO, category III.

Note: D — depleted uranium, N — natural uranium, LEU — low enriched uranium, HEU-high enriched uranium, category j: the level of physical protection.

2.5. UP-GRADING OF THE PHYSICAL PROTECTION

2.5.1. Basic concept of physical protection

The basic concept of the PPS for particular nuclear facilities and/or nuclear material in use and storage should fulfil the general requirements set up by Decree No. 144/1997 [5]. More datails on the physical protection of nuclear materials and nuclear facilities in the Czech Republic are given in papers [7-11]. To fulfil the requirements set up in this Decree for nuclear installations of category I the basic concept of physical protection is based on detection in depth, which can be represented as follows:

The layout of the nuclear facility is divided by the mechanical barriers into three adjacent areas as follow

- Equipment and nuclear materials of category I must be located in the inner area;
- Equipment and nuclear materials of category II must be located in the controlled area;
- Equipment and nuclear material of category III must be located in the protected area.

For PPS at NPP and nuclear facilities of the category I there is compulsory to installed an integrated protection system. This system guarantees:

a) Independent checking of authorized entrance of persons or vehicles into different areas of the NPP.
b) Detection in depth, representing detection of unauthorized entrance to selected devices, depending on their significance in ensuring nuclear safety (three categories according to “fault tree” analysis).

For another nuclear facilities there is compulsory to have direct output of the electronic alarming systems [12] to the central security control room of the local Czech police office.

All other provisions regarding the detection systems for barriers and inner areas, delay components, access control, vehicle barriers, CCTV system and other administration measures are set up in the safety report and in supplement documents (communication and guarding rules, response activities, tactics).

Following the amendment of the Law on the Police of the Czech Republic in § 44 of the Atomic Law, the police guarantees the timely response in the case of emergency situations, in accordance with the provisions of regulations [5] and governmental decision No. 937 dated September 18, 2000.

From 1 January 1992, a private security company has provided the inner guarding.

2.5.2. Basic up-grade

- all nuclear facilities prepared new safety analysis report declaring that new requirements has been fulfilled and received from SUJB new licence to ensure the physical protection; only two facility have a temporary licence because they should in high extend to change the control system (preliminary based on PC network) or completely installed the new integrated system (preliminary based only on separate electronic alarming systems);

- at the facilities of the II and III category has been performed direct connection of alarming systems to local offices of the Czech police, digital transfer of data by radio;
- delay time of the mechanical barriers has been increased: new design of the isolation zone, additional bared wires concertina, stop-roads equipment, safe doors, bullet resistance windows, vault type rooms and safes etc.;
- implementation of new detection systems with higher reliability and detection probability and lower false alarm;
- more sophisticated systems to control the entering persons, cars and luggage (rtg. devices, metal detectors);
- introducing the biometrics detection (hand geometry, finger print);
- implementation of video capture systems (pre and post alarm evaluation) and using only CCTV cameras;
- to fulfil the "Two persons rule" by technical system;
- to established the secondary alarm station.

This technical means are supporting by improvement of the administrative measures:

- in accordance with national regulations (see Ref. [5]) uranium concentrate [yellow cake] of an amount of >1000 kg is considered as nuclear material of category III;
- providing regular tactics exercises of licensee, police and guarding companies;
- to fulfil the requirements of QA in preparation of documents, installation, maintenance and testing of the physical protection systems;
- continuous activities to develop and improve the overall efficiency and reliability of the whole system.

Most of the up-grades are improving the deficiency of the original design of NPPs, both WWER-440 and WWER-1000 types, which did not take into account the general requirements of physical protection (e.g. unsuitable location of vital equipment, insufficient resistance of building walls, doors, windows, unprotected pipe channel, etc.).

2.5.3. IPPAS mission

On the request of the Czech government in the end of the 1998 IAEA performed the IPPAS mission in the Czech Republic focusing on the legislation and regulation aspects as well as on implementation of the physical protection. The IPPAS team visited NPP Dukovany and Temelín, training reactor at Czech Technical University in Prague and Nuclear Research Institute at Řež (Two reactors, storage of HEU fresh fuel and storage of high radioactive wastes including the irradiated fuel originally LEU and HEU type).

The results of the IPPAS mission declared the high level of the ensuring the physical protection at nuclear facilities as well as the legislation covering the physical protection in whole. Regulatory body and licensee have accepted the final report with recommendations, suggestions and good practises. Appropriate action has been taken.

As follow-up action in 1999 the workshop on DBT has been carry out in Prague. This was first opportunity to have a detailed discussion of the representatives of regulatory body, licensee, Ministry of Interior, Police of the Czech Republic and Intelligence Service on DBT together with experts of the IAEA, USA, UK and Germany. Conservatively the Czech utility are still basically dealing with DBT defined in early 80´s. There is under preparation to include the DBT into amendment of the Decree No. 144/1997 Coll.

There was established also direct co-operation between the NRI and Sandia National Laboratories focusing on up-grade of the physical protection system, which covered not only technical assistance but also the financial support to improve the physical protection of the NRI facilities handling HEU (originally 80 or 36 wt.% ^{235}U).

We preliminary agreed to invite the follow-up IPPAS to visit the NPP Temelin where the physical protection system has been finished for the 1st unit and is in the final stage of implementation for the 2nd unit. During mission in 1998 only the project and part of the outer perimeter were ready. The operation of the physical protection system has been approved by SUJB in January 2000 and it is in full operation from this time. The licensee fulfilled the basic requirements that integrated technical system must be in operation at least 3 months before first loading of the fresh fuel into the reactor core (July 5, 2000). This integrated system is under frequent inspections of the SUJB and results of inspection show that system is very reliable and it is operating without problems.

3. COMBATING

The aspect “combating” it is ensured through extensive co-operation of the state authorities focusing on investigation of illegal activities concerning “illicit trafficking” in nuclear materials coming to and/or through the territory of the Czech Republic from other countries. These activities also including the provisions to disclosed the possibility of illegal handling with nuclear materials at national level. Police of the Czech Republic and Security Information Service play a principal role in this matter. SUJB plays an important role in the co-ordination of the activities performed in this field.

It has been established standing working group of experts at SUJB, where are representatives of SONS, Ministry of Interior of the Czech Republic, Police of the Czech Republic, Ministry of Foreign Affairs of the Czech Republic and Directorate of Customs.

In combating illicit trafficking to follow the provisions of the Convention [1] it has been prepared the amendment of the Law No. 140/1961 — Criminal Code, by § 186 “Illegal Production and Handling of Radioactive Materials” of the Law No. 290/1993. SUJB as responsible national authority to Convention on the Physical Protection of Nuclear Material has been appointed as a Contact Point to Convention and also as a Contact Point to “Illicit Trafficking Data Base” under participation in programme describing in IAEA document N4.11.42.Circ dated 2 August 1995.

4. RESEARCH AND DEVELOPMENT (R&D) PROGRAMME

There are also R&D programmes supporting by SONS on the development of the analytical methods suitable for precise and forensic analysis of the nuclear materials of unknown origin. One of the programme was carried out by Central Analytical Laboratory of the NRI with close co-operation of the European Commission Joint Research Centre — Institute for Transuranium Elements (ITU, Karlsruhe, Germany) under project PHARE/CZ/PH5.01/95. This laboratory take part also in the activities of the Nuclear Smuggling International Technical Working Group.

4.1. ONGOING INTERNATIONAL SUPPORT

In the end of year 1999 ended the project PHARE PH 5.01/95 "Assistance to the Nuclear Research Institute (NRI) Řež (Czech Republic) in setting up special analytical services including a data bank for analysis of radioactive substances and nuclear materials of unknown origin". The final report has been approved in December 1999.

Under this project have been performed for the first time transportation of a HEU samples from NRI to ITU and subsequent analysis with participation of Czech expert, compilation of measured impurities data for HEU materials used in the Czech Republic and its transfer to the ITU database.

Under this project the following goals have been achieved:

- capacity of the Central Analytical Laboratory (CAL) NRI has been upgraded by delivering and installation of an Inductively Coupled Plasma Mass Spectrometer (ICP-MS);
- the ITU offered for one expert of CAL the possibility to familiar with the type of equipment and its application to analyses of trace elements in nuclear materials including respective working procedures;
- the trace elements concentration in selected samples of uranium materials and fuel elements for reactor LWR-15 were determined;
- possibilities for analysing nuclear material seized in the Czech Republic at ITU¨s laboratories were discussed and were solved technical conditions for performing a sample transport to ITU;
- a database of EK-10 and IRTM type fuel assemblies for reactor LWR-15 at NRI were compiled;
- impurities in HEU samples (87 wt.% ^{235}U, UO_2 type) and in LEU pellets (3.6 wt.% ^{235}U) were determined;

At present the CAL NRI will participate in "Round Robin Exercise" to analyse the HEU samples under project prepared by ITWG.

In the force is bilateral agreement between ITU Karlsruhe and NRI Rez on co-operation in the field of analyses of nuclear materials and exchange of information on analytical data concerning the different types on nuclear materials used at NRI and in Czech Republic.

4.2. ANALYTICAL ACTIVITY OF NRI

The NRI is only laboratory in Czech Republic providing on the request of SUJB the destructive analysis of nuclear materials for the safeguards and illicit trafficking purposes. During the seizure of HEU in December 1994, the IAEA was within one week provided by analytical data on uranium concentration and isotopic composition in ^{234}U, ^{235}U, ^{236}U and ^{238}U (figure 1) and by detailed information on other physical-chemical properties of seized samples.

The analyses of nuclear materials are carried out exclusively in the Central Analytical Laboratory NRI Řež. This laboratory is able to perform precise and accuracy determination of the concentration of U and Pu in different type of samples. Destructive methods using concentration of U, Pu and selected radionuclides also in environment and in wipes samples were developed under safeguards project "93+2". The laboratory is equipped with gamma and alpha spectrometry. For determination of U and Pu isotopic composition mass spectrometry is used. Additional characterization of samples is performed by determination of trace impurities using AAS and ICP-MS (provided under PHARE project). There are available other physical and-chemical methods.

The SUJB also supported development of the procedures and manuals for police and customs how to handle with seized samples. By NRI has been developed the comprehensive database including all available date on analysis of seized nuclear materials (as picture of the samples and containers, results of the determination of composition, isotopic analysis, determination of impurities, determination of radioactive nuclides, porosity, density, granulometric analysis, etc.). This database contains also data on analysis of samples taken under "Programme 93+2" at selected nuclear installations and in the vicinity of these installations (environmental samples). The software developed for these purposes allowed also using database to generate the report to the IAEA Illicit Trafficking Database Office.

4.3. EXISTING TECHNICAL INSTRUMENTATION AND TRAINING CAPABILITIES

4.3.1. Instrumentation

The inspectors of SONS are equipped with portable Multichannel Spectrometric Analyser with NaI(Tl) detector routinely used for safeguards measurements and in the case of incidents of trafficking in nuclear materials.

All regional centers of SONS are equipped with portable multichannel spectrometric analyzer using semiconductor/scintillation detector with possibility to identify the isotopes, to evaluate the activity and dose rate in the field. They are also equipped with hand-held contamination and dose rate meters. In addition these laboratories are able to perform radiochemical determination of the selected radionuclides, to measure tritium, gross alpha and gross beta activity.

In addition the SUJB have a possibility to request the National Institute on Radiation Protection to perform the complex analysis of radioactive materials in very well equipped laboratories. These laboratories routinely perform the analysis of environmental samples (water, sediments, soil, fall out, food, agriculture products) using destructive as well as non-destructive spectrometric measurements (alpha-gamma).

4.3.2. Training

The CAL NRI Řež has arranged the basic training for the Police of the Czech Republic. The training involved the basic information on radioactivity, detection and radiation protection. There are also covered topics dealing with safe transport of nuclear materials and radioactive materials.

In this area we appreciate very much the joint effort of IAEA, WCO and Interpol. The staff of the governmental organizations (State Office for Nuclear Safety, General Directorate of Customs and Czech Police) participated in the training courses, the last "IAEA/WCO/INTERPOL Awareness Training Course on Combating Smuggling of Nuclear and Other Radioactive Materials" was carried out on June 26–30, 2000 in Vienna.

5. REPORTING SCHEME

In the case of illicit trafficking in nuclear material the SUJB is informed by Police of the Czech Republic and/or Customs. The seized samples are transferred to the Central Analytical Laboratory of the NRI and SUJB requests this institution to perform the preliminary analysis. These analyses obviously cover the determination of quantity of seized material, determination of concentration and isotopic composition. The results are passed by NRI to SUJB. The SUJB informs on this data the Police of the Czech Republic.

On the basis of these results the NRI is obliged to follow the requirements of the national regulation on accountancy for and control of nuclear material [3] and on physical protection of nuclear materials [5]. The data on accountancy of nuclear material are reported by SUJB to IAEA under provision of safeguard agreement [4]. Data on illicit trafficking incident are reported by SUJB to IAEA Illicit Trafficking Database Office in accordance with the agreed form described in IAEA Circular Letter N4.11.42 Circ. dated 21 August 1996.

6. DESCRIPTION OF ALL INVOLVED ORGANISATIONS

- State Office for Nuclear Safety, Senovážné náměstí 9, 110 00 Prague 1, E-mail: emergency@sujb.cz;
- Ministry of Foreign Affairs, Loretánské nám. 5, 118 00 Prague 1;
- Police of the Czech Republic, Criminal Police — Section of Nuclear Materials, POB 41/V2, 156 50 Prague 5;
- Ministry of Finance, General Directorate of the Customs, Budějovická 7, POB 12, 140 96 Prague 4, E-mail: barta@m602.cs.mfcr.cz;
- Regional Centres of SUJB in Prague, České Budějovice, Plzeň, Hradec Králové, Ústí nad Labem, Brno and Ostrava,

Response in Radiation Protection co-ordinated by Deputy Chairman for Radiation Protection of SUJB, Contact through Emergency Centre of SUJB;

– National Radiation Protection Institute, Šrobárová 48, 10000 Prague 10, E-mail: rms@suro.cz;
– Nuclear Research Institute Řež, Central Analytical Laboratory, 250 68 Rez, E-mail: maz@nri.cz

7. CONCLUSIONS

The efficient state physical protection system of nuclear materials and the state system of accountancy for and control of nuclear material play a crucial role in preventing the possibility of illicit trafficking of nuclear materials from nuclear installations in the Czech Republic.

We are supporting the activities to provide IAEA and Member States in open form by the maximum information on detailed analysis of nuclear materials in illicit trafficking and in this way to go above the provisions of Agreement [2].

The Czech Republic support programmes for closer co-operation of the competent authorities for the illicit trafficking. We are sure that also technical co-operation in area of analytical methods to be used for forensic analysis of seized nuclear and other radioactive materials should be established. We would like to share the information relevant illicit trafficking and to support extension of the comprehensive database on nuclear materials to be held at ITU Karlsruhe. There should be established more close co-operation of customs and police to deal more effectively with illicit trafficking and accelerate joint effort concerning the effective installation of detection systems at boarders including the appropriate training at national and international level.

Physical protection of the operating NPP is provided by technical means (integrated PPS), guarding is performed by a private security company and response is guaranteed by the Czech police. The system fulfil as a minimum, the IAEA recommendation for nuclear material category I and corresponds to western standards of the physical protection of NPPs. As a result of of SONS inspections the system is continuously upgraded as given in paper.

All other nuclear facilities are also protected in accordance with IAEA recommendations. In addition the requirements of SONS and new regulations to reduce the risk of unauthorized handling of nuclear material also for category II and III require compulsory to use technical alarming systems.
We appreciate very much the effort of the IAEA to provide on the request of the Members States the IPPAS mission and in this way to promote the international co-operation in the field of the physical protection and to help the Member State improve the level of the physical protection of nuclear materials and nuclear facilities.

TABLE I. DESCRIPTION OF SEIZED HEU SAMPLES

№	Date	City	Facility	Material	Weight/Activity	Remarks
Nuclear Materials						
1.	14. 12. 1994	Prague		HEU	2.73 kg	87.7 wt.% ^{235}U, UO_2
2.	6. 6. 1995	Prague		HEU	0.415 g	87.7 wt.% ^{235}U, UO_2
3.	8. 6. 1995	České Budějovice		HEU	16.958 g	87.7 wt.% ^{235}U, UO_2
4.	24. 9. 1997	Prague		N	4.24 g	Uranyl Acetate
5.	28. 5. 1998	Prague		N	67.5 g	Unauthorised Transfer, $(NH_4)_2U_2O_7$
6.	1.5. 1999	Pardubice	ALIACHEM a.s.	D	27.66 kg	Theft, shielding containers
7.	17. 10. 1999	Sviadnov	Hutní montáže	D	1.64 kg	Theft, shielding container
8.	15. 9. 2000	Čelákovice	ŠKODA a.s.	D	19.5 kg	Unauthorised Possession, shielding container
9.	10. 3. 2001	Plzeň	Plzeňská Energetika	N	3.95kg	Unauthorised Use, $UO_2(NO_3)_2$
10.	9. 4. 2001	Dolní Poustevna	Dr. M. Winkler - Diagnostica	N, T	17 kg, 100g	Unauthorised Use, sulphate, nitrate, acetate,
Radioactive Sources						
1.	29. 10. 1996	Příbor		^{90}Sr	17 MBq	source
2.	27. 10. 1999	Rozvadov		^{60}Co	100 GBq	Scrap, Transfer: H to D
3.	21. 9. 2000	Liberec	LITES a.s.	^{241}Am	15 MBq	100 pcs of fire detectors

TABLE II. DESCRIPTION OF SEIZED HEU SAMPLES

DATE OF INCIDENT	**LOCATION OF INCIDENT**	**BATCH NAME**	TOTAL **WEIGHT [g]**	**U [%]**	ISOTOPIC COMPOSITION [%]			
					^{234}U	**^{235}U**	**^{236}U**	**^{238}U**
DEC. 14, 1994	PRAGUE	URAN-A	**1388**	**86.799**	**1.0781**	**87.7314**	**0.2108**	**10.9797**
DEC. 14, 1994	PRAGUE	URAN-B	**1342**	**86.735**	**1.0778**	**87.7682**	**0.2102**	**10.9438**
JUNE 6, 1995	PRAGUE	URAN-C	**0.415**	**86.84**	**1.0782**	**87.7408**	**0.2098**	**10.9712**
JUNE 8, 1995	**ČESKÉ BUDĚJOVICE**	**URAN-D**	**16.958**	**86.74**	**1.0756**	**87.7656**	**0.2110**	**10.9478**

NOTE: **ANALYSIS PERFORMED BY CENTRAL ANALYTICAL LABORATORY OF THE NUCLEAR RESEARCH INSTITUTE REZ** URANIUM CONCENTRATION : DETERMINED BY TITRIMETRIC METHOD, MASS VOLUMETRIC MODIFICATION OF THE NBS METHOD, MASS-SPECTROMETRIC ANALYSIS : USING MASS-SPECTROMETER MAT 261, COMPANY FINNINGAN MAT, BREMEN, GERMANY, STANDARD : SRM NBS U750

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, The Convention on the Physical Protection of Nuclear Material, INFCIRC 274/Rev. 1, Vienna (May 1980).
[2] Czech Law No. 18/1997, Coll. of 24 January 1997, Peaceful Utilization of Nuclear Energy and Ionizing Radiation [Atomic Law] and on Changes and Amendment of Selected Laws.
[3] Decree No. 145/1997 of the State Office for Nuclear Safety of 19 June 1997, Accountancy for and Control of Nuclear Materials and its Detailed Description.
[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Agreement between the Czech Republic and IAEA for the Application of Safeguards in Connection with the NPT, INFCIRC 541, Vienna.
[5] Decree No. 144/1997 of the State Office for Nuclear Safety of 19 June 1997, Physical Protection of Nuclear Materials and Nuclear Facilities and its Inclusion into Particular Category.
[6] INTERNATIONAL ATOMIC ENERGY AGENCY, The Physical Protection of Nuclear Material and Nuclear Facilities, INFCIRC 225 Rev.4 (Corrected), Vienna (June 1999).
[7] SEDLÁČEK,J., Physical Protection of the Nuclear Facilities and Nuclear Materials-Evaluation of Physical Protection System Efficiency, Special Publication, Institute of Nuclear Information Prague (1991) 5-18, (in Czech).
[8] SEDLÁČEK,J., “Implementation of the General Rules for Physical Protection of Nuclear Materials in Czech and Slovak Federal Republic”, (Proc. Int. Sem., Physical Protection of Nuclear Facilities, 11 Nov.-24 Nov. 1992), KfK, Karlsruhe (1992) 10 pp.
[9] SEDLÁČEK,J., “Physical Protection of Nuclear Facilities and Materials in Czech Republic”, (Proc. Int. Conf., Physical Protection of Nuclear Facilities and Materials, GOSTATOMNADZOR ROSII and GRSmbH), St.-Petersburg (1995).
[10] SEDLÁČEK, J., “Protection of Nuclear Facilities and Nuclear Materials in Czech Republic”, (Proc. International Training Course, Albuquerque, NM, 1997).
[11] FAJMAN, V., SEDLÁČEK, J., “Licensing of Spent Fuel Storage Facility including its Physical Protection in the Czech Republic”,. International Symposium on Spent Fuel Storage. IAEA, Vienna Oct. 10-14, 1994. Paper IAEA-SM-335/33.
[12] Devices of Electronic Security Alarming Systems, Czechoslovak State Standards ČSN 334590,4 Feb. 1986.

QUESTIONS AND ANSWERS

G. Bunn (USA): Do you carry out any mock attacks on PP barriers to test their effectiveness?

J. Sedlacek: Yes, with co-operation between licensee, police and guards. Generally the WWER-440 has some construction weaknesses, but these are compensated by reliable detection systems, barriers, access control and administrative measures.

THE GERMAN SYSTEM TO PREVENT, DETECT AND RESPOND TO ILLICIT USES OF NUCLEAR MATERIAL AND RADIOACTIVE SOURCES

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Abstract. The German system to prevent, detect and respond to illicit uses of nuclear material and radioactive sources was implemented in parallel to the German nuclear programme which started in the mid-fifties. Whereas prevention was the prevailing element until 1992, detection and response received particular interest after a significant increase of cases of illicit trafficking in radioactive materials had been experienced. The system consists out of international and national regulations pertaining to physical protection and safeguards of nuclear material, to security of radioactive sources, and to import/export control, of a licensing and regulatory supervision regime for all activities related to nuclear material and radioactive sources, of sanctions in case the licensee does not meet his responsibilities, of criminal investigations by law enforcement authorities and penalties for illegal acts, of technical detection and analysis capabilities for radioactive materials, of organizational response arrangements between the various authorities involved in hazard prevention in cases of illegal use of radioactive substances, and of the participation in international programmes and PoC-systems. The responsibilities for licensing and regulatory supervision of activities related to nuclear material and radioactive sources have been assigned to various authorities on the State ("***Länder***") and on the Federal level of the Federal Republic of Germany; for safeguards measures IAEA and EURATOM both are responsible. Law enforcement and criminal investigation in most cases are taken care of by State authorities, as well as measures for hazard prevention in cases of illegal use or transportation of radioactive substances. Ways have been found to integrate support from Federal authorities to State authorities into the State organization in severe cases of illegal use, and to ensure mutual and timely distribution of relevant information between all authorities involved in hazard prevention and law enforcement.

1. NUCLEAR PROGRAMME

The German system to prevent, detect and respond to illicit uses of nuclear material and radioactive sources has evolved in parallel to the nuclear programme which was started in Germany in the mid-fifties; the current size of this programme can be described by the following facts: 13 PWR and 6 BWR nuclear power plants are in operation producing about 33% of the national electricity consumption; another 16 units of different generating capacity are in different states of decommissioning. There are 4 research reactors, a 1800 t per year centrifuge Uranium-enrichment facility and a LWR-fuel fabrication plant in operation; 4 fuel fabrication facilities — among them the MOX-fuel fabrication plant at Hanau — have been shut down and are being decommissioned. 4 regional interim storage facilities using CASTOR dry-storage casks for spent fuel plus one on-site interim storage building at a nuclear power plant will be supplemented by another 12 on-site interim storage buildings within the next five years. One of the existing regional interim storage facilities has also been licensed to store vitrified high-level radioactive waste that has to be taken back from reprocessing of German spent fuel in France and the United Kingdom. Two final repositories for spent fuel and radioactive waste are under investigation.

About 600 to 700 shipments of nuclear material by rail and road vehicles, ships and airplanes take place within the German nuclear fuel cycle annually, including fresh fuel (LEU, MOX) transports to nuclear power plants, spent fuel transports to regional interim storage facilities and to reprocessing facilities abroad, vitrified high-level waste transports to interim storage, low enriched Uranium imported from foreign countries, and nuclear material samples transported to safeguards laboratories.

Apart from the on-site storage buildings for operational radioactive waste at each of the nuclear power plants there are 16 waste collection and storage facilities for low and intermediate level radioactive waste in the German *"**Länder**"*[1)] (Federal States). The State waste storage facilities keep collecting all radioactive waste which will result from the use of radioactive substances in industry, medicine, research, teaching and other applications for later shipment to a final repository. About 20 000 licences to use, store or transport radioactive sources are registered in Germany, corresponding to about 12 000 licensees; half of this number is using sealed radiation sources only. 80% of all radiation sources are used for industrial applications, 8% for medical purposes, 7% in research and teaching. In 1998 about 300 sources with A > 1,85 T Bq had been exported from Germany to 40 countries, whereas some 590 such sources had been imported into Germany from 12 countries.

In 1992 Germany experienced a substantial increase of the number of cases of illicit trafficking in nuclear material and radioactive sources from 1 to about 24–28 cases per year, as well as a marked increase of imports of contaminated metal scrap and of orphan sources. Until the end of the year 2000 nuclear material and radioactive sources of various isotopic compositions and quantities have been seized by the competent authorities in 108 cases; there had been four cases dealing with HEU and with Pu-239. This development was the reason why the elements of detection and response have been reinforced considerably since then in Germany.

2. THE ELEMENTS OF THE GERMAN SYSTEM

In order to prevent any unauthorized removal, theft or diversion of nuclear material, to keep control of the location and rightful use, storage or transportation of nuclear material and radioactive sources, to detect illegal uses of such materials in a timely manner, and to respond to cases of illegal use in case they have occurred, a variety of measures have been implemented by the German authorities:

- All activities related to nuclear installations, nuclear material and radioactive sources are subject to licensing and regulatory supervision by competent authorities.
- A system of international and national acts and ordinances covering physical protection, safeguards, and import/export control has been put in place and up-dated, whenever needed. The respective protection and control measures have been implemented.
- The responsibility for compliance with legal prescription and with licensing conditions, and for keeping nuclear and other radioactive material under control has been clearly assigned to the licensee. In cases of non-compliance the authorities are empowered to impose sanctions.
- Investigations and criminal prosecution by police and customs authorities are elements of law enforcement in case illegal actions related to nuclear material or radioactive substances have taken place. Severe penalties are foreseen for such cases in the national legislation.
- Capabilities to detect illicitly trafficked nuclear material and radioactive substances at the borders, on German territory and at metal scrap processing facilities by technical systems have been built up, accompanied by sophisticated analytical capabilities. Detection of illegal activities through intelligence gathered by security and criminal investigation authorities are of importance as well.

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1) The Federal Republic of Germany is a federation formed out of 16 "Länder"; these "Länder" will be called "***States***" throughout this paper.

- Response and co-operation arrangements for all cases of illicit use of nuclear material and of radioactive substances have been implemented by all competent authorities that might be involved in coping with such cases, in order to prevent any radiological hazard to the public from happening as a consequence of the illicit use.
- National prevention, detection and response activities are assisted by participating in international programmes in this field and by having joined the Point of Contact systems of the IAEA and of the G8-group.

3. PREVENTION

Measures that contribute most to the prevention of illicit use, storage or transport of nuclear material and radioactive sources are ***licensing and regulatory supervision*** by competent authorities, ***physical protection***, ***safeguards***, **and** ***import/export control***, a system of ***sanctions and penalties***. The details of the respective measures have been specified in international and national acts, ordinances and guidelines in Germany.

3.1. LICENSING AND REGULATORY SUPERVISION

The German ***Atomic Energy Act*** [1] and the ***Radiation Protection Ordinance*** [2] form the basis for licensing and supervising all activities related to nuclear material and radioactive sources.

The ***objectives*** specified in this Act [1] are:

- to protect life, health of human beings and property against the hazards of nuclear energy and the harmful effects of ionising radiation,
- to prevent risks to the internal and external security of the Federal Republic of Germany associated with the application or release of nuclear energy and of fissile or radioactive materials,
- to ensure the compliance of the Federal Republic of Germany with international obligations in the field of nuclear energy and radiation protection.

According to the ***Atomic Energy Act*** [1] the subsequent activities are subject to ***licensing and regulatory supervision***:

- Import and export of nuclear material;
- Transportation of nuclear material, including shipments in transit;
- Interim storage and use of nuclear material;
- Construction, operation, alteration and decommissioning of nuclear installations;
- Construction and operation of final storage facilities for spent fuel and for radioactive waste.

The Atomic Energy Act specifies the respective licensing prerequisites for these activities ***physical protection*** is a very important licensing prerequisite the obligations and responsibilities of the licensee, necessary conditions for modifying, amending or revocation of licences, sanctions for unauthorized activities and the competent licensing and supervisory authorities.

The ***Radiation Protection Ordinance*** [2] is a regulation which specifies the principles and requirements for precautionary and protective measures applicable for activities like the following ones:

- Possession, use or storage of radioactive sources;
- Purchasing of radioactive substances, their delivery, transportation and trans-boundary shipment;
- Licensing and operation of facilities for storage of radioactive waste.

The requirements have to be proven to be fulfilled during the licensing or authorization process and are subject to regulatory supervision thereafter; ensuring *security* of radioactive sources is one of the most important requirements when prevention of loss or unauthorized removal is addressed.

The Atomic Energy Act [1] and the Radiation Protection Ordinance [2] are Federal legislation; for most of the activities, however, they are carried through by respective competent authorities designated by the 16 German ***State ("Länder")*** Governments, on behalf of the Federal Government. In order to ensure uniform implementation of the legal requirements the ***Federal Ministry for the Environment, Nature Conservation and Nuclear Safety*** is empowered to exercise ***expedience supervision*** of the State authorities, and he may issue binding instructions to them. Apart from the ***Federal Office for Radiation Protection***, which is responsible for ***licensing*** shipments of nuclear materials, interim storage facilities for nuclear material and high-level radioactive waste, and of transportation of radioactive sources with $A > 10^{12}$ Bq, there is a large number of competent State authorities on the ministry level and on the State office or lower level charged with ***licensing and supervisory functions***; Figure 1. shows an overview of the assignment of these functions. As soon as issues of physical protection of nuclear material and security of radioactive sources have to be dealt with, these authorities will co-operate closely with the respective ***Federal*** or ***State Ministries of the Interior***, who are responsible for protective measures by the police.

Activity	Licensing	Regulatory Supervision
Construction, operation and decommissioning of nuclear installations; use of nuclear material	State Ministries for Environmental Protection	State Ministries for Environmental Protection
Transportation of nuclear material	Federal Office for Radiation Protection	State Ministries for Environmental Protection; Federal Railway Office
Storage, including interim storage, of nuclear material and high-level waste	Federal Office for Radiation Protection	State Ministries for Environmental Protection
Interim storage of low and intermediate level waste	State Authorities (Ministries, State Offices, District Authorities)	State Authorities
Final repository	State Ministry for Environmental Protection	Federal Office for Radiation Protection
Use, storage and transport of radioactive sources	State Ministries for Environmental Protection; Federal Office for Radiation Protection (for $A> 10^{12}$ Bq)	State Authorities (Ministries, State Offices, District Authorities); Federal Railway Office
Import/export of nuclear material and radioactive sources	Federal Export Office	Customs Border Control, Federal Ministry of Finance

FIG.1. Licensing and supervisory authorities in Germany.

The supervisory State authorities are empowered by the Act [1] to ***supervise*** permanently all activities licensed or authorized under provisions of the Act [1] or of the Ordinance [2], and they have the right of unannounced access to the respective facilities at any time; this is also valid for shipments of nuclear material or radioactive sources. In order to be capable of conducting all necessary inspections, the competent supervisory authority may task contracted experts with executing these inspections on her behalf. During supervisory inspections of nuclear installations and activities with respect to physical protection or security systems or measures provided by the licensee, the ***State Ministries of the Interior*** will participate as well, as they are responsible for protective measures by the police and for criminal investigation, when the need arises.

The supervisory authorities of the States are also responsible for operating ***a radiation protection register*** containing all information on the respective licensees, on the licensed practices or the licensed devices, on the properties, registration numbers and present locations of the radioactive sources; these State registers are helpful tools for the regulatory supervision, for the preparation of inspection plans, and for the identification of orphan sources.

The supervisory authorities of the States are responsible for accepting radioactive sources that will not be used any longer by the licensee for storage at authorized State waste collection and storage facilities. They are obliged to record all cases of illegal use, handling or any other unauthorized activity related to nuclear material and to radioactive sources and to report them to the ***Federal Ministry for the Environment, Nature Conservation and Nuclear Safety*** on an annual basis, at least.

3.2. SANCTIONS

The ***licensee*** (operator of a nuclear facility, user of radioactive sources, transporting agency of nuclear material or radioactive sources, etc.) ***is solely responsible*** for implementing all physical protection measures for nuclear material or security measures for radioactive sources as prescribed by the respective licence. He is also responsible for maintaining these measures in the state required by this licence at any time, for doing the necessary testing and inspection, for reporting of any abnormal event to the supervisory authorities, and for taking remedial actions in case he has identified technical failures or other kinds of malfunctions or deficiencies of his physical protection system or of his security measures.

He is obliged to co-operate and to co-ordinate all contingency activities with the police authorities and when the need arises with emergency management authorities.

Should the licensee fail to meet his obligations under the legal prescriptions of the Atomic Energy Act [1] or of the Radiation Protection Ordinance [2], or should he not adhere to the conditions contained in the respective licence, both legal documents specify a couple of sanctions which the competent supervisory authority may impose upon him in order to enforce compliance with the regulations. Under the national legal system these ***sanctions*** are: additional reporting obligations and supervisory inspections; additional safety or security/physical protection measures imposed through an amendment of the licence; temporary revocation of the licence until the required physical protection or security status has been achieved; administrative fines up to 50 000 € for the violation of licensing conditions; complete withdrawal of the licence.

A special system of sanctions can be implemented for nuclear activities in Germany by the European Commission in case safeguards obligations under the EURATOM Treaty [9] and the EURATOM Ordinance Nr. 3776/76 [11] are violated; these sanctions are specified in Article 83 of the EURATOM Treaty [9]. They range from an admonition, to withdrawal of financial or technical support or to complete withdrawal of nuclear material; these sanctions may also result in the submission of the operation of a nuclear facility under the direct supervision by a commissioner from the European Commission.

3.3. PHYSICAL PROTECTION OF NUCLEAR MATERIAL

Physical protection of nuclear material in use, storage and transportation is a very important element to prevent any illicit use of these materials from happening. It is the ***objective of physical protection*** to establish and maintain conditions to prevent

- theft or any other unauthorized removal of relevant quantities of nuclear materials,
- a direct release of considerable quantities of nuclear or other radioactive materials, and
- the initiation of plant conditions with inadmissible radiological consequences,

which may be caused by sabotage and by other criminal or terrorist acts. The implementation of physical protection measures by the licensee, therefore, is a ***compulsory licensing prerequisite*** specified in the Atomic Energy Act [1] for all activities regarding nuclear material as mentioned in section 3.1. above. The design of the respective physical protection systems has to be based on the national German design basis threat (DBT) and on the assumption, that counter measures by police response forces will become fully effective not earlier than after 30 minutes following an alert. The licensee's physical protection measures alone have to cope with the DBT for this initial time interval of an illegal intervention by third parties.

The DBT in Germany has been specified jointly by police and criminal investigation authorities, intelligence agencies and nuclear regulatory authorities on Federal and State level. It is based on the analysis of criminal and terrorist activities in Germany and abroad. This DBT is reviewed by the authorities from time to time in order to revise it when necessary. In addition, the current threat situation with respect to nuclear activities is closely monitored by police and intelligence authorities every day, to be able to initiate additional administrative and personnel physical protection measures by the licensee and by the police at facilities and for transports, in case the regular physical protection of the licensee needs to be upgraded because of an aggravation of the current threat situation.

The ***legal basis for physical protection in Germany*** consists out of four legally binding regulations:

- Act on the Convention on the Physical Protection of Nuclear Material [3];
- Atomic Energy Act [1];
- Ordinance for the Security Screening for Trustworthiness [4];
- General Administrational Regulation on the Protection of Classified Information [5].

Through the ratification process of the ***Convention on the Physical Protection of Nuclear Material*** [3] in 1990 several improvements of the German physical protection system were initiated: the categorization scheme in Annex II of the Convention became legally binding even for national nuclear activities. The assurances required by Article 4 of the Convention improved physical protection during international transports; the ***Federal Office for Radiation Protection*** is responsible for collecting and issuing these assurances in Germany.

The ***Atomic Energy Act*** [1] does not specify physical protection measures in detail; it only requires that

"the necessary physical protection measures against intrusions or other perturbations by third parties have to be ensured."

Specific regulations on physical protection measures in Germany therefore have been laid down in several ***authority guidelines***, most of which have been classified because of their sensitive content. At present, guidelines are in force on the following subjects:

- Design Basis Threat Confidential
- Physical Protection of LWR Nuclear Power Plants and Category I Nuclear Facilities Restricted
- Physical Protection of Interim Storage Facilities for Spent Fuel Restricted
- Physical Protection of Category III Nuclear Facilities Restricted
- Physical Protection of UF_6-Storage Facilities Unclassified
- Physical Protection Against Insider Actions in Nuclear Fuel Cycle Facilities Unclassified
- Physical Protection of Transports of Nuclear Material and High-Level Radioactive Waste Restricted
- Requirements Pertaining to Physical Protection Commissioners, Security Guards and Escort Personnel Unclassified.

In addition, there are recommendations on training of operator's guards services, on plans for periodic inspections and tests of physical protection systems, on illumination systems for physical protection of nuclear facilities, on back-fitting of barriers, on reporting of abnormal occurrences relevant to physical protection, on advance notifications of shipment of nuclear material, and on security concepts for computerized systems. The various structural, other technical, personnel and administrative physical protection measures specified in these authority guidelines and recommendations are based on a graded approach, reflecting the respective physical protection category and the radiological risks associated with potential releases of radioactive substances through sabotage or other criminal acts. With these acts, ordinances, regulations and technical requirements Germany meets the recommendations of the IAEA on physical protection INFCIRC/225 [7].

It has to be added, that ***protective measures by the police*** complement the physical protection provided by the licensee; these measures include general surveillance outside nuclear facilities, response and contingency planning, provision of adequate response forces up to SWAT[2)]-teams for every site and transportation route, a centralized alerting system, co-ordination centres for police actions, joint exercises by police forces and security guards, and transport escorts.

The ***Ordinance for the Security Screening for Trustworthiness*** [4] specifies all details related to the security screening for trustworthiness of all personnel working in nuclear installations, using or storing nuclear material, or participating in shipments of nuclear material. There are three different levels of screening, depending on the category of the

[2)] Special Weapons and Tactics.

respective plant, on the safety and security significance of the respective work or function, on the kind and quantity of accessible nuclear material, and on other criteria. The administrational procedure for conducting the screening process and the sources of information to be used by the regulatory authority are specified. The Ordinance [4] does also specify the acceptance criteria and requires, that the security screening has to be passed successfully by an employee before he is admitted access. The screening has to be repeated every five years.

The ***Regulation on the Protection of Classified Information*** [5] is a binding prescription of technical, personnel and administrative measures to protect all classified information of restricted, confidential, secret or top secret nature by all German authorities. For the general economy this administrational regulation is complemented by a so called "Handbook on the Protection of Classified Information by the Economy". Information on time schedules and routes envisaged for transports of nuclear material is treated as classified information.

3.4. SECURITY OF RADIOACTIVE SOURCES

Whenever the use, possession, storage or transportation of radioactive sources needs a licence, security measures are required as a licensing prerequisite by the relevant sections of the ***Radiation Protection Ordinance*** [2]. Section 74 of this Ordinance requires, that *"**radioactive substances, the activity of which exceeds certain limits specified in this Ordinance, have to be stored in protected rooms or protective containers against any loss or access by unauthorized personnel, as long as they are not used, processed or otherwise worked with**"*.

Standards give additional recommendations on how these protected rooms or protective containers should be designed. Furthermore, additional requirements regarding control of the radioactive sources by the licensee, his obligation to report to the competent supervisory authority on any loss, theft or other disappearance of a source, and on periodic inventories of the sources are specified in the Ordinance [2]. This way the requirements on security of sources to be found in Section II. 6.1 of the Basic Safety Standards [8] are reflected in the German legal system.

3.5. SAFEGUARDS OF NUCLEAR MATERIAL

Safeguards are an important complement to physical protection. All nuclear activities in Germany are subject to safeguards measures by the IAEA and by EURATOM (see figure 2). The legal basis for ***IAEA safeguards*** is the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) of 1 July 1968, which was ratified by Germany on 4 July 1974 [10], in particular Article III of this Treaty, and the safeguards agreement between the IAEA and Germany in force since 21 February 1977, based on document INFCIRC/153.

The legal basis for ***safeguards by EURATOM*** is the EURATOM Treaty of 25 March 1957 [9], in particular Articles 77 to 85 of this Treaty. Articles 86 and 87 state, that all fissionable nuclear material is EURATOM's property, and that all Member States, persons or enterprises have the unlimited right of utilization and consumption of this material as long as it has been rightfully procured.

The EURATOM Ordinance Nr. 3227/76 [11] is based on the EURATOM Treaty and specifies in detail how EURATOM safeguards have to be implemented; this ordinance is a multinational legal document which is directly legally binding in Germany like national legislation. The Ordinance [11] specifies the reporting of the technical design information and of the specific operational programmes of all nuclear facilities including storage facilities, of the respective nuclear materials, the details of containment and surveillance measures, accounting records, operational records, reporting on material balances and changes of the inventory, inspections, physical inventory taking, reporting on imports and exports of nuclear material. On the basis of all the information received from the operator the EURATOM Safeguards Inspectorate will draw up special safeguards provisions which will be the framework for the safeguards activities of EURATOM inspectors.

The ***safeguards activities by IAEA and by EURATOM*** have been put on a common legal foundation for the non-nuclear-weapon Member States of EURATOM through concluding the so called Safeguards Agreement of 5 April 1973 [12] between these States, EURATOM and the IAEA regarding the implementation of Article III Sections 1 and 4 of the NPT.

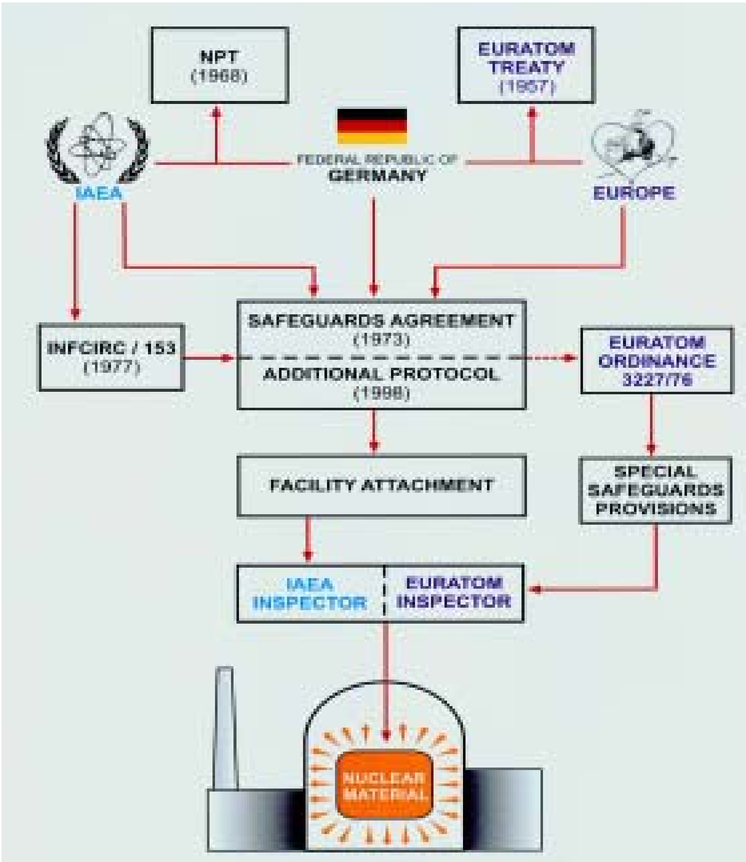

FIG. 2. Safeguards system in Germany.

Articles 3 and 31 of the Safeguards Agreement [12] state that the IAEA shall apply its safeguards in such a manner as to enable it to verify findings of the EURATOM’s safeguards system, making full use of and taking due account of the effectiveness of that system. According to Article 89 of the Agreement [12] EURATOM and the Member States have the right to accompany IAEA inspectors during their visits by EURATOM inspectors and representatives of the State; this has been common practice for a long time. Furthermore, the Safeguards Agreement [12] contains regulations on the objectives of safeguards, on the implementation of IAEA safeguards measures (provision, examination and verification of information; inspectors and inspections, records and reports systems), on statements on the results of IAEA verification activities, on transfers into and out of States, and a characterisation of EURATOM’s safeguards system.

As a result of the "93+2"-process the Member States of the European Union have signed the ***Additional Protocol to the Safeguards Agreement of 5 April 1973*** on 22 September 1998; the German Act on the Additional Protocol to the Safeguards Agreement [13] specifies the information on nuclear and non-nuclear materials, on specific equipment, certain activities and installations, that have to be reported to the IAEA by the Member States or by EURATOM within certain time frames under the new Safeguards Agreement [13]. It further regulates the right of access of IAEA inspectors in general simultaneously with a EURATOM inspector and the activities to be carried through by them, the obligations of the IAEA to inform the Member States and EURATOM about the course and the result of their work, the designation of inspectors, and the protection of confidential information.

Additional regulations concerning the implementation of the Safeguards Agreement [12] and of the Additional Protocol to it [13] in Germany have been specified in the Implementation Act [14]. Section 6 of this Implementation Act again clarifies that safeguards measures by the IAEA will be taken simultaneously with EURATOM safeguards measures.

Facility attachments therefore are jointly agreed upon by the IAEA, EURATOM and the European Member States.

3.6. IMPORT AND EXPORT CONTROL

The ***import and export control system*** in Germany is based upon several legally binding regulations:

- Foreign Trade Act [15].
- Foreign Trade Ordinance [16]
- Ordinance (EU) Nr. 3381/94 of the Council on Export Controls of Dual Use Items [17].
- War Arms Control Act [18].

The export of any installation, equipment, material or other item in particular those usable for nuclear applications under the ***Foreign Trade Ordinance*** [16] and the ***EU Ordinance*** [17] needs an export licence, if it is contained and described in the export list (Annex AL to Ordinance [16]). These legal restrictions are in force for exports to all countries, partly also for trade in transit. The Ordinance [16] is complemented by an import list, Annex to the Act [15].

The specific items contained in this Annex AL to Ordinance [16] reflect the content of agreements drafted by international bodies like the Zanger Committee and the Nuclear Suppliers Group (NSG). The Trigger List of the Zanger Committee has been published by the IAEA as INFCIRC/209/Rev. 2; the NSG Guidelines for Nuclear Transfers and for Transfers of Nuclear Related Dua Use Equipment, Materials, Software and Related Technology were also published by the Agency as INFCIRC/254/Rev. 4, Parts 1 and 2 in March 2000. Thus international agreements on export control have been incorporated into the national legal system of Germany.

The ***War Arms Control Act*** [18] pertains to the development, production, import, export and transit of such arms, equipment and materials as listed in the War Arms List (Annex to Act [18]).

The ***Foreign Trade Act*** [15] and the ***War Arms Control Act*** [18] impose fines up to 500 000 € on specific types of irregular conduct under these laws (for penalties see section 3.7).

Furthermore, the ***Atomic Energy Act*** [1] requires that any import or export of nuclear material needs to be licensed, and the ***Radiation Protection Ordinance*** [2] demands that the import or export of specified radioactive sources require licences as well. For radioactive sources of an activity level < 10^8 of specific exemption levels the export is admitted without prior authorization and after timely notification of the competent supervisory authority. In general, facilities or other institutions in Germany have to notify their competent supervisory authority about the importing of radioactive sources; these authorities can check the notifications against the information on trans-boundary movements of radiation sources provided by the central licensing and supervisory authority, the ***Federal Export Office***.

Responsibilities for licensing and regulatory supervision of import and export activities have been assigned to a variety of different authorities in Germany:

- ***Licensing of import and export*** under the Foreign Trade Act [15] and under the Ordinances [16], [17]: ***Federal Export Office***.
- ***Licensing of import and export*** under the War Arms Control Act [18].
- ***Federal Ministries of Defence, of the Interior, of Finance,*** and ***for Economy***, depending on their specified departmental responsibilities.
- ***Supervision of import, export and transit*** under the Acts [15], [18] and under the Ordinances [16], [17].

Customs Offices, Customs Investigation Offices, Customs Crime Office under supervision by the ***Federal Ministry of Finance***. For certain aspects under the War Arms Control Act [18] the ***Federal Export Office*** is also involved. For the supervision of the trans-boundary flow of goods the ***Federal Ministry of Finance*** can rely on the services of about 900 different ***Customs Offices*** and 48 ***Customs Investigation Offices***, in order to verify that all the restrictions of the aforementioned Acts and Ordinances regarding trans-boundary import or export are adhered to.

The large number of authorities engaged in licensing and supervising import and export activities, which becomes even larger when one includes investigation and prosecution authorities, has made it inevitable to convene a special body for the centralized co-ordination of the authorities regarding issues of general importance and important individual cases. Members to the so called *"**Interministerial Circle on Export Control**"* are: ***Federal Chancellery, Foreign Office, Federal Ministries for Economy, Finance, Interior, Justice, Traffic, Defence, Technology, Environment and Nuclear Safety, Federal Export Office, Federal Criminal Investigation Office, Customs Crime Office, Federal Intelligence Service, Federal Office for Protection of the Constitution***.

The German system of import and export control is capable of providing the IAEA with the declarations on exports of NSG Trigger List items called for under Article 2.a (IX) of the Additional Protocol [13] and of tracking any import of such items to provide the confirmation of the import to the Agency, as foreseen under the same Article.

3.7. PENALTIES

Penalties for offences against nuclear laws and regulations and for offences against import and export legislation, especially for any kind of illicit use of nuclear materials and radioactive sources, are stipulated in the German Penal Code [6], in the Foreign Trade Act [15] and in the War Arms Control Act [18]. The penalty, to which a perpetrator will be sentenced by the court, will depend on the specific characteristics of the respective case. The subsequent examples should therefore serve as a general overview:

- Unauthorized export (including transit) of certain goods related to nuclear energy and mentioned in the export list in Annex AL of the Foreign Trade Ordinance [16]: fine up to 250 000 €;
- Unauthorized disposal of radioactive substances and waste: up to five years imprisonment or fines;
- Preparation of an explosion or radiation crime: one to ten years imprisonment;
- Unauthorized use, storage, transport, import, export or handling of nuclear material or of radioactive sources including release of ionising radiation and unauthorized initiation of nuclear fission processes, which could result in death or severe injury of a third person: up to five years imprisonment or fines;
- Passing on nuclear material or radioactive sources to unauthorized persons or brokering such deals: up to five years imprisonment;
- Misuse of ionising radiation resulting in the danger of death or severe injuries of another person: up to ten years imprisonment;
- Radiation exposure of an undeterminable number of people: not less than five year up to life time imprisonment;
- Development, production, purchasing, import, export or transit of a nuclear weapon: up to five years imprisonment;
- Initiation of an explosion with nuclear energy: not less than ten years up to life time imprisonment.

The requirements of Article 7 of the Convention on the Physical Protection of Nuclear Material [3] regarding certain punishable offences with nuclear material had initiated a partial amendment of the German Penal Code [6] in this area when the Convention was to be ratified. The German Law on the Convention [3] made the respective offences punishable under the German Penal Code even when they have been committed by German nationals in foreign countries.

Criminal investigations and prosecution on such crimes will normally be executed by ***State Criminal Investigation Offices*** and ***State Police*** in close co-operation with the competent ***State Public Prosecutor***. Severe nuclear crimes under the War Arms Control Act [18] and nuclear crimes with a terrorist background will in most cases be investigated and prosecuted by the ***Federal Criminal Investigation Office*** in close co-operation with ***State Police*** and with the ***Federal Public Prosecutor General; Customs Investigation Services*** and the ***Customs Crime Office*** may also be involved. In general, criminal offences under the Foreign Trade Act [15] and under the War Arms Control Act [18] are investigated and prosecuted by the ***Main Customs Offices*** or by the ***Customs Investigation Services*** together with the competent ***State Public Prosecutor***.

4. DETECTION

Investigation activities and intelligence collection are the first important element of detection. German criminal investigation authorities (***Federal Criminal Investigation Office, State Criminal Investigation Offices, Customs Investigation Service, Customs Crime Office***) and the ***Federal Intelligence Service*** provided indications and information on up-coming illicit trafficking events in a couple of cases, often many days in advance. Such indications and information may have been obtained by these authorities through systematic investigations also making use of under-cover agents, through information exchange with foreign partner services (for example via INTERPOL), through collection and evaluation of evidence gathered during licensing or supervisory activities related to transboundary trade, or just by chance. In particular, the ***Federal Criminal Investigation Office*** and the ***Customs Crime Office*** systematically collect and evaluate indications on offences against the Acts [15] and [18] and on ongoing relevant criminal investigation activities. They will receive additional information from other Federal Ministries and the ***Federal Export Office***, as well. The ***Federal Intelligence Service*** contributes information about events in foreign countries which may be of relevance from the proliferation or disarmament point of view.

Additional helpful information on cases of illicit use of nuclear material or radioactive sources may result from the information distributed through ***national and international reporting systems***:

a) National

- Reporting obligations of licensees to national supervisory authorities under the Radiation Protection Ordinance [2].
- Reporting system regarding important events, which interconnects all German State and Federal Police Authorities from the local level up to the ministerial level and nuclear supervisory authorities that may be affected.
- Nuclear rapid reporting system, which interconnects all Federal Ministries and Federal Offices that may be affected, and the Federal level with the State level.
- (For additional information see paper [19]).

b) International

- IAEA Illicit Trafficking Database.
- Point of Contact (PoC) system under Article 5 of the Convention on Physical Protection [3].
- Expanded G8 PoC-system.

Detection of orphan radioactive sources or radioactively ***contaminated metal scrap*** **by** ***technical means*** is facilitated by the fact that nearly all metal scrap processing facilities and most scrap yards in Germany are equipped with radiation detection systems. There are stationary truck and railway wagon detection portals, mobile detection devices, and also devices for laboratory measurements for slag, dust and melts. Several Cs-137 sources with activities between 2.2 and 200 GBq had been detected in 1998 this way. For ships detectors have been installed at the cabins of some cranes. For the industry voluntary acceptance levels have been agreed upon, which are restrictive from the radiological point of view, not prescribed by regulations:

Steel industry: 8 15 nSv/h total radioactivity;
6 8 nSv/h artificial radioactivity.

Incinerating plants: 1 μSv/h total radioactivity;
200 nSv/h artificial radioactivity.

There also is a ***systematic surveillance*** of personnel and goods traffic via road or railway vehicles, aircraft or ship ***at border*** crossings, air- and seaports for illegally imported or exported radioactive material by ***radiation detection equipment*** applied by ***customs border officers*** and by the ***Federal Border Police***. Customs officers have been equipped with some 400 gamma dose-rate meters for detection purposes plus alarm-dosimeters for radiation protection; the ***Federal Border Police*** has received about 200 gamma dose-rate meters, alarm-dosimeters and some neutron detectors in addition. One border crossing is permanently monitored by a stationary gamma detection portal using plastic scintillators, one seaport is equipped with a truck lock monitored with a big plastic scintillator. In addition, there are 50 highly sensitive mobile gamma radiation detection modules using plastic and NaJ-scintillators, which are fitted to cars and operated by special mobile search squads. These mobile teams operate within an area of 30 km behind the respective border. Customs officers in general have far reaching rights which sometimes are more powerful than those of the ordinary police or justice officials: they can search luggage, vehicles, load, and even persons for unauthorized imports or exports of nuclear material without any reason for suspicion within 30 km behind the border and within 50 km off the German sea coast. In case there are reasons for suspicion, they can perform search activities throughout the whole German territory. Customs authorities and nuclear regulatory authorities have agreed on an ***intervention level of 1µSv/h*** for additional radiation measurements and investigations by State radiation protection authorities or contracted specialists at the border. This intervention level is also valid for mobile customs detection squads. From gamma radiation dose-rates equal to or exceeding 6 µSv/h the respective load will in general be rejected at the border crossing without further investigation.

Customs services closely co-operate with the ***State radiation protection authorities***, as soon as radioactive material has been detected; the State authorities can be contacted 24 hours a day. The State radiation protection authorities will also take care of any in-depth analysis of radioactive sources that have been confiscated, either by making use of their own capabilities or by asking university institutes or research centres for assistance. When the confiscated material is nuclear material, it will be turned over to the ***EURATOM Institute for Transuranium Elements*** at Karlsruhe which is equipped with all scientific techniques to implement full-scope nuclear forensic analyses on that material.

Police and criminal investigation authorities on the Federal and on the State level are also equipped with gamma and beta radiation detection systems and with personal alarm-dosimeters, in a few cases also with neutron rem-counters. This equipment will not be capable of determining the kind of radioisotopes, the isotopic composition, and whether it is nuclear material or not. In case they will need neutron detection systems, gamma spectrometers or contamination detectors in the course of any mission, these authorities will have to call for assistance by the State radiation protection authorities or by the ***Federal Office for Radiation Protection*** (see section 5.2. for further details).

Training and re-training of police, border guards and customs officers have proven to be an essential element of improving detection of illicitly trafficked nuclear material and other radioactive substances. In order to ensure appropriate personal radiation protection behaviour and the capability to interpret radiation detection system readings correctly, the basic training had to focus on making law enforcement personnel familiar with basic radiation protection matters, with detection of nuclear radiation and with the use of relevant equipment. Radiation protection experts from State authorities and from the ***Federal Office for Radiation Protection*** participate in these training programmes as lecturers. As this kind of training needs to be repeated on a regular basis for various reasons, experience from actual illicit trafficking cases is being fed into the training courses, in particular regarding types of seized radioactive material, types of packages and containers, and other characteristic features. Subjects related to illicit trafficking of dual-use items, which would include modus operandi procedures (senders, receivers, mode of transport, transport routes, payment procedures, etc.) are normal elements of training courses for customs personnel.

Joint seminars and exercises are organised for law enforcement officers, explosives disabling specialists, and radiation protection experts. Such seminars and workshops serve also the purpose to get the involved staff from the different authorities to know each other and, thereby, to co-operate confidently and effectively.

5. RESPONSE

Paragraph 1 of Article 5 of the Convention on the Physical Protection [3] mentions *"**recovery and response operations in the event of any unauthorized removal, use or alteration of nuclear material or in the event of credible threat thereof**"*. Paragraph 4.1.6 of INFCIRC/225/Rev. 4 [7] recommends: *"**The State should develop and implement emergency plans for any needed response to unauthorized removal and subsequent unauthorized use of nuclear material or sabotage of nuclear material …**"*. In Germany the respective planning of ***hazard prevention measures*** in cases of unlawful possession or use of nuclear material and other radioactive substances in particular concentrates on events like

- accidental finding of nuclear material or radioactive sources,
- nuclear material missing from a facility or transport (loss, unauthorized removal),
- robbery or forced extortion of nuclear material,
- illegal possession, including illicit trafficking of nuclear material or radioactive sources,
- hreats concerning,
- release or dispersion of nuclear or other radioactive material by conventional explosives (Radiation Dispersal Device RDD),
- construction and/or use of a critical assembly or of an **i**mprovised **n**uclear **d**evice (IND).

For ***criminal investigation and prosecution purposes*** a wider definition of "nuclear crimes" is applied: "illegal activities involving radioactive materials or materials which the perpetrator claims to be radioactive".

5.1. STATE LEVEL

As a consequence of Germany being a federation of sixteen States, each State has its own police, criminal investigation and public prosecution authorities, as well as nuclear supervisory authorities, radiation protection authorities, and emergency management authorities. Apart from a few types of events, in which the ***Federal Criminal Investigation Office*** will be responsible for investigations, these ***State authorities are primarily responsible for law enforcement and hazard prevention*** in cases like the ones just mentioned, for constitutional reasons.

In addition to these State authorities, several Federal authorities with specific responsibilities may be involved, depending on the specific nature of the case: ***Federal Criminal Investigation Office, Federal Border Police, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety,*** **and** ***Federal Office for Radiation Protection*** (see 5.2.).

In the German response system for cases of illegal use of radioactive substances (including illicit trafficking) the tasks of the various State authorities have been specified in additional

State regulations or administrative guidelines, taking into account what is regulated already in a more general way in existing Federal and State legislation. These regulations specify responsibilities and tasks assigned to the respective authorities, coordination procedures and leadership, communication links, reporting and alerting procedures. Under these regulations ***the tasks assigned to law enforcement authorities*** (police, criminal investigations, customs) are:

- collection of indications, information or evidence for cases of illegal use of radioactive substances and informing other authorities possibly affected;
- assessment of the credibility and feasibility of threats;
- criminal investigation and criminal assessment of the situation;
- etermination of the suitable area (for search activities with radiation detectors) through criminal investigations;
- upport of search activities with radiation detectors by police personnel;
- urgent hazard prevention measures such as measurements of radioactivity for self-protection, cordoning off and access control to target area, as long as radiation protection authorities have not yet arrived on the scene;
- disabling of explosive devices;
- control of vehicle and personnel traffic crossing borders or entering the country through airports or seaports (Federal responsibility);
- confiscation of radioactive materials, arresting of perpetrators, collection of evidence, forensic measures.

The law enforcement authorities will be assisted by fire brigades and by explosives disabling experts available in every State, should the specific event demand their deployment.

The ***nuclear supervisory authorities*** and the ***radiation protection authorities*** of the German States ***have been assigned the following tasks*:**

- expert advice to and support of the law enforcement authorities from the very beginning of a specific case regarding radiological or nuclear criticality risk assessment, detection, radiation protection, analysis, and safe handling;
- assessment of the technical feasibility of threats involving radioactive or nuclear materials, and of potential radiological consequences;
- search for radioactive materials with mobile radiation detectors;
- radiation measurements on the scene (local radiation fields, contamination of people or vehicles, isotope analysis, total activity, quantity of nuclear material);
- specification of isolation or access control areas and of permissible radiation exposure limits for law enforcement personnel;
- radiation protection measures, including measurements of incorporated material and decontamination;
- determination of internal structure of RDD or IND by non-destructive analysis;
- determination of meteorological conditions and atmospheric transport coefficients, calculation of potential off-site radiation exposure;
- expert advice on measures to mitigate radiological consequences from disabling actions on RDD;
- recommendations regarding emergency measures;
- safe handling, packaging and transport of confiscated radioactive materials to secure storage places;

- detailed laboratory analysis of the physical, chemical and nuclear characteristics of confiscated radioactive materials, including isotopic composition, enrichment factor, impurities, etc., and nuclear forensic measures.

As far as possible, all actions to be taken are specified and agreed upon *jointly* by State law enforcement and radiation protection authorities and when necessary by explosives disabling experts; the advice and participation of the radiation protection authorities are sought as early as possible.

When special technical or scientific support pertaining to radiation detection and analysis, nuclear criticality safety, radiation protection or risk assessment is needed, the State authorities will draw from the experience and the resources available at the nuclear research centres in Jülich and Karlsruhe, at university institutes, and at the ***Federal Office for Radiation Protection***. Detailed analysis of all confiscated nuclear material for determining their isotopic composition and chemical characteristics, as well as their possible origin, is done by the European Institute for Transuranium Elements at Karlsruhe.

Radiation detection and analysis equipment available with the nuclear and radiation protection authorities of the States in general are contamination detectors, neutron detectors, mobile gamma spectrometers, dose-rate meters. For mobile search activities by road vehicles or helicopter the State Authorities will have to ask the ***Federal Office for Radiation Protection*** for assistance, as the State Authorities do not have the necessary technical equipment; this is also valid for covert search actions on foot.

The State authorities have been provided with a "***Handbook on Nuclear Hazard Prevention***", which contains a lot of useful information and which is up-dated twice a year: structure of the Federal support (see section 5.2.); links of communication (telephone, fax) to all operations centres, nuclear supervisory and radiation protection authorities, ministries of the interior on State and Federal level plus listing of liaison officers; catalogue of recommended actions in cases of unlawful activities involving nuclear material and radioactive substances; guidelines for joint actions by radiation protection experts and disabling specialists; overview of support offered by the ***Federal Office for Radiation Protection*** (see section 5.2.); list of characteristic data of radioisotopes, on nuclear criticality risks and on radiation protection; search strategies; legal conditions for transportation of seized radioactive material, availability of containers; EURATOM support; State specific regulations.

In addition to State law enforcement authorities and nuclear supervisory or radiation protection authorities, who will deal with ***routine cases of illegal use or transportation*** of radioactive materials like illicit trafficking, additional authorities or services may have to participate in response activities to ***severe cases of illegal use*** of radioactive substances, which may include RDD or IND cases; emergency management authorities, the ***State Ministries of the Interior, of Justice,*** **and** ***of the Environment*** as well as explosives disablement services may have to be integrated on the State level. For these cases ***Interministerial Coordination Groups*** have been installed on the level of State governments. These groups will do part of the risk and hazard assessment, will jointly specify necessary measures to be implemented under the responsibility of each ministry, will monitor the co-ordinated implementation of the response measures, and will prepare political decisions.

Further information on principles, on reporting, distribution of information, and on 24 h availability of the authorities has been provided in paper [19].

5.2. FEDERAL LEVEL

The ***Federal Ministry of the Interior*** **and the** ***Federal Ministry for the Environment, Nature Conservation and Nuclear Safety*** have ***no direct responsibility for hazard prevention*** because of constitutional reasons. However, as the latter ministry has been nominated as being the Point of Contact under Article 5, Paragraph 1 of the Convention on the Physical Protection [3], the ***Federal Ministry for the Environment, Nature Conservation and Nuclear Safety*** is also responsible for the co-ordinated response to cases of illegal use of radioactive substances if such cases may affect several States or if a case cannot be localized within the territory of a specific State; this ministry will execute his co-ordinating function in close co-operation with the ***Federal Ministry of the Interior***. The ***Federal Ministry for the Environment, Nature Conservation and Nuclear Safety*** also has the task to maintain liaison with the IAEA, the EURATOM Safeguards Inspectorate, and with foreign countries with regard to nuclear or radiological aspects.

The ***Federal Office for Radiation Protection*** has the legal responsibility, the technical and the personnel resources to ***"… support the competent authorities upon their request in cases of losses or finds of radioactive materials as well as in cases of illegal activities in connection with such materials in their search and analysis, and by providing protective measures during seizures, as far as lives, health and goods are severely endangered and the competent authorities are not capable of carrying out these measures without this support"***.

In order to meet its responsibilities, the Federal Office has set up a standby service capable of convening a task force at three different locations in Germany for the search (overt and covert) for radioactive materials, for the analysis and determination of the isotopic composition and quantity or activity of radioactive material involved, for risk assessment and prediction of radiological consequences, and for containment measures. Search for gamma and neutron radiation may be done on foot and also using a road vehicle; search activities using helicopters apply Na J-gamma detectors. Mobile HP Ge-spectrometers in combination with gamma and X ray radiography will provide information on the isotopic composition of the radioactive material, and on the spatial distribution of radioactive material inside a container. A containment system designed to minimize radiological consequences of a disabling action carried out on a RDD makes use of aqueous foam; it has been tested up to 10 kg of conventional explosives, and shows 99,3% efficiency for retaining dispersible radioactive particles. Tests on a larger system for up to 100 kg of explosives are under way.

Currently a ***Federal Support Group*** is being set up which will combine the expertise, technical and personnel capabilities of the ***Federal Office for Radiation Protection,*** **the** ***Federal Criminal Investigation Office*** and the ***Federal Border Police***. The main tasks of this support group will be:

- determination and analysis of the isotopic composition of radioactive substances and materials,
- assessment of nuclear criticality risks,
- predictions on nuclide propagation and radiation exposures,
- determination of meteorological parameters needed for atmospheric transport calculations,
- assessment of possible radiological impacts of RDD,
- overt or covert search for radioactive materials, detection of radioactive material,
- non-destructive and remote analysis of objects of unknown content,
- nuclide identification and assessment of activity levels,

- measures to mitigate radiological consequences,
- identification and deactivation of access denial devices,
- disabling of fuses and igniters.

The support group will have an operations commander and three separate operational sections formed by each of the Federal partners mentioned above; it will have its autonomous logistic supply with respect to telecommunication, surface and air transportation, detection and protection equipment. The reasons for the formation of **this *centralized support group*** were:

- to make best use of the technical and personnel resources available with Federal services;
- to establish ***optimised response structures for severe cases of illegal use*** of nuclear material and other radioactive substances;
- to enable regular training of highly qualified experts from different professional fields and thereby optimise co-operation;
- to set up an efficient centralized response tool which the 16 State governments would not be able to install with their own personnel and technical resources.

In an actual case, the ***Federal Support Group*** can be deployed upon request of the responsible State Interministerial Coordination Group; its deployment will have to be authorized by the ***Joint Federal Coordination Group*** **(*Federal Ministry of the Interior, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety*)**. The Federal Support Group will be integrated as a whole into the organizational structure of the responsible State; Figure 3. shows an example for such an organizational structure. The ***Joint Federal Coordination Group*** may also issue recommendations on appropriate actions to the Interministerial Coordination Group of the State, and it will contact international organizations and foreign countries for additional support, in case this is necessary.

6. FINAL REMARKS

Since May 1997 the number of cases of illicit trafficking in radioactive substances in Germany, in which radioactive material could be seized by the competent authorities, has decreased considerably to about 5 to 8 cases per year; since that time only radioactive sources and contaminated metal scrap was involved, no nuclear material. The German authorities nevertheless are convinced, that every effort has to be made to keep the national system for prevention, detection and response to the illicit use of nuclear material and of radioactive sources effective and to improve it, wherever necessary. Germany is also convinced, that support to and co-operation with international programmes in this field is an important contribution to improve the situation regarding prevention, detection and response world-wide. Therefore, German authorities participate actively in the IAEA programme “Measures Against Illicit Trafficking in Nuclear Materials and Other Radioactive Sources”, in particular in the “Illicit Trafficking Database” project, since November 1994, and in the G8 “Programme for Preventing and Combating Illicit Trafficking in Nuclear Material” agreed upon at the Moscow Special Summit on 20 April 1996. Furthermore, Germany is directly engaged in bilateral support projects regarding training in physical protection, and up-grading physical protection systems since 1992.

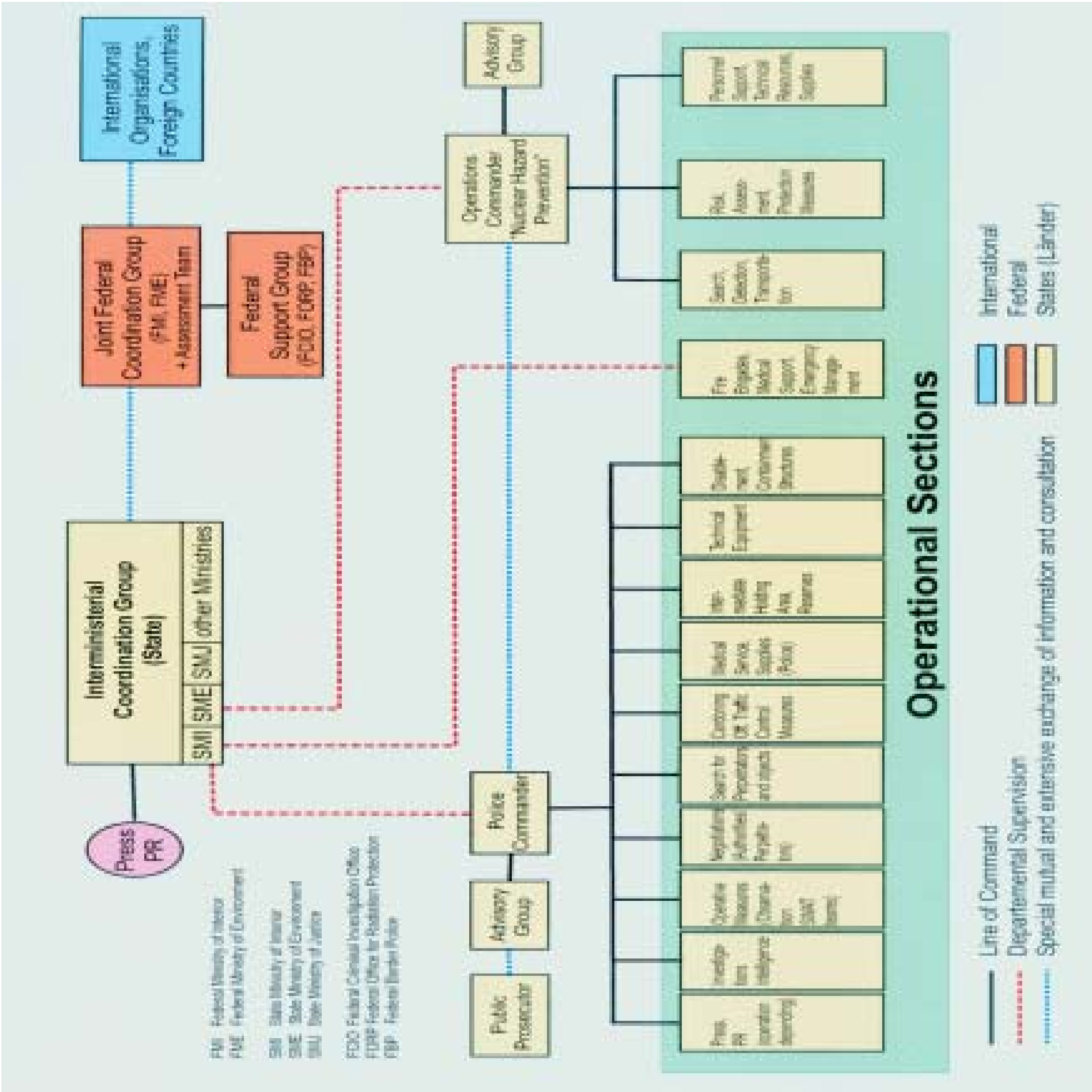

FIG. 3. Organizational structure for response to severe cases of illegal use.

REFERENCES

[1] Atomic Energy Act Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren i. d. F. der Bekanntmachung vom 15. Juli 1985 (BGBl. I S. 1565), zuletzt geändert durch Artikel 1 des Gesetzes vom 03. Mai 2000 (BGBl. I S. 636, ber. S. 1350) (in German).

[2] Radiation Protection Ordinance Verordnung über den Schutz vor Schäden durch ionisierende Strahlen vom 30. Juni 1989 (BGBl. I S. 1321, 1926), zuletzt geändert durch Verordnung vom 18. August 1997 (BGBl. I S. 2113) (in German).

[3] Act on the Convention on the Physical Protection of Nuclear Material Gesetz zu dem Übereinkommen vom 26. Oktober 1979 über den physischen Schutz von Kernmaterial vom 24. April 1990 (BGBl. II S. 326) (in English, French and German).

[4] Ordinance for the Security Screening for Trustworthiness Verordnung für die Überprüfung der Zuverlässigkeit zum Schutz gegen Entwendung oder erhebliche Freisetzung radioaktiver Stoffe vom 06. Juli 1999 (BGBl. I S. 1525) (in German).

[5] General Administrative Regulation on the Protection of Classified Information Allgemeine Verwaltungsvorschrift zum materiellen und organisatorischen Schutz von Verschlusssachen, Federal Ministry of the Interior, 1994 (in German).
[6] Penal Code Strafgesetzbuch i. d. F. der Bekanntmachung vom 10. März 1987 (BGBl. I S. 945, ber. S. 1160), zuletzt geändert durch Artikel 1 des Gesetzes vom 26. Januar 1998 (BGBl. I S. 164) (in German).
[7] INTERNATIONAL ATOMIC ENERGY AGENCY, The Physical Protection of Nuclear Material and Nuclear Facilities, INFCIRC/225/Rev.4 (Corrected), IAEA, Vienna (1999).
[8] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, IAEA, Vienna (1996).
[9] EURATOM Treaty Vertrag zur Gründung der Europäischen Atomgemeinschaft vom 25. März 1957 (BGBl. II S. 753) (in German).
[10] Act on the Treaty on Non-Proliferation of Nuclear Weapons Gesetz zu dem Vertrag vom 01. Juli 1968 über die Nichtverbreitung von Kernwaffen vom 04. Juni 1974 (NV-Vertrag) (BGBl. II S. 785) (in English, French and German).
[11] EURATOM Ordinance Nr. 3227/76 Verordnung (EURATOM) Nr. 3227/76 der Kommission vom 19. Oktober 1976 zur Anwendung der Bestimmungen der EURATOM-Sicherungsmaßnahmen (ABl. EG Nr. L 363/1 vom 31.12.76) (in German).
[12] Act on the Safeguards Agreement of 5 April 1973 Gesetz vom 04. Juni 1974 zu dem
[13] Übereinkommen vom 05. April 1973 zwischen den Nichtkernwaffenstaaten der Europäischen Atomgemeinschaft, der EURATOM und der IAEO in Ausführung von Artikel III Absätze 1 und 4 des Vertrages vom 01. Juli 1968 über die Nichtverbreitung von Kernwaffen (BGBl. II S.794) (in English and German).
[14] Act on the Additional Protocol of 22 September 1998 to the Safeguards Agreement of 5 April 1973 Gesetz vom 29. Januar 2000 zu dem Zusatzprotokoll vom 22. September 1998 zu dem Verifikationsabkommen vom 05. April 1973 (BGBl. II S. 70) (in English, French and German).
[15] Act on the Implementation of the Safeguards Agreement of 5 April 1973 and of the Additional Protocol of 22 September 1998 Ausführungsgesetz vom 29. Januar 2000 zu dem Verifikationsabkommen vom 04. April 1973 und zu dem Zusatzprotokoll zu diesem Abkommen vom 22. September 1998 (BGBl. I S. 74) (in German).
[16] Foreign Trade Act Außerwirtschaftsgesetz vom 28. April 1961 (BGBl. I S. 481), zuletzt geändert durch Artikel 13 des Gesetzes vom 09. Juni 1998 (BGBl. I S. 1242, 1254) (in German).
[17] Foreign Trade Ordinance Verordnung zur Durchführung des Außenwirtschaftsgesetzes i. d. F. der Bekanntmachung vom 22. November 1993 (BGBl. I S. 1934, 2493), zuletzt geändert durch die 44. Verordnung zur Änderung der Außenwirtschaftsverordnung (in German).
[18] Ordinance (EU) Nr. 3381/94 of the Council Verordnung (EG) Nr. 3381/94 des Rates vom 19. Dezember 1994 über eine Gemeinschaftsregelung der Ausfuhrkontrolle über Güter mit doppeltem Verwendungszweck (ABl. EG Nr. L 367 S. 1, geändert durch Verordnung (EG) Nr. 837/95 vom 10. April 1995, ABl. EG Nr. L 90 S. 1) (in German).
[19] War Arms Control Act Gesetz über die Kontrolle von Kriegswaffen i. d. F. der Bekanntmachung vom 22. November 1990 (BGBl. I S. 2506), zuletzt geändert durch Artikel 2 des Gesetzes vom 06. Juli 1998 (BGBl. I S. 1778) (in German).

[20] KRÖMER, P.W., FECHNER, J.B., KILLUS, W., "Experience with Illicit Trafficking in Nuclear Materials in Germany, Situation report and co-operation between law enforcement and radiation protection authorities" (Proc. Conference on Physical Protection of Nuclear Materials: Experience in Regulation, Implementation and Operations, 1997), IAEA, Vienna, (1998).

QUESTIONS AND ANSWERS

S. Fernandez Moreno (Argentina): What is the role of EURATOM with regard to illicit trafficking in nuclear materials?

J. Fechner (Germany): EURATOM Safeguards requires a report on the amount and the isotopic composition of any nuclear material confiscated during illicit trafficking events and then conveys the information to IAEA Safeguards. The European Institute for Transuranium Elements, Karlsruhe, does nuclear forensic analysis of confiscated nuclear material, sends EURATOM inspectors — when needed — to the scene of confiscation, and provides interim storage.

S. Fernandez Moreno: Could you describe in more detail the actions taken by the German authorities when customs detect nuclear material or radioactive sources?

J. Fechner: Customs call upon specialist support from the State radiation protection authorities, who decide the fate of material.

D. Flory (France): a) What resources do the state (Länder) authorities have for licensing in PP? b) How is homogeneity of PP measures ensured across the 16 states?

J. Fechner: a)The licensee submits a proposal to the authorities, who specify the criteria for a review and contract expert organizations to review the proposal. The cost of this review is born by the licensee/applicant. b) Homogeneity of PP measures is ensured through authority guidelines — agreed on between federal and state ministries — and through the fact that the Company for Nuclear Safety (GRS) is generally the only organization contracted for review and assessment.

A. Nilsson (IAEA): Could the comprehensive approach taken by Germany and the UK serve as a model for other States?

J. Fechner: Yes, the approaches taken by these countries in responding to cases of illegal use — including illicit trafficking — of nuclear materials and other radioactive sources can be useful in developing models for other countries, particularly as the approaches are similar and were arrived at independently.

THE SWEDISH POLICE AS PART OF THE SECURITY SYSTEMS OF NUCLEAR AND OTHER RADIOACTIVE MATERIALS

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Abstract. In Sweden a special transport system has been developed for transports of nuclear substances and nuclear waste. This system in itself includes a high security level. Extraordinary circumstances can give cause for protective police measures and intervention. In concerned provinces an incident and emergency response planning is carried out of the police actions that may be needed at the following types of events:
(a) bomb threat;
(b) attack or threat of attack on transport vehicle;
(c) demonstrations.
If a Swedish nuclear power plant is the subject of a bomb threat or other criminal assault, it is in Sweden, according to the Police Act, the task of the police to intervene, interrupt criminal acts and to restore order and security. The role of the Swedish police as regards the physical protection is, among other things, to carry out a certain control within protected area by specially trained police personnel before a reactor is put into operation or restarted after revision or repair. Police authorities that have a nuclear power station within its jurisdiction should establish a plan for police actions at the nuclear power station in consultation with legal owner or management of the plant, the Swedish Nuclear Power Inspectorate and the county administration. Special training and frequent practice of response personnel is crucial as well as co-training with key personnel at nuclear power stations. The National Criminal Investigation Department co-ordinates and commands police measures concerning different types of nuclear transports. Close co-operation with security and operational personnel at the nuclear power stations, operators of the transport system, the Swedish Nuclear Power Inspectorate and the Swedish Radiation Protection Institute is very important.

1. INTRODUCTION

Technology is developed by engineers and inventors in order to satisfy something that is needed in society. The development complies with laws of nature and formulas of technology. What is good may, however, be put to improper use. Technology can be frightening and therefore provoke counter forces. Technology is not only hard ware but also soft ware. There is an ethical dimension to everything that is technical. Evaluation, progress and adaptation are not always synchronized, and owing to this conflicts arise from different reasons and in different ways. The principal duties of the Swedish Police is stated as one aspect of community involvement in the promotion of justice and security and should be aimed at maintaining public order and safety as well as providing protection and assistance to the public.[1]

As a background to the involvement of the Swedish Police in the measures to prevent, intercept and respond to illicit uses of nuclear material and radioactive sources it is important to first have a look in the rear view mirror. To understand a position it is also important to know the place and have some feeling about circumstances with regard to the time context. Understanding yesterday is advisable in a process of looking forward.

1.1. DEVELOPMENT OF TECHNOLOGY

The first nuclear reactor that was a research reactor was put into operation in December 1942 in Chicago, USA. With this it was proved from an experimental point of view that it was possible to set free nuclear energy from uranium in a reactor. After a tentative beginning in

[1] 1 § The Police Act (1984:387).

the late 1940s the development of nuclear reactors for submarines and for the production of electric power was started.

The first reactor in Sweden, the research reactor R 1, was taken into operation in 1954. R 1 was located in the Royal Institute of Technology in Stockholm and was designed for operation with natural uranium as fuel and heavy water as moderator. In 1955 Sweden reached a latent capacity to produce nuclear weapons and a protective research programme was conducted up to 1968, when the Swedish government signed the Non-Proliferation Treaty[2]. The first reactor in Sweden for heating and power production was the reactor situated in Ågesta that was taken into operation in 1963.

Much has happened since then. Twelve reactors have been built in Sweden. These reactors are distributed among four power stations: Oskarshamn, Barsebäck, Ringhals and Forsmark one reactor at Barsebäck has recently been shut down. We have experienced the events at TMI-2[3] in March 1979 and how about 144 000 Three Mile Island residents were evacuated some time in the course of the disaster. Twelve days before the TMI disaster the movie "The China-Syndrome", starring Jane Fonda, was released in the USA. It was a film about nuclear safety and about television. The film expounded a popular theory that an uncovered reactor core could melt through the bottom of the plant straight to China. Also in Sweden people were standing in line in order to see this movie. Swedish media made comparisons between TMI and the Swedish sites devoted to the theme "if it had occurred here". As a consequence of the TMI disaster there was a referendum in March 1980 in Sweden and we had a change of the Swedish nuclear programme. It was established that the emergency preparedness was unsatisfactory. The owners of the plants received the media in order to inform about nuclear power. The representatives of the media wondered at the fact that they were let into the plants without any difficulties and that they were not subjected to enough rigid security controls. What would have happened if we had brought an explosive charge, the journalists asked. They meant that the threat of sabotage was not sufficiently taken into consideration and associated, not to proliferation or theft of the nuclear material, but to the risk of radioactive damages in the surrounding environment. Nuclear power demanded nuclear police and involved the way towards a control and police state, some people claimed.

This occurred at the same time as the Swedish Nuclear Power Inspectorate issued new directives with regard to physical protection at the Swedish nuclear power plants. The National Police Board studied these directives and could establish that the directives implied the participation of the police as an essential part of the physical protection. Even if the directives of the Swedish Nuclear Power Inspectorate were not directly directed towards the police but towards the owners of the plants, what was demanded from the part of the owners of the plants and the design scenario that was presented constituted clear information about what was expected from the part of the police. The project work that was initiated within the Swedish police shaped a basic policy that in principle is the same today.

Also the issue of the nuclear waste and the transport of fissile material was focused. Regardless of how Sweden´s energy requirements will be met in the future and regardless of whether the Swedish people are for or against nuclear power the spent fuel exists and must be managed and disposed of.

[2] Swedish Nuclear Inspectorate Report 01:15, March 2001.
[3] TMI, Pennsylvania, USA.

A central interim storage facility for spent nuclear fuel, CLAB, has been located adjacent to the Oskarshamn power station. The construction of CLAB started in 1980 and the operation was started in 1985. Spent nuclear fuel from the Swedish nuclear programme is transported to CLAB where the fuel is stored in deep water-filled pools for radiation shielding and cooling.

After 30–40 years of interim storage in CLAB, the spent fuel will finally be disposed of. This is planned to be done in a deep repository, about 500 meters down in the Swedish bedrock. After eight feasibility studies a site investigation will start in 2002 in three different places (Oskarshamn, Östhammar and Tierp). Finally the Swedish Government will have to decide whether or not to issue a siting permit for the building of the facility under the Nuclear Activities Act and the Environmental Code.

In the autumn of 1983 the construction began to create a final repository for all the low (LLW) and intermediate (ILW) level radioactive operational waste from nuclear power stations, medical care, industry and research facilities in Sweden. In this repository 50 meters below the Baltic Sea at Forsmark replaced parts from nuclear power plants and parts from decommissioned and dismantled reactors are disposed of. The Swedish Final Repository for Radioactive Operational Waste — SFR — started receiving waste in April 1988. A special transport system was constructed for the handling of radioactive products.

1.2. IDENTIFICATION OF THE ROLE OF THE POLICE

According to the Police Act (1984:387) the duties of the Swedish police are, in a wider perspective, aimed at crime prevention and to prevent disturbances of public order and safety and to take actions when such disturbances occur. The police shall carry out investigative and criminal intelligence work in connection with indictable offences. Thus, it is the task of the Swedish police to intervene and restore public order and security and to investigate the crime if the physical protection or the secure and safe operation at a nuclear power station is in danger. In the same way the police are a part of the physical protection at transports of fissile material. The police are the intervening part of the systems.

1.2.1. A personel perspective

For the author, first as chief of Tierp Police department from 1977 to 1992 and then as provincial commissioner in the Uppsala province in which Forsmark power station is situated and now as national commissioner with responsibility for nation-wide and international operations, nuclear issues have constituted a predominant part of his professional life. There have been many milestones. The first incident that the police took part in at Forsmark in 1977 concerned an accident caused by an explosion during the period of the construction of the power station. The incident created the basis of trustful co-operation for several intense years. The first large-scale demonstrations against nuclear power at the Barsebäck nuclear power plant and at Forsmark. The study visit in 1979 at the German nuclear power plant Biblis outside Wiesbaden, a leading plant with solutions also to police issues that had a certain influence on what later on took place in Sweden. The demonstrations against nuclear power at Brokdorf in Schleswig-Holstein and the massive police interventions in February 1981 in what was called “the battle of nuclear power in Western Germany” by media, and in the same year the visit at the shipyard in Le Havre where the special ship Sigyn was still a heap of steel plates. The first training course of the Swedish police in physical protection of nuclear power plants in the autumn of 1980.

A visit in Harrisburg and the meeting with Keven Malloy, emergency manager, in 1988 and the discussions with him regarding the TMI events also belong to the milestones. The Tierp police department received the site alarm from Forsmark on the hot Monday, 28 April 1986 at 11.04. By that time the thrilling and dramatic hunt for the source of the radioactive fall-out outside the Forsmark power station had been going on since seven o'clock in the morning. In the morning radiological safety engineer Bengt Bellman had passed through the frame monitor on his way **into** reactor 1. The monitor gave an alarm. There was radioactive stuff on him. A couple of hours later Forsmark declared a site emergency alarm. The alert was as follows: "A small emission has taken place at Forsmark. Site emergency". At the same time we understood that there was no fuel failure. The personnel that were not needed at the power station were evacuated. Shortly after that Kevin Molloy from Harrisburg called the author at the police command room from overseas and asked if he could be of any assistance. That demonstrates the importance of professional networks with regard to police work. Shortly after 14.00 the action was called off. The same day, in the evening, there was a short statement from the Soviet government in the news program Vremja (that means time). "An accident has occurred at the nuclear power plant in Chernobyl, one of the nuclear reactors has been damaged. Measures have been taken to eliminate the consequences of the accident. Those that have been affected are being treated". For a number of days the search for the person that one month previously had murdered the Swedish Prime Minister Olof Palme in the street in Stockholm came only as a second item in the Swedish news.

In the first year of the Swedish nuclear power history the Swedish Nuclear Fuel Supply Company signed a contract with the French state-owned company COGEMA for the reprocessing of spent fuel in La Hague. Another contract for the Oskarshamn power station was signed with the British state-owned company British Nuclear Fuels Ltd and fuel was sent to its reprocessing plant at Windscale.

According to a decision made by the Swedish parliament Sweden shall nowadays be completely independent of other countries with regard to the handling of the nuclear waste from Swedish nuclear power plants. For this reason, through an exchange procedure, transports to Sweden of so called MOX fuel from Germany via Lübeck and later Emden took place. These transports were surrounded by protest actions in Germany as well as in Sweden. The author was tasked with the responsibility of the police part of the physical protection of these transports that took place on ten occasions in 1987 and 1988 and one transport of uranium hexafluoride in January 1988 from Germany to Sweden that attracted much attention. These transports were targeted and occasionally blocked by Greenpeace, groups of environmental activists and met with protests in Germany, Denmark and Sweden. Even if the public order and safety was disturbed and crimes committed, the nuclear security and safety were never endangered.

The retrospect that has been presented with examples from a personal perspective clearly shows that nuclear technology involves a lot of duties for the Swedish police. The interest of the public and the media in these issues makes those tasks belong to the especially difficult ones within the scope of the police work. What are we then doing today within the Swedish police to tackle these tasks?

1.2.2. The protection of the nuclear power plants

Before the year 1973 the operation at the nuclear power plants in Sweden was carried on, as has appeared from the above, without much public attention given to the security protection (the physical protection). The circumstances were the same with regard to the transports of fissile material. This does not actually mean that that there was no physical protection at all but it was not much discussed, definitely not by media and the public in the way that was later the case. And more widespread expressions of opinion did not exist in public places.

On 6 April 1973 the crisis committee at the Swedish National Grid presented in a document to the Supreme Commander of the Armed Forces and to the National Police Board "the urgency of a survey of the measures that should be taken in order to reduce, to a reasonable degree, the risks of sabotages against "thermal power plants". The crisis planning committee suggested the appointment of a committee charged with a closer study of relevant questions at issue with a view to reducing the risks by means of different directives.

The background of this was that the Swedish National Grid had established that "the technical possibilities to carry out, by means of comparatively simple means, extensive sabotage against industrial plants of different kinds, against means of transportation etc. have to an increased degree been used abroad and can henceforth to an increasing extent be expected to be used in peace as well as in times of unrest for more or less subversive purposes or as threats of blackmail"[4].

A committee submitted a report in October 1974. It resulted in recommendations with regard to the physical protection of nuclear power stations. In July 1978 the National Police Board appointed a working team within the police in charge of elaborating proposals for training in sabotage and terrorist protection at nuclear power plants. Shortly after that it was decided to, in a special way, investigate how to carry out intervention efforts at terrorist attacks against nuclear power plants, that is propose the creation of a national counter terrorist unit.

In those years' terrorist actions, principally hijackings and kidnappings, had become a more and more usual way of achieving different purposes. There was talk about international terrorism, i.e. acts of violence that reached outside the actual area of conflict and thus affected uninvolved states and intimidated innocent people — killing people that happened to be at the wrong place at the wrong time. Pursuing widely varying objectives some people and groups of people had found one indisputable common ground for agreement: the utility of terrorism as tactics for the achievement of a number of goals, including publicity, fund raising or simply practice.

More and more the aim was not the victim of a criminal activity but violence for effect, violence aimed at people watching, to frighten and spread fear among the people watching TV[5]. Turning criminal activities into a form of mass communication.

Terrorism in authoritarian societies has been used by governments to discipline their people. In democratic societies it has been the weapon of minorities, a tool for the weak to defeat the strong. The uniqueness of its strategy is that it achieves its goal not through its acts but through the response to its acts. The ancient Chinese had a proverb: "kill one to frighten ten thousand". Terrorists are not guided by rationality in the normative sense, but of course goals exist beyond the act, a purpose that transcends the act itself. Today the perpetrator can frighten millions of people through international media. Terrorism is used as a headline grabber. Very little is to be gained by killing many, so long as the death of a few is newsworthy. Therefore it is usually more productive to threaten damage than to destroy

[4] Letter 6 April 1973.
[5] Brian Jenkins, *International Terrorism: A New Mode of Conflict*, Research Paper No. 48, California Seminar on Arms Control and Foreign Policy (Los Angeles: Crescent Publication, 1975), p.1.

facilities. The response to threat and threat incident management therefore is a very strategic issue.

Throughout history many different forms of terrorism have existed. It may be directed downwards like the repressive terrorism, upwards like the revolutionary terrorism and horizontal between political units and between states. The development of terrorism is closely related to the development of democracy, through fear you force your own will on an adversary. It is also associated to the development of the industrial society that has increased the importance of the state authority and its dependence on economic and technological factors.

Terrorism has, as mentioned above, adjusted to the up-to-date information technologies and their forms of expression[6]. It has also in another way been linked to the technological development. Since the beginning of the nuclear age the unorthodox use of nuclear items has been discussed. The risk of nuclear terrorism appeared in the journals of the social and natural sciences, in legal and military journals, in think-tank prognoses and in official documents.[7]

Some scientists estimated that under conceivable circumstances a person in possession of an about normal-density “fast” critical mass of fissile material and a substantial amount of chemical high explosives could design and build a crude fissile bomb. Such a crude nuclear weapon would not satisfy a military commander but would represent an awesome increase in the firepower of a group of terrorists or criminals. Others meant that this was such a difficult and dangerous task that a perpetrator would quite likely turn to already available chemical or biological weapons. Any way, this calls for attention and controlled, safe and secure handling of nuclear material and radioactive sources.

Technological defensive measures can prevent terrorism from occurring or divert it, as the use of different electronic surveillance devices at airports has demonstrated in connection with hijacking and bomb threats against air traffic. Therefore it is advisable to demand that important technologies, especially those of great importance to society, incorporate a minimum standard of preventive strategies and internal defensive measures against criminal attacks. However, no technology or security system is perfect. There will always be somebody that will manage to slip past any defensive measure that has been created. This calls for intervention capabilities.

2. GENERAL SWEDISH SECURITY POLICY FOR POLICE INVOLVEMENT

2.1. PREVENTIVE SEARCH OF NUCLEAR FACILITIES

Bomb threats and threats of sabotage constitute a serious problem that every police force must be ready to tackle. Bomb threats may have many different purposes. The background of the threats is usually some commonplace event that the perpetrator wants to revenge. Someone has been turned away from a restaurant. A pupil that wants to postpone an examination. An employee that has been fired and that wants to express a special thanks to his former employer. Someone that wants to create publicity with regard to an object, an event or an

[6] Jean Pierre Derriennic, *The Nature of Terrorism and the Effective Response*, International Perspectives May-June 1975.

[7] Studies in Nuclear Terrorism, edited by Augustus R. Norton and Martin H. Greenberg, G.K. Hall & Co, (Boston, 1979).

opinion. But there are also threats aiming at the disturbance of the execution of official events, for instance the visit of political leaders in a certain place. The bomb threats are mostly directed against schools, hotels, restaurants, shops, public places, embassies and similar places. The bomb threats can also have a more serious and long-term purpose, be part of the blackmail against a person, against a company or against society, and be a part of a political agenda with a long-term aim. A bomb threat is a phenomenon with mostly epidemic effects. The commotion stirred by one threat often causes threats from other persons. Nowadays threats are also delivered through e-mail and thus a part of the cyber criminality.

Nuclear facilities and transports can be the target of bomb threats and sabotage for many different reasons, some of them can have a very common cause others can be very sophisticated. They can also be out of all reasons and like many types of criminal activities they follow their own logic.

In the nature of a bomb threat there are elements of unclear points: Who is the perpetrator in question? What is the real purpose of the threat? Does the perpetrator really possess the capability of carrying out the threat? Is there really a bomb and what would be the effect of an explosion? Is there reason to consider this as a serious threat?

The preventive work of society involves preventive measures that make the adverse consequences of a bomb explosion, a bomb threat or a threat of sabotage as small as possible. This involves, among other things, that people must not be injured and that activities important to society not necessarily will have to be interrupted or stopped.

There are many examples of what criminals can do with home made-explosive devices. A terrifying example took place on April 19, 1995, at 9:02 a.m. on a morning filled with promise of spring. A bomb blast destroyed the nine-story Alfred P. Murrah Federal Building in downtown Oklahoma City, US. An act of domestic terrorism claimed 168 lives, including 19 children, and wounded 674 people. Twenty-five buildings were severely damaged or destroyed. The force and heat of the blast set fire to cars parked in the area. The explosion came from the detonation of an ammonium nitrate fuel oil bomb of about 2179 kilos carried in a truck that was parked at the entrance of the building[8].

Oklahoma City Bombing is one expressive example, but not a unique one, of what explosives can do in the hands of criminals. This and other examples are enough to give cause for protective measures at important community plants such as nuclear power stations. Shutdown and evacuation of nuclear power plants in the case of a criminal threat is not desirable for many reasons and must be avoided. It takes time to get the reactor in a non-critical condition. It is also more or less impossible and life threatening to search for possible explosive devices in certain areas of a running or a just shut off reactor. Shutting off a nuclear reactor always include moments of stress that must be avoided if not absolutely necessary. At the same time all measures must be taken to prevent the release of radioactive substances into the surroundings due to a criminal act. Special proactive measures that involve the police therefore are standard in Sweden and outlined in co-operation between the National Police Board, the Swedish Nuclear Power Inspectorate and the Swedish Radiation Protection Institute.

[8] The City of Oklahoma City, Alfred P. Murrah Federal Building Bombing, April 19, 1995, Final Report, 1996.

The physical protection at nuclear power stations consists of different measures with the purpose to protect against unauthorised intrusion, sabotage and other malignant influence that could cause radiological accidents and to prevent unlawful dealing with nuclear material and radioactive sources. The Swedish philosophy of physical protection is constructed like an onion. If you penetrate the first shell you immediately face a new one to peel. Layer to layer gives a lamination of physical protection that means a strong construction.

The technical overhaul of the nuclear power plants and the refuelling process that periodically must take place means a disturbance of the physical protection. The power stations face a stream of external people and objects during these periods. Even areas of vital importance get their visitors. Therefore, and to make assessments easier in the event of a bomb threat, the Swedish police is engaged in the final phase before a reactor is restarted. Specially trained teams go through the station searching for apart objects. This is a preventive measure much like the one that is routine in the protection of very important official persons for example at state visits. After the search the ordinary physical protection is in full operation and the plant considered bomb free.

The Police in districts with nuclear power stations continuously receive information from the power station about planned overhauls and refuelling. In close co-operation the police and the power station plan for a protective search. Searching areas are identified from a basic index of areas of vital interest. Search routes, search methods and the composition of search teams are decided for each specific area.

The search team is led by a police officer that has special training in physical protection of nuclear facilities. The team consists of a dog unit approved to search for explosive devices and a police officer qualified as a bomb technician. The whole team is given a radiation protection briefing similar to what is presented to contractors engaged at the plant. The nuclear station provides the team with radiation protection personnel and personnel with a good and familiar knowledge of the areas that are to be searched in order to assist with expert knowledge.

The final phase of an overhaul always is under hard pressure to start the producing of electricity as soon as possible. Every minute that can be gained is important and every minute that is lost means loss of money. This gives the search enterprise a special nerve and the work requires a lot of flexibility. But, the work must be professional and you cannot compromise security and safety. Therefore the search is not started until the works of revision have been finished in the space in question and the area cleaned up and not needed equipment moved away. During the search only personnel directly engaged in the security work and staff necessary from an operational point of view are allowed to be present.

The responsible police department keeps records of each search. This is made in such a way that the documentation can form the basis of the planning of future searches and for the threat assessment in the event of a criminal threat. The documentation and the results of the search are secret information.

This strategy of prevention has been very successful in Sweden. Bomb threats and sabotage aimed against nuclear facilities and transports are a very rare criminality. The preventive search also keeps the police in close contact with the nuclear context, creates a good platform for mutual understanding between the police and the industry and good conditions for co-operation in acute and critical situations.

2.2. POLICE RESPONSE TO SERIOUS CRIMINAL ACTIVITIES AT NUCLEAR POWER STATIONS

When it comes to operational police activities one usually distinguishes between events that occur unexpectedly and those that are known beforehand. Important is also the difference that exists if the common conditions generally seen are calm, uncertain or turbulent. Another way of classifying events is to distinguish between, on the one hand, static situations, which can be stable or unstable and, on the other hand, dynamic situations. The uncertain and turbulent situations imply, as a rule, that they can develop in many different directions and that there exists diversity concerning development and alternative actions. It is no longer a question of the managing of the everyday routine process, where the consequences of faulty or insufficient action stay in the small context[9]. Criminal activities at nuclear power stations, especially in dynamic situations, require a synthetic and analytical decision-making on strategic level. Failure can have immediate consequences on the subsequent course of events.
Extensive or complex special events in general affect several public institutions, which must be able to co-operate on strategic level and on lower level, in order to reach a positive result. There must be a stage of mutual respect for the roles of different actors, the overall priorities and an understanding of the processes for decision making. This cannot be achieved the first time involved actors meet to handle a real problem under stressing and pressing conditions. This should be practised repeatedly through applicable case studies and exercises. The considering over possible and impossible events is generally of great value in preparing for a special event.

If a nuclear power station is the subject of a bomb threat or another serious criminal activity, it is, according to the Police Act, the task of the Swedish police to intervene and restore public order and security, to arrest the perpetrators and to investigate the crime. This means that in Sweden the police are one of four legs in the physical protection policy of nuclear facilities. Even if the security staff at the power stations has special official authorities as authorized security officers (safety guard and watchmen) it is the task of the police to confront the criminals. This is done by specially trained local police units and the National Counter Terrorist Unit.

The police authorities that have a nuclear power station within their jurisdiction shall establish a plan for police response at the station in the event of an assault alarm or a serious criminal activity. Such an emergency planning shall be done in close co-operation with the management of the power station, the Swedish Nuclear Power Inspectorate and the County Administration. The plan shall be subject to exercises.

The National Police Board, through the National Criminal Investigation Department, has issued advice for the response by the police at nuclear power stations and supports the local work within the police[10].

At an assault on a nuclear power station the police response can be divided into four different phases:

1. alarm phase;
2. primary phase;

[9] Lars Nylén, *The role of the police in total management of disaster, Disaster Prevention and Management*, Volume 5, Number 5 1996, p. 21-28, MCB University Press, Bradford, UK.
[10] Directives and advice from the National Police Board, FAP 206.

3. averting phase;
4. restoring phase.

ALARM PHASE

The alarm phase includes measures to confirm and verify an alarm from the power plant. False alarms have their own agenda[11]. During this phase the police re-dispose and mobilize its response and commanding resources. Reinforcement is called up. Special response equipment is dispensed. The police organize to handle what is called a special event. This will probably also mean a special event of national concern. Information is gathered and intelligence co-operation starts within the police. Of course this can include international police contacts. Communication with the management of the power station is secured.

PRIMARY PHASE

During this phase the strategic command unit starts its work and the response resources gather at pre-planned assembly areas at the power station. An incident commander is appointed and an incident command staff is established adjacent to the incident manager at the power station.

This phase is very essential for a proper and effective response to a siege or a similar crime at a nuclear power station. First of all it is necessary to get a general picture of what has happened and to update information about the situation at the power station. What areas have been infected or threatened by the crime. What has happened to the staff? Is anybody taken hostage? What is the nuclear situation at the plant? Who is the perpetrator and what motivates him? Through different briefings the situation is assessed and the task of the police and the possibilities to act are decided. It is important to identify what must be done immediately and evaluate different alternatives.

A very crucial task will be to isolate the perpetrator and to protect vital areas from falling in the hands of the adversary. To do this there must be a very close co-operation between the police and the power station management. A lot of technical and police tactical factors must be thoroughly considered.

AVERTING PHASE

The purpose of the police response during this phase is to neutralize the threat against the power plant step by step. Technical considerations in the power plant can be very important to the police. Different time factors are of great concern. Of course the actions from the adversary play a crucial part in the course of events. Negotiating activities normally are introduced at this stage.

RESTORING PHASE

During the restoring phase the police take actions to free hostages, interrupt the criminal act, arrest the perpetrator and restore public order and security. The crime scene is secured and investigated.

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[11] A person, who by furnishing a false statement that danger exists for the life or health of one or more people or for extensive destruction of property, occasions unnecessary safety measures, shall be sentenced for **false alarm** to pay fine or to imprisonment for a maximum of two years. (The Swedish Penal Code, Chapter 16, section 15).

PLANNING AND TRAINING

To be able to handle special events at nuclear power stations the police must have action plans for different situations and police personnel that are trained for their duties. Action plans at the power stations must be compatible with the police plans. Co-operation with key persons at the power station must also be regularly subjected to training.

Since the 1980s police officers and commanders in police departments with a primary responsibility for intervention at nuclear power station practice on a regular basis how to act if the power station is the target for a criminal activity and how to respond if technical problems cause a release of radiation.

Four different police authorities are involved: Uppsala County, Kalmar County, Skåne and Halland County. They all have special response teams that are familiar with the environment of nuclear facilities and the response strategies. For severe cases and the confronting of barricaded subjects these police departments will be reinforced by the National Counter Terrorist Unit that has full anti terrorist capacity and is stationed with the Stockholm County Police Department. This unit also practices to a larger or smaller extent on a regular basis at the Swedish nuclear power stations.

2.3. PROTECTION OF TRANSPORTS OF NUCLEAR SUBSTANCES AND NUCLEAR WASTE

All handling of spent nuclear fuel is subject to strict safeguards and accounting requirements based on Swedish nuclear legislation, the Treaty on Non-Proliferation of Nuclear Weapons and special agreements with other countries and organizations. The Swedish Nuclear Power Inspectorate has issued instructions on physical protection at transports of nuclear substances and nuclear waste. The purpose of this is to prevent unlawful handling of the material and sabotage.

For the transportation of spent nuclear fuel and some irradiated nuclear waste a special transport system is used. A special sea transport system has been built up for the handling of these radioactive products. In January 1981 a specially designed ship for the transportation of radioactive waste was ordered from the French shipyard Société Novelle des Atelliers et Chantiers du Havre. She was given the name Sigyn. Safety during transportation is by casks and containers designed for the type of waste they are to carry. They are designed to withstand much greater technical stress than can reasonably be expected to arise during the waste shipment, including free fall from a height of at least nine meters onto a rigid surface, fire of a temperature of 800 degrees Celsius for 30 minutes, and an external pressure equivalent to a water depth of 200 metres without the integrity of the casks being affected.

This system in itself includes such a high security level that routine police protection can be minimized. Only extraordinary circumstances give cause for activities from the police. In most of the cases this has happened in connection with political activities when people for example have wanted to express their views on proliferation and the use of nuclear power. Thus, international transports of spent fuel have been targeted by activists, who have tried to interfere with and stop sea transports. Since the end of the 1980s Sweden has, however, had a calm situation.

During transports at sea the specially designed ship communicates with the surveillance centre at the nuclear power station where the ship is and on route with the corresponding transport centre at the Oskarshamn nuclear power station. The ship also communicates its position when passing certain report positions in the Baltic Sea to the Swedish Coast Guard.

The National Communications Centre at the National Criminal Investigation Department is continuously informed on all moves of the ship and transfers this information to the local police and the Coast Guard.

The National Communications Centre is also informed by the Swedish Nuclear Power Inspectorate about all transports of nuclear substances assigned to security class 1. This type of transports normally is protected by means of police escort according to a threat assessment made by the National Criminal Investigation Department.

Alarms from road transports are transferred to concerned police department that has to take immediate actions. Alarm from the sea transport system is forwarded to the National Communications Centre. The National Criminal Investigation Department has a commanding role in these situations and initiates proper actions through the police. The Swedish National Counter Terrorist Unit practices their response to a hijacked ship at sea and is well prepared to handle police intervention in serious situations.

The European Police Office — EUROPOL[12] Europol is the European Union law enforcement organization that handles criminal intelligence in the union. Its aim is to improve the effectiveness and co-operation between the competent authorities of the Member states in preventing and combating serious international organized crime. The mission of Europol is to make a significant contribution to the European Union's law enforcement action against organized crime, with emphasis on targeting criminal organizations.

Europol's mandate applies where an organised crime structure is involved and two or more Memeber States are affected. Among other forms of serious international organized crime the Europol mandate includes activities against trafficking in radioactive substances and terrorism[13].

3. CONCLUSION

The Swedish police have preventive duties and are the intervention leg in the security systems of nuclear and radioactive material. A close co-operation takes place with the nuclear industry and competent national bodies.

QUESTIONS AND ANSWERS

A. Coker (Nigeria): What is the "Stockholm syndrome"?

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[12] The establishment of Europol was agreed in the Maastricht Treaty on European Union on 7 February 1992. Based in The Hague, the Netherlands, Europol started limited operations on 3 January 1994 in the form of Europol Drugs Unit (EDU) fighting against drugs. Progressively other important areas of criminality were added. The Europol Convention was ratified by all Member States and came into force on 1 October 1998. Following a number of legal acts related to the Convention, Europol commenced its full activities on 1 July 1999.

[13] Crime connected with nuclear and radioactive substances means the criminal offences listed in Article 7(1) of the Convention on Physical Protection of Nuclear Material, signed at Vienna and New York on 3 March 1980, and relating to nuclear and/or radioactive materials defined in Article 197 of the Euratom Treaty and Directive 80/836 Euratom of 15 July 1980.

L. Nylén (Sweden): It is identification with the aggressor, a psychological response —named after a siege in a Stockholm bank — in hostage situations.

A. Nilsson (IAEA): a) How do you prepare police officers for nuclear work, in which they probably have no background education? b) How do you handle the turnover rate, which is likely to be high?

L. Nylén: a) They receive one week of basic training and a few days' retraining every second year on working in and around NPPs. In addition, the provincial administration trains them to handle situations involving relaese of radiation. b) The turnover rate, which is actually very low, is handled by repeating basic courses.

J. Fechner (Germany): A basic assumption by the Swedish authorities in designing the PP system was that terrorists wanted to attract wide public attention rather than cause severe radiological consequences. Has this assumption been modified more recently?

L. Nylén: We constantly reassess our assumptions. The terrorist threat is still a design scenario. Swedish NPPs have a huge capacity to handle radioactive release caused by criminal activities.

M. Singh (India): How do police and customs co-operate in combating illicit trafficking? Is there common training in PP?

L. Nylén: There is no special training programme but very close co-operation in daily work.

G. Bunn (USA): Information on the DBT tends to be classified. Isn't it necessary to publish it for people dealing with threats?

L. Nylén: DBT information is classified in Sweden but given to responsible police authorities. Individual officers get more general information.

PROTECTING FACILITIES AGAINST TERRORISM AND SABOTAGE: IS JAMAICA PREPARED TO DEAL WITH THIS POTENTIAL THREAT?

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Abstract. As a developing country, Jamaica does not have the capability or the resources to necessary to secure all its assets and must prioritize its allocation of resources. To date the incidents of terrorism and sabotage have been few to non-existent. Jamaica needs to set up units to focus on the potential threat to key facilities and to complement them with scientists who have expert knowledge. Such a group could examine issues such as reducing vulnerability, developing guidelines and rules for responses, and planning for the aftermath of terrorist attacks.

Jamaica, a developing Caribbean country, is presently experiencing an economic recession. This has lead to the government having considerable difficulty in acquiring much needed financing, even financing that is necessary to protect the county's resources and facilities from terrorist and sabotage.

Essential national facilities includes our International Airports, Embassies and High Commission, Hospitals, Utility Plants- Electricity, Water and Telecommunications, Oil-Refineries, Government ministries, Parliamentary Houses and Educational Facilities. These facilities are vulnerable to terrorist attacks and sabotages. Terrorist acts and acts of sabotage can come from internal as well as external sources, they can be commandeered form the air, land or sea. They can be politically, socio-economically or otherwise motivated.

As a third world developing nation, Jamaica does not have the capability or the resources necessary to secure all its assets, the government must prioritize on such resource allocation. With it's high level of debt servicing, dealing with recurrent and capital expenditure and addressing other Social Issues, some important issues will be placed on the back burner, dealing with terrorism and sabotage will fall in the category.

One contributing factor, is the fact that, to date the incidents of terrorism and sabotage have been few to non-existent. This has encouraged the government to become somewhat complacent, subscribing to the belief that acts of terrorism and sabotage will never happen. This practice can be detrimental to the country, as one cannot under estimate the threat of terrorism and sabotage.

With the steady increase in drug related incidents, and, with the deportation agreement the government has with some first world countries such as the USA and England, this threat is very realistic. Drug "Lords"\ "Dons" are known to promote terrorism and sabotage as revenge mechanism against government for unfavorable decision handed down by the courts of the land.

Our Airports, Oil refinery and some utility facilities are located in close proximity to the sea. This is very accessible to attack from the sea. Our other essential facilities are not as easily accessed as they are located inland and may be more difficult to access. All these facilities have security protection, but none is equip to deal with any level of terrorism. No security equipment currently been used has the capability to combat, detect and or prevent any terrorist attacks or acts of sabotage.

The nation needs to expand resources to set up units to focus on this potential threat. This unit should focus on analysis of threats from:

- Terrorism.
- The proliferation of weapons of mass destruction.
- Vulnerabilities attended on increasing economic and
- societal dependence on information technologies.

There is a wide variety of novel attack available to the terrorist today, it would advised that the unit, through constant training and workshops be aware of as many these attack methods as possible. There should b collaboration between several entities to analyze and plan for the potential threats. The army and Police forces will have to be complemented by scientists who have expert knowledge on this subject area. Experts could be drawn from:

I. Information and Communications centers.
II. Banking and Finance entities.
III. Utility entities.
IV. Environment Protection agencies.
V. Land, Air and Sea transportation agencies.
VI. Fire services.
VII. Law enforcement agencies.
VIII. Defense (Army & Police).
IX. Health services.
X. Oil and gas refineries.
XI. Disaster preparedness program.

This group would examine issues such as:

- How to reduce the vulnerabilities of their institutions to terrorist attacks (Threat /vulnerability management).
- How to respond to terrorist acts? Guideline or rules to follow when faced with the problem of terrorism. (Crisis management).
- How to deal with the aftermath of terrorist attacks, including providing essential aids, services and emergency relief for the victims of these terrorist acts.
- (Emergency Management).

Given the level of sophisticated weaponry available to terrorist today, Jamaica needs to seriously consider the threat of terrorism and sabotage. Our countrymen need to see these threats as real and develop a real sense of urgency where dealing with terrorism and sabotage is concerned.

Therefore in concluding I must say that as far as protecting our national facilities and essential services from the threat of terrorism and sabotage, my country is totally ill-prepared as we have no plans in place to deal with the very real threat of terrorism and sabotage.

QUESTIONS AND ANSWERS

S. Erickson (USA): Terrorists have no respect for economic circumstances or geography and attacks can occur anywhere in the world. Do you know of any resources available to assist your country in developing a PP system?

E. Powell (Jamaica): No, I don't know of any agency that can be contacted for funding.

A. Nilsson (IAEA): Has Jamaica joined the CPPNM?

E. Powell: I do not know. It would benefit our country to do so.

PHYSICAL PROTECTION II
(Session 4)

Chairperson

D.M.G. FLORY
France

UKRAINE–JAPANESE–SWEDISH PROJECT: UPGRADING OF PERIMETER PROTECTION SYSTEM AT THE KHARKOV INSTITUTE OF PHYSICS AND TECHNOLOGY

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[3] Advisory Group of Security (ANS), Consultant to SKI, Stockholm, Sweden
[4] Technical Secretariat of the Japan-Ukraine Committee for Co-operation on Reducing Nuclear Weapons (TC), Tokyo, Japan
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Abstract. In 1996, under the auspices of the IAEA, Japan, Sweden and the US agreed to provide technical assistance for the improvement of the nuclear material accountancy and control, and physical protection systems at the Kharkov Institute of Physics and Technology (KIPT). The biggest task was to upgrade the perimeter protection system including new fencing, intrusion detectors, providing an emergency power supply and building a central alarm station. This was completed at the end of 2000. Service and maintenance support will be provided by Japan to end 2002 after which maintenance expenses are to be provided by Ukraine. This will be difficult to achieve.

Since the Ukraine voluntarily accepted the status of a non-nuclear-weapon State and concluded a Safeguards Agreement with the IAEA, the Kharkov Institute of Physics & Technology (KIPT) as a nuclear facility using the nuclear Material of Category 1 has become a Ukraine priority object for the International community's efforts to ensure nuclear non-proliferation measures and to bring the existing protection systems to the generally accepted security standards.

In March 1996, at the meeting held under the auspices of the IAEA in Kiev, the representatives from Japan, Sweden and USA agreed to provide technical assistance concerning improvement of the nuclear material accountancy and control, and physical protection system (MPC&A) available at KIPT.

The Technical Secretariat of Japan-Ukraine Committee for Co-operation on Reducing Nuclear Weapons and Swedish Nuclear Power Inspectorate undertook to solve the most expensive and labor-consuming task, namely the upgrading of the perimeter protection system at KIPT. This included that the current perimeter system, comprising several kilometers, should be completely replaced.

Besides the above-mentioned problem, the upgrading should be carried out with the Institute in operation. Thus, it was not allowed to replace the existing protection system by a new one unless KIPT was constantly protected. This did require the creation of a new protected zone that to a large extent was occupied by the communication equipment, buildings, trees, and other objects interfering with the work. All these difficulties required very comprehensive development of the project design as well as a great deal of flexibility during the implementation of the project. These problems were all successfully resolved thanks to a well working project organization, composed of experts from KIPT, JAERI and ANS, involving the highly qualified Swedish technical experts who played a leading role.

Figure 1.

Figure 2.

Figure 3.

In the framework of implementation of the project a lot of equipment manufactured in Sweden, Japan and partly in the USA was procured by funding of Japan and delivered to KIPT. Completion of the work was scheduled to take about one year. However, despite the selfless work of the KIPT personnel and other experts, the upgrading of the perimeter initiated in October 1998, was completed, due to difficult weather conditions and custom problems etc, by the end of 2000.
The project included installation of more than 6 kilo -meters of the standard external and internal fencing along the perimeter of protected area of the nuclear facility, microwave and other systems for intrusion detection, system for cable TV alarm assessment and control (CCTV), diesel-generator to serve as an emergency power supply source for the entire physical protection system.The central alarm station (CAS) integrated the control equipment for the perimeter protection system provided by the Sweden and Japan as well as for the equipment delivered by the USA. The CAS was tested and came into operation as integral part of the entire physical protection system at KIPT in December 2000.
The successful completion of the project has led to a significant improvement of the protection level at KIPT.

Thereby it has significantly reduced the possibility for unauthorized withdrawal of the special fissionable material that is available at KIPT in quantities and forms attractive for nuclear terrorism and saboteurs.

The commissioning of a new modern physical protection system specially designed for KIPT points at some future problems, in particularly, as regards training of operation and engineering personnel, providing service and maintenance, and providing necessary spare parts.

Figure 4.

Figure 5.

The Japan Technical Secretariat and the Swedish Nuclear Power Inspectorate has undertaken to provide necessary support for service and maintenance, including spare parts, until the end of 2002.
For a longer period of times the KIPT Management needs to cover the expenses connected with operation the constructed physical protection system independently. But, at preservation of a present adverse economic situation in Ukraine it is a very difficult task to solve.
Therefore, expressing sincere gratitude to IAEA and countries - donors for support and given help, simultaneously would like to hope that the Agency will not leave KIPT tete-a-tete with the above-stated problem in interests of providing the nuclear non-proliferation regime.

IMPORTANT DATES:

March 02, 1994 — Sign the Agreement between the Government of Japan and the Government of Ukraine concerning cooperation for the elimination of nuclear weapons reduced in Ukraine and the establishment of a Committee on this cooperation

March 5-6, 1996 — Meeting at KIPT (Kharkov) between representatives of KIPT, MEPNS, Japan, Sweden and the United States

March 27–28, 1996 — Meeting in Kiev between representatives of the donor-countries (Finland, USA, Japan, Sweden) and IAEA

May 30, 1996 — Meeting in Kiev between representatives of USA, Japan, Sweden to provide

assistance to KIPT in MPC&A

May 26-27, 1997 — Meeting at SKI between representatives of KIPT(Ukraine), JAERI-Committee(Japan) and SKI (Sweden) - elaboration of Perimeter Protection project

July 15-17, 1997 — Meeting at KIPT between representatives of KIPT, JAERI - Committee and SKI - discussion of PP project

November 19–20,1997 — Meeting in IAEA between Japan- Ukraine Committee, SKI and KIPT- agreement of the PP project

January 16, 1998 — approval the project by the Ukraine authorities

September 25,1998 — first delivery of equipment

March 23, 1999 — sign the Sweden-Ukrainian Agreement concerning collaboration in nuclear safety area

December 19, 2000 — completed final inspection in KIPT

QUESTIONS AND ANSWERS

U. Mirsaidov (Tajikistan): Has the level of protection risen significantly?

V. Mykhaylov (Ukraine): Yes, it has.

D. Flory (France): What was the role of Ukraine’s competent authority in the analysis, acceptance and licensing of the system installed at the Kharkov Institute of Physics.

V. Mykhaylov: It’s role was decisive. The process of gaining acceptance took only two months.

THE HALLAND MODEL — AN INNOVATIVE MODEL FOR THE PHYSICAL PROTECTION OF A NUCLEAR FACILITY

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Abstract. The Halland Police Force is responsible for physical protection at Ringhals nuclear power station in co-operation with the Västra Götaland Police Force. Plans are formulated to respond to demonstrations, assault, dangerous objects and disturbed individuals. Incident response are divide into 'Emergency standby' where no radioactive release has occurred, and 'Incident alert' where a radioactive release has occurred or is imminent. Agreed plans of action describe in detail how these situations should be managed. Regular training ensures that skills and competences are maintained.

HALLAND

Halland is situated on the West Coast of Sweden about 20 kilometers north of the town of Varberg. The entire West Coast borders on the sea the Kattegatt and the Skagerack. The local population of the County Halland is about 280 000, and is considerably larger during the summer.

The county comprises six municipalities Falkenberg, Halmstad, Hylte, Kungsbacka, Laholm and Varberg. Halmstad is the seat of the county administration.

RINGHALS

Ringhals is Sweden's largest power station with four nuclear reactors here and another two reactors in Skåne County further down south. The Ringhals facility is located near to the sea and has been in operational use since 1974 (Reactor # 2).

An extensive set of plans exists for work at Ringhals Nuclear Power Plant. The plans relate to

- Physical protection,
- Emergency standby and
- Incident response in connection with technical problems.

PHYSICAL PROTECTION

The physical protection rests on three grounds:

- vital parts secured by alarms,
- locks and surveillance,
- watch guards around the clock.

The responsibility for physical protection at Ringhals is not carried out by i.e. a private or a military unit but by the *Halland Police Force*. The Chief Constable carries the full responsibility for the protection of the nuclear plant.

Police officers have been appointed to ensure that there is adequate preparedness and competence within the Police Force. Some police officers at the staff board have been assigned to the planning and training of this special kind of police work. The Police work in close cooperation with the County Administrative Board and the municipalities involved as well as with the management of Ringhals Power Plant.

The plans for *physical protection* are formulated so that they coincide with Ringhals's status with respect to threats. Emergency alerts and measures exist in order to cope with the following events:

• ***Demonstrations***

- *Peaceful demonstrations* concern offsite activities that do not have a significant impact on Ringhals's activities and which mainly aim at influencing external opinion.

There have been several of peaceful demonstrations throughout the years but there has never been any risk for the safety of the power plant.

- *Threatening demonstrations* concern offsite activities that have a significant impact on Ringhals's activities or which involve masked or armed participants as well as any form of demonstration where the participants enter the Ringhals site.

A threatening demonstration took place in 1966 when demonstrators forced themselves into the site and all the way into reactor area #2. No essential systems were threatened.

• ***Assault***

This means threats that arise if an armed individual or a group of people enter the Ringhals site and/or congregate on the site.

• ***Dangerous Objects***

This is the situation that occurs if unknown objects are found. It could also be objects with unknown contents that could be bombs and that could involve a risk to the personnel or the facility.

In 1976 a powerful package of Dynamex was found on the site. Technicians from the Police disarmed the package and there was no further risk for the safety of the power plant.

• ***Disturbed Individuals***

The definition refers to an individual who is under the influence of drugs, mentally imbalanced or who is in any other way out of control of his/her actions, who threatens the personnel or facility safety.

An "assault" will automatically cause an emergency standby to take effect. This means that a combination of alerts/physical protection measures (in the case of a criminal attack) and incident response plans will apply.

INCIDENT RESPONSE PLANS

If a technical fault occurs or could occur this could jeopardize the operational safety of Ringhals Nuclear Power Plant. Therefore emergency alerts and incident response plans exist for:

• ***Emergency standby***

If an event has occurred at the plant that is or could be important to reactor safety there will be an “emergency standby”. In this situation no radioactive releases have occurred and the essential systems function as intended.

• ***Incident alert***

When a radioactive release is initiated or is considered to be imminent we reach the level of “incident alert” - the most serious situation that can occur here.

MEASURES UNDERTAKEN BY THE POLICE

Measures undertaken by the police in the event of a criminal attack or an incident situation are handled in co-operation with the Västra Götaland Police Force. An agreed plan of action involving both police authorities has existed since 1998. The plan contains a detailed description of how measures in the situations described above should be managed and implemented. Strategic and operational management levels and staff operations are detailed in the agreement/plan. A lot of effort is put into maintaining the skills and competence of the two forces.

The plan also contains guidelines for the cooperation with Ringhals Nuclear Power Plant during the work. It also describes how liaison, reinforcement, maintenance, personnel reporting and joint training should be conducted. All this requires special training.

The Halland Police Force has the territorial responsibility for the police measures. Upon request, this is reinforced by police troops from the Västra Götaland Police Force. Measures relating to physical protection are implemented on Ringhals's site (inside the fence) by the police reinforcements while the Halland Police Force’s own troops implement the other measures. The police supervisors of the different forces coordinate the measures.

Regular drills, on a small or large scale, are held in order to practice these measures and the management and staff operations.

The responsibility for the Police also includes the sea vessel “Sigyn”, transporting used nuclear fuel around the Swedish coast from Ringhals to Oskarshamn.

TRAINING

At different times every year, the Halland Police Force trains its own resources in cooperation with some of the authorities and organizations involved in the preparedness organization. The training focuses on the situations described above and it also comprises training in the evacuation of the population living closest to the Nuclear Power Plant in the inner emergency-planning zone.

The evacuation situation includes the most complicated work to carry out. It requires all available manpower and it will take place over a huge geographical area in a short period of time. The population to be evacuated will soon be worried and act very confused and many people will refuse to leave their homes.

CONTROL

A private Company runs the nuclear power plant. It would perhaps seem natural that the physical protection was done by i.e. a private business or company. But the presence of a national police force will grant that all regulations set by the parliament and the government are controlled which is essential with the Swedish legal cultures.

QUESTIONS AND ANSWERS

J. Jalouneix (France): Are there any on-site response forces at the NPP? If so, what are the responsibilities of these forces and the police?

A. Boode (Sweden): There are no on-site response forces in the Swedish/Halland model. Our police units are trained to take measures off- and on-site but do not enter an NPP site until an incident has actually occurred. The operator has watch guards on duty around the clock.

J. Fechner (Germany): Who provides protective equipment for police officers in a radiological emergency at an NPP?

A. Boode: The police do not have their own protective equipment. In an "incident alert" situation, the county administrative authority co-ordinates all actions. Special teams with dosimeters evacuate all people in risk areas.

A Hagemann (Germany): a) Do the police charge the operator for their PP efforts? b) Do police officers have problems accepting the idea of exposure to radiation when their duties involve going inside a facility.

A. Boode: a) The police to not charge the operator but the county administrative board pays some of the training costs. b) The safety of personnel is of utmost importance but there has not yet been a discussion about acceptance of possible exposure.

MODERNIZATION OF THE PHYSICAL PROTECTION SYSTEM OF IPEN-CNEN/SP

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Abstract. A general study of the physical protection system was carried out in order to review and to update the physical protection plan of the IPEN. Important alterations accomplished at the institute were considered in the study, as the installation of a cyclotron 30 MeV and the new operation conditions for the nuclear research reactor IEA-R1, that include the increase of its operation power from two to five megawatts and the establishment of the 72 hours weekly continuous operation.

1. INTRODUCTION

In 1980, a federal law defined the responsibilities and attributions for the physical protection of nuclear material and nuclear facilities, by establishing the Protection System of the Brazilian Nuclear Programme (SIPRON). As a member of the SIPRON, the Brazilian Nuclear Regulatory Authority (CNEN) is responsible for defining detailed rules and requirements for the physical protection by issuing regulations and guidelines.

In 1981, the CNEN issued the regulation CNEN-NE-2.01, “Physical Protection of Operational Units of the Nuclear Area” [1], reissued in 1996. In this regulation the CNEN established a system to define and to evaluate physical protection systems in order to ensure that the licensees provide appropriate levels of physical protection. By this regulation, in Brazil, the physical protection plans of nuclear facilities must be reviewed and updated every two years.

Following that regulation, an internal group (IGPP) was created at IPEN to study the physical protection plan and to evaluate if the actual system met the plan. Based on this study, a modernization programme of the physical protection system has been carried out.

2. THE STUDY

There are two research reactors at IPEN, the IEA-R1, open pool type of 5 MW, and the IPEN-MB/01, critical assembly of 100 W. There are also two cyclotrons of 28 and 30 MeV and many other facilities including those to produce the nuclear fuel for the research reactors. IPEN also produces 21 radioactive products for use in nuclear medicine that have been distributed, weekly, for more than 350 hospitals and clinics all around the country and also in some countries in Latin America. About 222 TBq of radioactive material are processed per year. IPEN is located in an area of 478 000 m^2 (101 850 m^2 built area of 107 constructions), where about 1300 employees work.

The IGPP started analysing the updated version of the radioactive material inventories, process descriptions and emergency plans of each facility. The results of the analysis were compared with those presented at the physical protection plan. Based on this study, in addition to the alterations accomplished at the institute, as the installation of the cyclotron 30 MeV, the construction of a new Radioactive Waste Treatment Unit and the new operation conditions of the IEA-R1, the IGPP redefined some vital and protected areas. The design basis threat was considered the same as in the plan.

The next step was to conduct site tours and interviews with facility personnel in order to evaluate, *in loco,* the conditions of the physical barriers and detection systems of inner and protected areas. During these tours the IGPP tested the communication systems used by the security force, as the extension phone lines that are located in each entrance area and the portable VHF radios used by the guards. The detection systems had their functionality tested as well as their assessment by the security force.

The IGPP consulted the facility personnel about the radioactive inventory and operational procedures. The performance of the security force personnel on the conventional procedures, as access control to the facilities, control of material flow, area monitoring and patrol were evaluated. The response for special situation procedures in the case of a physical protection emergency was verified by observing conduct of the guards in some protection procedures. The facts observed in these tours were registered in reports, as well as, suggestions given by the facility personnel.

Based on these facts, the IGPP analysed the performance of the physical protection system and detected some points that could be reinforced at inner and protected areas. The conclusions of this process, including the necessity of changing some vital and protected areas, were informed to the high administration by means of a consolidated report of the physical protection system of IPEN.

3. MODERNIZATION PROGRAMME

The high administration of IPEN, based on the study and suggestions from IGPP mentioned in the consolidated report of the physical protection system, decided to revitalize the whole physical protection system and not only to reinforce some points.

In order to elaborate a modernization programme of the physical protection system, using the results of the study as basis, it was created an internal committee (ICOM) composed of specialists in physical protection, nuclear safety, operation of reactors and engineering areas. The programme elaborated by the ICOM strengthens the physical protection system by applying the defence in depth concept [2]. At the same time, it attempts to provide a balanced protection in order to minimize the consequences for the failure of one component of the physical protection system.

The programme is comprehensive and includes diverse items as the periodic maintenance of physical barriers, as fences, in order to keep the level of opponent retard and the reinforcement of the radiological monitoring procedures at protected areas exits.

Some measures, which depend of small expenditures, as the purchasing of portable VHF radios to improve the security force communication by creating redundancy in the communication channels, have already been taken.

Others measures, which take advantage of existent resources in the institute, have been implemented, as the security force personnel training by the experts of the institute. The performance of the physical protection system largely depends on the security force personnel. For this reason, the modernization programme dedicates special attention to the training of these professionals. Emphasis has been given to the emergency procedures; because of the personnel action in those cases is considered an important point. The specific training on radio communication has also been reinforced.

The implementations of some points of the modernization programme are more expensive, as the creation of a central alarm station (CAS). The CAS is an installation that will provide continuous monitoring of the intrusion sensors and it will permit assessing the alarms through the signals received from the TV cameras installed all around the fences of protected areas and at strategic points of the inner area. The CAS is planned to be equipped with redundant communication means with the security and response forces and the high administration of the institution.

IPEN submitted a project to SIPRON to obtain budget to implement the CAS and other items of the modernization programme of the physical protection system. Experts from SIPRON have already visited the IPEN facilities to analyse the project.

REFERENCES

[1] COMISSÃO NACIONAL DE ENERGIA NUCLEAR, Proteção Física de Unidades Operacionais da Área Nuclear, CNEN-NE-2.01, CNEN, Rio De Janeiro, Brazil, (1981).

[2] ORGANISMO INTERNACIONAL DE ENERGIA ATOMICA, Protección Física de los Materiales Nucleares, Infcirc/225/Rev. 3, IAEA, Vienna, Austria, (1993).

QUESTIONS AND ANSWERS

R. Warren (USA): Was any integration of threat analysis or a DBT used as part of the review for upgrading physical security?

F. Suzuki (Brazil): Threat analysis was much discussed during the elaboration of the modernization programme but a DBT was not defined formally for the review.

V. Lapshyn (Ukraine): When you planned the PP system, did you consider the difference between the systems of a cyclotron and a reactor?

F. Suzuki: Yes, the cyclotrons and the reactor are in different protected areas. The cyclotrons' PP system is designed to prevent sabotage whereas the reactor's PP system is designed to prevent unauthorized removal of nuclear material as well.

PROTECTION OF NUCLEAR INSTALLATIONS AND NUCLEAR MATERIAL AGAINST MALEVOLENT ACTIONS

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Abstract. The paper presents the process used in France to cope with sabotage of nuclear material or facilities. Design basis threats are associated with the risk of aggression and the means used. Implementation of regulations uses a performance-based approach which gives the operators flexibility to choose the means and measures to be taken. The physical protection system is based upon the principle of 'defence in depth'. This concept is applied to the design and operation of the physical protection system. Sensitivity is defined by the level of radiological consequences resulting from malevolent action determined by using safety analyses to identify potential accident sequences. Vulnerability is assessed by estimating the resources required to destroy a system or function, and the paths which lead to sensitive zones or systems. Acceptable consequences are defined as levels of release which are equal to, or less than, the levels defined in the facility safety case.

1. INTRODUCTION

In France the basic document in the field of the protection of industrial installations against sabotage is the Ordinance 58 1371 published on 29 December 1958. This text deals with the protection of high sensitive installations. This text concerns different aspects of the protection such as fundamental interests of the Nation (commercial or military), the non-proliferation of nuclear material and the security of the public. Specific ministerial instructions detail the arrangements defined for nuclear installations.

How to protect nuclear material and installations against such actions?

The French approach as regards malevolent actions is aimed at protecting nuclear material and nuclear facilities from the following two events:

- actions which could lead to the release of radioactive substances into the environment,
- the theft of nuclear material which could lead to the construction of a nuclear explosive device.

The aim of this paper is to present the process used, in France, to cope with sabotage against nuclear material or nuclear facilities.

2. DESIGN BASIS THREATS

What are the appropriate threats to protect against?

Concerning malevolent action, threats have been defined concerning internal and external threats.

To this term 'threats' are associated the **risk** of aggression and the **means used** by malevolent people. These means are considered as basic assumption in the studies performed to assess the foreseen or the already existent protection measures.

The approach adopted for considering sabotage affecting the design and operation of nuclear facilities is aimed at determining the extent to which the facilities are protected. When carrying on these studies, the operators have to demonstrate that they are complying with the objectives set by the Competent Authority for reducing the risk of internal or external malevolent actions. The method to be followed is developed in section 4.

Several types of threats are taken into account for the purposes of these studies:

- Demonstration of a hostile crowd.
- Internal threats involving actions taken by insiders acting alone or not.
- External threats involving actions by small groups of attackers. Two assumptions are made when testing the ability of protection systems to counter aggressions of this type. The first one involves a small team of attackers with limited resources, and the second one takes into account a larger team with more sophisticated resources.

Assumptions are also made as to the type of actions which could be taken by malevolent workers in sensitive zones and the aggravating factors to be considered. As an example the loss of the offsite power supply could be taken into account.

Acceptable consequences are taken as being those leading to levels of radioactive releases less than, or equal to, those taken into account in the facility safety case.

But, taking into account malevolent actions against nuclear facilities requires being able to define precisely the characteristics of the corresponding threats. In order to well appreciate the reasons for and the means used by an adversary, it has been decided to collect information in relation to these kinds of actions (successful or not) and try to improve our knowledge of these actions.

A specific list is made from the compilation of events related by medias, by French intelligence agencies or reported by the staff facilities. In 1990, the competent authorities asked the operators of nuclear facilities to declare, without delay, the malevolent actions which may happen in their facilities and to make a report when there is reason to suspect that any malevolent activity has occurred. The criteria selected to characterize the malevolent actions to be declared were specified in 1995. These criteria which are similar to those used by the US NRC are:

1) Bomb related criterion, this category covers all actions involving use of real or hypothetical explosives and incendiary devices.
2) Security criterion related to incidents of attempted or actual penetration of an installation's security system
3) Demonstration involving several people (crowd) taking place in the vicinity of the plant
4) Aircraft or vessel considered to be in an exclusion area.
5) Installation or security system operation harm criterion related to operation of the installation itself and its security system.
6) Nuclear material criterion related to the nuclear materials that may be lost, allegedly lost, considered missing, or unexpectedly discovered in an unauthorised place.
7) Weapons criterion related to incidents which take place inside an installation or in its immediate vicinity, and involving firearms.
8) Radioactive material criterion. This criterion regards the use of radioactive material to create a real or potential threat or to aggravate an existing threat.

Since 1996, the competent authorities have asked the operators to use a specific form to make their declaration. This form contains the following items: description and chronology of the event, kind of threat, evaluation of the consequences, action undertaken to avoid such an event happens again, preliminary analysis and lessons learned.

Today, this list contains around 600 events which have occurred in France and concern nuclear facilities. First listed events go back to 1975. 40 to 80 events appear each year.

Concerning the breakdown of these events in relation to the relevant criteria, it should be noted that a significant part (about 1/3) of those events are related to the operation of the facility or the physical protection of the facility, then events in relation to aircrafts or vessels, explosive devices, demonstrations and intrusion. Few actions concern radioactive material. The actions concerning nuclear material or involving firearms are rare.

3. LEGISLATIVE AND REGULATORY FRAMEWORK

The French regulatory system regarding physical protection is based on two different sets of texts.

The first set is oriented towards the detection and prevention of loss, theft or diversion of nuclear material usable for the fabrication of a nuclear explosive device. The basic text is a law passed in the parliament on 25 July 1980. This law is supplemented by a set of decrees, orders and ministerial instructions which go into detailed requirements for nuclear material holders. The concerned operators are required to take appropriate measures to ensure that these objectives are met. The Competent Authority with its technical support body, makes checks on the operators concerned. Depending on the case, this may include assessment of technical files and inspection.

The second set is oriented towards malevolent actions on nuclear facilities. The basic document in this field is the Ordinance 58 1371 published on 29 December 1958 dealing with the protection of high sensitive installations. Specific ministerial instructions detail the arrangements defined for nuclear installations. The latest is the ministerial instruction HFD 50 of 16 May 2000 upgrading older documents. In this frame, two standing advisory groups of experts (one for reactor and one for other facilities) have been created in 1983 to examine how malevolent actions have been taken into account in the conception and operation of nuclear facilities.

3.1. IMPLEMENTATION OF THE COMPETENT AUTHORITIES

The function of the Competent Authority has been devoted in France to the ministry in charge of industry, and more precisely to the High Civil Servant for defence and a specialised division: the Division for protection and control of nuclear and sensitive material. As concerns the protection of nuclear facilities against sabotage, the link with safety issues is materialised via a two-headed authority, shared with the safety authority.

3.2. RESPONSIBILITIES OF THE ENTITIES INVOLVED

Three different entities are involved in the French national control system: the Competent Authority mentioned previously, its technical support body (namely the Nuclear Protection and Safety Institute-Radioactive Material Security Department) and the Operators. The organization clearly defines the roles and responsibilities between these entities.

It is important to note that such an organization closely involves together the authorities and the operators and allows a profitable dialogue between them.

3.3. REGULATORY STEPS

For the design and the operation of a nuclear facility the competent authorities consult the relevant restricted standing advisory group of experts (experts' group), for reactor or for other facilities according to the case, and ask to examine how malevolent actions have been taken into account in the design or operation of this facility.

The group is composed of experts in the field of safety and experts in the field of security and physical protection.

Operating organizations have to perform studies aimed at demonstrating that they are complying with the objectives set by the Competent Authorities for reducing the risk of internal or external malevolent actions.

The technical support body of the Authorities has to assess the operating organization studies and to produce a report which is presented to the experts' group. On the basis of this report, the group issues advice and any specific recommendations that may be necessary to the Competent Authorities.

Then, the Authorities notify the operators by letter, if need be with requirements to upgrade the foreseen or existing arrangements. Requirements are aimed at improving the physical protection measures or decreasing the consequences to the environment in case of malevolent action.

3.4. PRINCIPLES

3.4.1. Performance-Based Approach

The French regulatory bodies have adopted a performance-based approach which gives flexibility to the operators to choose the means and measures which have to be taken and independence to the authorities who are not obliged to judge arrangements more or less imposed through the regulations. Moreover, this approach permits a better adaptation to the risks which might occur in each type of facility and allows us to improve physical protection techniques on a continual basis.

3.5. DEFENCE IN DEPTH PRINCIPLE

The French physical protection system is mainly based on the principle of defence in depth. This concept of defence in depth is organised around prevention, management of the event and mitigation as regards the theft of nuclear material or the sabotage of nuclear facilities. It takes the form of several lines of defence including both administrative aspects (such as procedures, instructions, sanctions, access control rules, confidentiality rules…) and technical aspects (multiple barriers fitted with detectors and delaying devices). This concept of defence in depth is applied to the design and operation of the physical protection system and takes the concrete form of successive barriers, delimiting security areas placed between the sensitive elements of a facility (nuclear material or equipment whose failure would lead to radiological consequences for the environment) and the public area. These areas have to be included one within another and the barriers are designed to be functionally independent.

The physical barriers generally consist of fences for the outside areas and building walls for the areas inside the buildings. These barriers contribute to deterrence and delay for potential intruders and provide uniform and uninterrupted protection. In particular, they are built in order to prevent them from penetration without the need of auxiliary means. They are equipped with devices that detect any intrusion or attempted intrusion and, for the majority, with surveillance and/or alarm assessment systems, as well as lighting devices where necessary. The access points in these barriers (gates and doors) are kept to a strict minimum and are equipped with the appropriate detection devices.

The conditions for access become increasingly stringent as the areas become more sensitive. The conditions for checking individuals become increasingly strict the further they progress inside the facility. In addition, the management of the facility is responsible for establishing, with the adequate procedures, the grounds for granting access authorization to the different areas, but authorization also depends on the results of individual trustworthiness checks made by the Competent Authority as well as work purposes.

Moreover, the operator has on-site response forces which essentially performs the function of control and surveillance of the facility and participate in the deterrence. They are responsible for assessing the alarms, transmitting the alert to the State authorities and, generally speaking, taking countermeasures in the event of any malevolent action in order to mitigate the consequences of these actions. They act as the first level of intervention.

In connection with the on-site response forces placed under the responsibility of the operators, the off-site response forces are, in France, under the responsibility of the State authorities represented by the National Gendarmes forces or the National Police. Exercises are carried out periodically in order to check the effectiveness of the response forces organization.

4. METHOD

The approach to be followed can be summed up as follows:

1. The sensitivity of each zone is determined; this can be characterised by the level of the radiological consequences resulting from a malevolent action. Sensitivity is determined by taking into account:
   - the radioactive product inventory,
   - possible accident situations,
   - an estimate of the consequences of these accidents.
2. The vulnerability of the various zones to each type of aggression is estimated, in other words, an estimate is made of the extent to which it is difficult to carry out a malevolent action in the zone in question.
3. If need be, counter-measures are taken to protect zones for which the consequences would be unacceptable compared to the force of the aggression. Counter-measures are intended both to minimise sensitivity and make it more difficult to carry out the aggression envisaged.

4.1. DETERMINING SENSITIVITY

Analysis of the sensitivity of a facility involves using safety analyses to identify potential accident sequences, which, if they occurred, would have significant consequences for workers, the public or the environment.

An accident sequence is taken to mean a series of events resulting from one or more initiating events (the failure of one or more components or functions, or human error) and which put the facility into a degraded situation with the possibility of radiological consequences, despite the engineered safety systems and mitigation devices installed in it. Safety analyses are performed to study these sequences and the counter-measures to be taken, mainly by using a standard incident and accident list taken into consideration at the facility design stage.

In fact, sabotage is not taken into account in the safety demonstration, as an example: the simultaneous failure of the redundant equipments of a safety related system as the pumps of an emergency cooling system cannot be considered as probable in the safety analysis if there is no common failure risks. And yet, this failure caused by an action of sabotage can lead to an incident or an accident with radiological consequences.

Facility sensitivity analysis deals firstly with components, systems or functions which are important for the safety of the facility and identifies those that would lead to a degraded situation if they were lost or caused to fail by a malevolent action.

Specific initiating events leading to degraded situations caused by malevolent actions also have to be considered. To this end, a study is made of the particular cases of failure resulting from malevolent actions with possible losses of functions or equipment not taken into account in the safety case.

Thus the method put forward allow to identify the most sensitive elements in the facility (components, systems or functions) and therefore the zones in which they are located; there are three types of zone depending on the gravity of the consequences of a malevolent action in the zone:

- zones or systems at risk, when an action is not serious enough to lead to radiological consequences; to cause a significant accident, at least two zones or systems at risk have to be affected,
- critical zones or systems, when an action leads to radiological consequences deemed acceptable from a safety point of view,
- vital zones or systems, when an action leads to more serious radiological consequences than those taken into account in the safety case.

The study of measures permitting to decrease the sensitivity of vital or critical zone must be performed. When it is feasible these measures have to be implemented, as an example by limiting the quantity of radioactive materials contained in a capacity.

For the zones which sensitivity cannot be reduced, the vulnerability is examined either in any case for vital zones or as the case may be for critical zones.

4.2. ASSESSING VULNERABILITY

The vulnerability assessment of the zones and systems identified previously can be broken down into two parts:

- an estimate of the resources required to destroy or sufficiently damage a system or function (for example, the quantity of explosives necessary),
- qualification of the paths leading to zones or systems deemed sensitive.

The second part can be dealt with by identifying all the paths leading to sensitive zones or systems and estimating for each one the difficulties involved or, more generally, the time taken to overcome obstacles and the potential for detecting adversaries.

The previous approach, which has to be linked to response forces interventions, must make it possible to estimate, at least qualitatively, the vulnerability of zones and systems and the need, if any, to take additional steps to strengthen the system (design modifications, additional physical protection devices etc.). This analysis has to strike a balance between the need for adequate physical protection measures and the problems associated with facility operating conditions, facility safety and the mitigation of accident situations.

The resources in the possession of the adversaries depend on the threats being considered, in accordance with the relevant DBT. A distinction is made between internal and external threats. In the case of external threats, adversaries are armed or equipped with explosives, whereas in the case of internal threats, adversaries only have access to everyday tools or perhaps more sophisticated ones if they are usually on hand in the facility. It is therefore clear that inside adversaries have more limited resources than external ones; on the other hand, insiders are assumed to be familiar with the facility and they are operational immediately since they have authorised access. What is more, it may be more difficult to detect an aggression by an insider than one by an outsider. Thus it is that vulnerability assessments vary enormously depending on whether internal or external threats are being considered.

The steps to be taken to reduce the vulnerability of components, systems or functions also vary depending on the kind of threat (internal and external). Although physical protection devices installed between the area outside the facility (public area) and the identified targets effectively counter external aggressions, they are of no use in the case of internal threats and other steps have to be taken. For example, poor operation of an item of equipment has to be detected as far as possible by adding sensors for sending alarms to the control room or by making items of equipment less accessible (under lock and key if necessary) according to their sensitivity.

4.3. CRITERIA

Acceptable consequences are taken as being those leading to levels of radioactive releases less than, or equal to, those taken into account in the facility safety case. This implies that vital zone vulnerability be reduced to a minimum so that an excellent level of protection can be provided for these areas. In the case of critical zones, the level of protection is considered on a case-by-case basis, depending on the consequences of malevolent actions.

QUESTIONS AND ANSWERS

S. Erickson (USA): Do you use EVA or some other software to assist you?

J. Aurelle (France): The computerized code EVA is used by operators for security studies in order to demonstrate that their facilities are well protected against threats of theft. We do not used a computerized method to protect a facility against sabotage.

D. Ionescu (Romania): You classify the terrorist threat as either small group or commando. Would you comment on the difference?

J. Aurelle: Since the details concerning the threats are confidential, it is difficult for me to make further comment.

J. Jalouneix (France): Although the details are confidential, we can say that the idea of having two types of threats is a way to assess the extent to which a nuclear facility can be protected against them.

I. Badawy (Egypt): How do you estimate sensitivity and acceptable consequences?

J. Aurelle: Sensitivity is determined on the basis of facility safety studies. Acceptable consequences are determined according to the safety analysis. If the consequences are equal to or smaller than those allowed for in the safety demonstration, they are acceptable; if they are greater, they are not acceptable and countermeasures are then essential.

J. Fechner (Germany): From your slide on the characteristics of the insider threat, I inferred that you assumed the insider to have no knowledge of the plant. If I didn’t misunderstand the slide, what are the reasons for this assumption?

J. Aurelle: On the contrary, the internal threat involves people who have a good knowledge of the plant because they work there.

EVALUATION OF EFFECTIVENESS OF PHYSICAL PROTECTION SYSTEMS AT NUCLEAR FACILITIES IN SLOVAKIA

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Abstract. This paper contains short presentation of the state supervision in approach to the evaluation of the effectiveness physical protection systems at the nuclear facilities as one kind of measure used to prevent combat illicit trafficking of nuclear and other radioactive materials in Slovakia.

1. INTRODUCTION

Nuclear Regulatory Authority of Slovakia (UJD SR) performs the state supervision of the nuclear safety in Slovakia. Its main objective is to ensure that the nuclear power is utilized in accordance with valid legislation and relevant international agreements in Slovakia.

The utilization of the nuclear power in Slovakia is based upon the Act No. 130/1998. According to this act, physical protection of the nuclear facilities and nuclear materials is an integral part of measures necessary to ensure the nuclear safety. It is the nuclear facility operator who is responsible for the construction, operation, and physical protection of the nuclear facilities.

2. PHYSICAL PROTECTION SYSTEM AND EVALUATION OF ITS EFFECTIVENESS

Every organization which intends to begin construction or operation of the nuclear facility can do so only on the basis of the permission issued by the UJD SR. So-called “physical protection plan” is part of the reviewed documentation necessary for issue of the licence. The plan must take into account all requirements imposed upon the physical protection system as stipulated in the UJD SR’s Regulation No. 186/1999 which details the physical protection of the nuclear facilities, nuclear materials, and radioactive wastes.

The physical protection of the nuclear facilities and nuclear materials is defined as a system of the technical and organizational measures which are aimed to prevent unauthorized manipulations with the nuclear facilities and nuclear materials mainly to prevent their abuse, damage or sabotage. At the same time, it represents a set of measures for verifying of the capability and trustworthiness of the persons being assigned to the working activities inside the nuclear facilities, manipulating with the nuclear materials, or having access to the information on the physical protection of the nuclear facilities and nuclear materials.

The government of former Czechoslovakia decided that there was a need to create a new physical protection system which would increase the level of the nuclear facilities physical protection, back in nineteen eighties. It was decided that the physical protection would be preferably provided using an Automated Complex of Security Protection of NPPs — AKOBOJE. The AKOBOJE system represents technical solution of the whole physical protection system, and it is designed so that any uncontrolled access of persons into individual categorized areas (i.e. into guarded, protected, and inner areas) and into the buildings, where categorized equipment is located, is prevented.

After the split-up of Czechoslovakia, Slovakia decided to continue in further enhancement of the physical protection, and in cooperation with western companies, it improved the existing AKOBOJE system to the level comparable with the one of the industrially developed countries.

UJD SR's inspectors perform the inspections aimed at an evaluation of the physical protection systems levels in accordance with the valid legislative regulations. The main objective of these inspections is to assess conditions of the physical protection system and its changes since the previous inspection, assess the training and qualification programs of the physical protection team members, evaluate the plans and procedures to be applied during events at nuclear facilities. At the same time, fulfillment of remedial measures imposed upon the nuclear facility operator is checked. In these cases, they are so called routine inspections performed in accordance with an UJD SR's Inspection Plan. In case of exceptional events, the inspectors perform unplanned so-called special inspections, which are UJD SR's response to the applicable event in the responsible organization.

When inspecting the level of the physical protection system, compliance of the system equipment conditions is compared with the ones described in the relevant physical protection plan for the applicable nuclear facility. The attention during these inspections is focused on the following:

(a) check of the persons and vehicles entries into individual areas of the nuclear facility;
(b) check of the guarded, protected, and inner areas barriers;
(c) check of the detection elements in the individual categorized areas;
(d) check of the AKOBOJE control center;
(e) check of the performance of the examinations, maintenance, and compensation measures including proper installation, examinations, and maintenance on the equipment.

Part of the security system is also physical protection team that comprises of the own employees of the responsible organization, private security service employees and police response forces of Slovakia.

In case of the inspections aimed at the evaluation of the required level of training and qualification of the security service employees, the inspectors focus on verification whether employees are sufficiently qualified and whether they have sufficient knowledge and skill for performance of the assigned duties and responsibilities including procedures at the response action and use of special tactics during these action.

During the assessment of the total effectiveness of the physical protection system, the inspection is aimed at the detailed examination of the physical protection systems, and determines if these systems are functional and operational in accordance with the regulations and obligations stated in the relevant physical protection plans.

Assessment of the total system efficiency is carried out by simulation of an incident and inspection of the individual physical protection elements procedures and capability to act in the shortest possible time when delaying the intruder's progress towards the predefined intrusion target. The attention is paid during such an inspection to the following:

(a) functionality check of the AKOBOJE systems in service,
(b) vigilance check of the AKOBOJE control room staff and preparedness of the physical protection elements to cope with the incident — barriers defeat and intrusion into categorized areas,
(c) check of connection and effective communication between individual physical protection elements during response,
(d) check of response management system and activities coordination of all involved elements.

The inspections of this type take place under strict precautions, and must be in compliance with existing plans for incident management.

In case of the changes influencing the total effectiveness of the nuclear facility physical protection system, it is necessary that the operator asked UJD SR for issue of the permission of these changes before their implementation. UJD SR then verifies the effectiveness of the proposed changes and their total impact upon the physical protection system by its inspection activities. The main focus is that the conceivable changes should not impair the physical protection system level.

3. CONCLUSION

Based on the inspections performed up to date, it can be satisfactorily stated that the automated security system AKOBOJE installed in the nuclear facilities in Slovakia is fully functional and reliable and it complies with even highest requirements imposed upon the systems of this type in the developed countries.

QUESTIONS AND ANSWERS

J. Fechner (Germany): What inspection intervals apply to the different types of inspections in your PP system?

A. Stefulova (Slovakia): According to the inspection plan of Slovakia's nuclear regulatory authority (UJD SR), there are approximately ten planned inspections a year at the nuclear facilities in the State. There are also some unplanned inspections depending on events at the NPPs.

D. Flory (France): Do you differentiate between an inspection and an analysis/evaluation.

A. Stefulova: Not in principle. Our PP system is evaluated/analysed through inspections.

PHYSICAL PROTECTION III
(Session 5)

Chairperson

D.M.G. FLORY
France

REVISED PHYSICAL PROTECTION AT AUSTRALIA'S FORTY-YEAR OLD RESEARCH REACTOR

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Abstract. This paper describes the work done by Australia to update physical protection measures at the High Flux Research Reactor (HIFAR) at the Lucas Heights Science and Technology Centre research reactor in line with the recommendations of INFCIRC/225. Physical protection at the reactor now meets the minimum standards of the latest (Rev.4)

INTRODUCTION

The High Flux Australian Reactor (HIFAR), a DIDO class, 10 MW (thermal) research reactor operating with HEU fuel, is over forty years old. The design of installations of that era called for a protected area which encompassed not only the reactor but a number of other site facilities. As a research reactor it was exempt from the recommendations of INFCIRC/225, but times and circumstances change. This paper describes the work done by Australia to update Physical Protection measures at ANSTO's Lucas Heights site in line with INFCIRC/225 recommendations. The work was commenced in 1991 and completed in 1995 and PP at the reactor now meets or exceeds the latest (Rev.4) recommendations, which Australia has adopted as its national standard.

The Site

The Lucas Heights Nuclear Science and Technology Centre is owned by the Commonwealth Government (i.e. it is on federal land) and operated by the staff of the Australian Nuclear Science & Technology Organisation (ANSTO) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). The site is situated in scattered timber and scrub and has many native eucalypts. In a paddock near the Administration Building (B1) are a mob of kangaroos kept these days as a public relations exercise. We have fostered the idea that these are specially trained 'attack' kangaroos who will carry explosive in their pouches and cling to any intruder; sort of the ultimate deterrent.

The 10 MW(t) research reactor is located at the western end of the site where the ground is highest. This causes some problems for maintaining operations during lightning storms. The reactor is of the UK DIDO class, 1950s vintage. Similar research reactors are or have been operated by the UK (DIDO and PLUTO at Harwell) and also by Germany (Juelich) and Denmark (Risoe). The High Flux Australian Reactor (HIFAR) went critical on Australia Day 1958 (26/01/1958). Its original fuel was enriched to 93% in U-235, but as the years progressed so the enrichment dropped through 80% and 70% to the present 60% U-235. There are no plans for further reductions in enrichment level. Instead, Australia has decided to build a new reactor, fuelled with low enriched uranium (LEU = 19.95% U-235), which should be operational in 2005. The irradiated or spent fuel from HIFAR will either be returned to the

USA as part of the RERTR program or sent to France for reprocessing into vitrified waste which will be returned to Australia for long-term storage. This latter option is also that chosen for the new reactor's LEU fuel. Although the core inventory of HIFAR is only about 4.25 kilograms U-235, at times we have had more than 25 kilograms of U-235 in our Fresh Fuel Vault. Since this is more than 1 Significant Quantity (1SQ) as defined by the IAEA we were subjected to monthly Agency inspections between April 1997 and July 1999.

The Need for Upgrading

The storage and physical protection regimes were assessed in 1989 by the national regulator (ASNO — the Australian Safeguards & Non-Proliferation Office) to be less than satisfactory if we were to meet the changes then being mooted as part of the on-going review of INFCIRC/225, '*The Physical Protection of Nuclear Material'*. ASNO recommended the operator, ANSTO, perform an upgrade of security, in particular to construct a revised 'protected area' (RPA) around HIFAR. The old protected area was deemed to be within the perimeter fence which, although regularly patrolled, had no specific illumination or detection equipment. The most cost-effective method by which to proceed was judged to be the rationalisation and relocation of facilities to a greatly-reduced protected area at the western end of the site. The revised protected area (RPA) was provided with physical protection in accordance with the categorisation of the nuclear material held within it and the security systems installed took account of concerns for the potential for sabotage. The RPA included new and relocated fencing, intruder detection and alarm systems, new lighting, new roads and car parks and other civil construction. It has the advantages of a smaller and less costly protected area as well as permitting a more appropriate level of Commonwealth Government protective security for the whole of the site. That is to say, there are less restrictions on persons, information and assets in the other activities and businesses being conducted in other areas of the site. The upgrading commenced in 1991/92 and the RPA was operational in 1995 at a cost of AUD 2.75 in 1995 dollars. Holdings of nuclear material other than HIFAR fuel were relocated inside the RPA or HIFAR Protected Area as it has become known. Only one small facility was too costly to relocate and was provided with its own, smaller protected area.

The Rational

The overall approach was to examine the existing facility characteristics and address the categorisation of the various categories and quantities of nuclear material (see Section 5 of INFCIRC/225/Rev.4) which provide the basis for varying levels of protection. The principal consideration in establishing categorisation is the concern for theft of material and its subsequent use in a nuclear explosive device or as a radiological dispersal device. Sabotage is also a concern, in that an act of sabotage against a nuclear facility or against a shipment of nuclear material could create a radiological hazard to the public. INFCIRC/225/Rev.4 identifies this concern and resulted in the recommendation that research reactors be treated with similar consideration as power reactors. The recommendations state that the primary factor for determining the physical protection measures is the nuclear material itself. In other words, the level of protection given an activity should be based on the type and quantity of the nuclear material involved.

Design Basis Threat

One of the primary considerations in the design of a physical protection system is threat definition and analysis. The designer of the system must take into consideration the intentions and capabilities of the perceived adversaries and their motivation.

The relevant Australian Government body that addresses these items is the Australian Security Intelligence Organisation (ASIO). Their personnel include persons expert in the methods that could be used in penetrating fences and locked doors and bypassing alarm systems. They also conduct an evaluation program which assesses the relative efficiencies and the strengths and weaknesses of locks, seals, filing cabinets, alarm systems and communication devices proposed for use in the Australian Government service. Testing is carried out in a variety of Australian climatic conditions, ranging from the cold, dry wastes of Antarctica to the heat and wet of the tropics and taking in the desert country that comprises the bulk of the Australian hinterland.

As a result of these evaluations, ASIO endorses certain products for particular situations, and prescribes how they should be installed. It also indicates how the devices should perform in service. ASIO, on behalf of the Commonwealth's Security Construction and Equipment Committee, publishes a Security Equipment Catalogue, the Australian Government's purchasing guide to ASIO-endorsed products. Australia is a large country with several climatic zones, so the information in the Catalogue is very useful to ASNO when prescribing physical protection measures at our uranium mines. These are found in the middle of desert-like terrain (as at Olympic Dam in South Australia) or in a tropical environment (like the Ranger mine at Jabiru in the Northern Territory).

Once the design basis threat has been determined we can work out what to protect and how to protect it. The system then designed should meet four basic functions-deterrence, detection, delay and response.

Having said all that, ANSTO's overall business and mission must be borne in mind. It is all well and good to have an effective physical protection system, but the organisation still needs to function. ANSTO's mission consists of four components:

- To provide expert scientific and technical advice across the nuclear fuel cycle to the Government and to support Australia's national strategic and nuclear policy objectives.
- To operate large nuclear science and technology based facilities in Australia and overseas for the benefit of industry and the Australian Research & Development community.
- To undertake research on specific topics to advance the understanding of nuclear science and the nuclear fuel cycle, and
- To apply resulting technologies and other relevant, unique capabilities to focussing research and development and other scientific activities to increase the competitiveness of Australian industry and improve the quality of life for all Australians.

The Lucas Heights Science and Technology Center (LHSTC)

The LHSTC has 80 buildings situated on 70 Hectares located 30 kilometres south-west of the centre of Sydney, Australia's most populous city. The site is in the general vicinity of residential areas. Most of these residents moved into the area after the reactor was built, knowing it was there, but they are now among its most vociferous opponents. There are 900 staff, not all of whom perform nuclear-related work. There is regular interaction with other research businesses and scientific research organisations and universities. The daily business includes operating the HIFAR reactor, the manufacture of radiopharmaceuticals and industrial radioisotopes, which are supplied both domestically and through South East Asia, and the commercial processing of minerals and ceramics.

So you can see that while there was a need to protect the reactor and other nuclear assets, there was also a requirement to affect the general day-to-day running of the Centre as little as possible. This is why it was decided to consolidate all nuclear material at the western end of the site, close to the reactor and then provide enhanced protection for all these assets.

The Revised Protected Area

The HIFAR reactor and other facilities are enclosed within an area of double fencing with complementary detection technologies on the fences and entry-points. The whole fence line has CCTV coverage with both alarm and assessment capability. The outer fence is also fitted with an arrester wire to prevent vehicles crashing through it. The 3-metre exclusion zone between the two fences is lined with pebbles to give good contrast for the CCTV system. High quality illumination covers the exclusion zone but the spread of light is carefully arranged so that it does not disturb neighbouring residents.

Access to the HIFAR Protected Area is restricted to personnel who have a need to enter the area for work purposes. It goes without saying that these staff have been assessed as trustworthy by regular security vetting. The access control consists of two turnstiles with entry by identity card swipe and individual PIN number entry. Each staff ID card bears its owners photograph. Exit is by swipe only.

All private vehicles are barred from the area. Entry and exit for work vehicles is controlled by access control through a double-gated traffic barrier. Passengers are required to alight from each vehicle at the first barrier gate and use the turnstile, while drivers have to use the access control (card swipe and individual PIN) at the second barrier gate.

Safety requirements have been recognised and arrangements are in place to handle emergency situations or evacuation of the area, including generating evacuation reports. There was also a need to comply with all Australian building and fire codes in relation to turnstiles, gates (safety beams, etc) and access control entries.

Before and after

In the ‘good old days’ there was unlimited access for staff, visitors, contractors, private cars, buses, delivery vans etc to the HIFAR area. It was possible to park a very large tanker immediately adjacent to the reactor shell, for example. The only ‘security’ was provided by the perimeter fence, which was more for delineating trespass than for protection of assets and carried signs saying as much. The main deterrent was the guard force provided by the Australian Protective Service (APS) who are uniformed and armed. They are posted at the main entrance to the site, and now at the entrance to the RPA. Before there was no intruder detection and no special guarding of the HIFAR reactor. The Site Alarm Centre was co-located with the Fresh Fuel Vault in its own building.

After the construction of the RPA there is very limited access to the HIFAR area. Only essential staff are allowed access, no private vehicles, and only essential delivery vehicles and site transport are allowed through the traffic barrier. Photographic ID card swipe access is provided for the essential staff who also need to use an individual PIN number to gain access. The system is ‘anti-passback’ and precludes tailgating. An audible alarm sounds when the turnstiles are in use. A possum once decided to set up house in the turnstile mechanism in order to scrutinise staff entering, but this additional security feature was not successful and the possum’s contract was not renewed.

Visitors are required to exchange their blue site access badge, issued at the Reception Centre at the Main Gate, for a special HIFAR Protected Area red badge and use the turnstile under the supervision of the APS guards. Bags are checked outside the turnstiles and a metal detector is used. All vehicles entering the RPA are subject to a chassis examination by mirror.

Other factors which were taken into account

The power system for HIFAR's normal operations was already on an uninterrupted electrical circuit. The new Physical Protection installations are now on this and other uninterrupted circuits. These installations include all computers associated with the Physical Protection System (PPS) and also the access control systems. The choice of detection systems for the RPA was made on the basis of site weather conditions, ground and general environment and local flora and fauna. It is important to keep nuisance and false alarms within acceptable limits. In the event the fence systems selected for the site (an Israeli Taut Wire installation plus microphonic cables) and the entry point systems (stacked PIRs) have worked very well in practice and have proved very reliable. All detection elements are only effective when correctly installed, operating as designed, and regularly maintained and tested. Equipment malfunction does of course occur, but down-time is kept to a minimum due to ANSTO's access to trained and experienced technicians, with appropriate security clearances, who are available 24 hours a day, 7 days a week. Supervision by appropriate facility security personnel is also required at all times.

The Guard Force

We have already mentioned the Australian Protective Service (APS). This is the federally funded and organised guard force which provides guarding, on-site and off-site response forces and incident co-ordination. The APS is Australia's counter terrorism first response (CTFR) organisation. Officers are empowered to arrest, without warrant, people contravening specified Commonwealth Acts. The next layer of armed response for an incident at Lucas Heights is the New South Wales Police Force. Exercises have shown that four police cars can be on the site within ten minutes of receiving an alarm. The NSW police have their own Tactical Response Group which is heavily armed and protected and trained in siege and hostage situations. The 'ultimate solution', who would be called in by the civil power if it judged the situation to be beyond its control, are units of the Australian Army's Special Air Service (SAS). These units were based in Sydney for the duration of the 2000 Olympics.

The whole goes to providing a secure work environment for staff as well as secure environment for the Australian public.

PHYSICAL PROTECTION UPGRADE IN AN EXISTING RESEARCH REACTOR

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Abstract. Improving physical protection (PP) of nuclear materials in existing facilities requires design and constructions to be fitted into structures which might have not been prepared for the purpose. Limited funds available for improvements are additional constraint. The IPPAS** Mission arranged by the IAEA for Poland in 1997 assessed the situation and through assistance from two participating States considerable improvement in PP of nuclear materials was obtained in the Świerk Nuclear Center, mostly in 20 MW research reactor. The paper describes main features of the approach.

Poland was among the countries which invited an advisory mission (the International Physical Protection Advisory Service, IPPAS) arranged by the IAEA to evaluate status of physical protection of nuclear materials in the State and eventually to arrange for possible improvements. The mission, with participating experts from France, Germany, United States and United Kingdom visited Poland in 1997 (with a later follow up visit) and formulated a number of recommendations, most of them concerning the Institute of Atomic Energy, Świerk, where more significant activities involving use of nuclear materials were centered around a research reactor.

The reactor, originally commissioned as material testing facility operating now up to 20 MW power level, uses fuel being purchased in moderately large batches. Storage of the fuel and its handling require adequate physical protection procedures, materials being categorized as in use or in storage. Since the reactor, and its building, has been erected in early 1970-ies, specifications regarding physical protection were somewhat different from contemporary state of art. A number of recommendations provided by the IPPAS mission were difficult for direct implementation because of quality of existing civil engineering structures; this was even more difficult because of inadequate funding for the purpose available for the Institute.

Two IAEA Member States — United States and the United Kingdom arranged for a follow-up visit to asses Poland's adherence to the recommendations and feasibility of implementing them in prevailing financial circumstances. As some of the recommendations were impossible to be implemented in short term without outside support, the two Member States made funds available to cover most urgent needs and delegated their representatives to co-ordinate works in the PP System upgrades.

Chris Robertson of Sandia NL (US) and Steve Atkinson of DCNSy (UK) proposed a concept of improvements based on concentrating structures and means around the target, in order to attain optimal increase in protection using funds available. Their Draft Design Document dated January 1999 initiated works toward the improvements. Hardening some structures (walls, doors, special locks) provided multi-layer defense approach advised by the basic

* Affiliation at the time of the work performed.

recommendation INFCIRC/225 rev.4. Some other enhancements of physical protection also included:

- Building a Guard Station close to the target, equipped with hardened walls, doors and windows.
- Providing alarm detection and video assessment capability.
- Providing a modern computerized access control system to allow only authorized persons to enter some areas.
- Increased passive defenses around target — tie-downs.
- Providing radio-communication equipment to be used by guards on duty and between alarm stations, thus enabling effective use of response force in emergency.

The vault, where fresh fuel is stored, beside hardened walls and doors, is equipped with sensors to detect intrusion and with CCTV for assessment. Two-men principle for door operating, requiring a permission from the access control system, creates a real obstacle for any unauthorized entry.

Additionally, the containers with fresh fuel are engaged mechanically with steel, robust structures, named tie-downs, immobilizing the nuclear material. The access to the material is through combination of locks, involving again two-man principle.

The structure creates additional delay for an adversary attempting theft. The tie-downs, of relatively low cost and easy to maintain, were designed and manufactured in the Institute. An assessment by specialists from Sandia National Laboratories confirmed adequacy of the tie-downs for the purpose.

The response force consists of specially trained guards, some of them operating the new alarm station located within the reactor building. Access to the station is also controlled by electronic equipment requiring use of magnetic cards and codes. Alarm detection, assessment and response are coordinated from this location. The station is manned 24 hours a day seven days a week, since operators of the reactor work in shifts.

Besides, armed response force team members are positioned in several other locations throughout the Institute. Portable radios, together with base stations at control posts allow for coordination of response and for communicating with local and national police.

All of the physical security upgrades were procured, installed and build during 1999. The radio communication equipment and spare parts for the security system were provided during February 2000. Local contractors were used for civil engineering work. They were selected on the basis of experience gained in similar installations in banking sector.

The system was designed with sustainability in mind. Future cost and resources to maintain the system were considered throughout the design and implementation stages.

Additionally, the system was engineered to enable the Institute to expand their current security configuration in accordance with potential changes in threat defined by Polish security organizations.

QUESTIONS AND ANSWERS

J. Jalouneix (France): Having improved your installation’s PP, how do you assess the effectiveness of the modifications?

K. Kruk (Poland): The effectiveness of the modifications, which were made according to the recommendations of IPPAS experts, was analysed during inspections of the PP system.

G. Bunn (USA): What was the main reason for the major change in the PP of your research reactor? Was it a change in the DBT to the HEU in the reactor?

K. Kruk: Yes, the new DBT for HEU in research reactors, which was incorporated into national legislation, was the main reason for making the improvements.

J. Koziel (Poland): In conjunction with this presentation, I should like to remark that when MARIA — Poland’s high flux research reactor — was designed and commissioned, PP was not taken into account. The improvement in PP systems was possible thanks to financial assisstance from the Governments of the United States of America and of the United Kingdom. On behalf of the Institute of Atomic Energy, Swierk, Otwock, Poland, I would like to express my thanks to these Governments for their assistance.

UPGRADING OF PHYSICAL PROTECTION OF NUCLEAR MATERIALS IN AN OLD NUCLEAR RESEARCH REACTOR FACILITY

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Abstract. The present paper describes a system for upgrading the physical protection of nuclear and other radioactive materials in an old nuclear research reactor facility. The approach was based on the integration with the existing nuclear material accountancy system of the facility. The upgrading technique used an entry-exit control system of personnel and equipment, and the capability of detecting the movement of nuclear materials. Performance of the upgraded system of physical protection showed that the upgrading process is in the appropriate direction.

1. INTRODUCTION

Physical protection of nuclear materials and nuclear facilities untill the early sixties of the twentieth century was dominated by the need to protect classified information. The consequencies of failure were potentially much more serious than the monetary value of the resources. As a matter of fact, the physical protection provided against unauthorized use or transfer or theft of nuclear materials (NMs), and against any act of sabotage of nuclear facilities by individuals or terrorist groups is a very important factor of security which should be considered at the national level and by the world as a whole [1-2].

It is well known that the responsibility for the establishment, operation, maintenance and development of a comprehensive physical security system for NMs and nuclear facilities within a State rests entirely with the Government of that State. In the same time, the cooperation between States is essentially needed in the field of physical protection of NMs and Nuclear facilities so that it might be possible to detect and defeat or prevent any hostile actions against these targets — particularly — in the case of NMs transport across frontiers [3-5].

In the present work, a physical protection system was designed and implemented to upgrade the security of an old nuclear research reactor.

2. APPROACH

An approach for a physical protection system of a nuclear facility and NMs requires a designed mixture of hardware, procedures and the nuclear facility design. The approach in this work was based on the integration with the existing NM accountablity system of the facility nuclear safeguards [6].

The upgrading of the physical protection system was designed specifically to suit an old nuclear research reactor facility.The First Egyptian Nuclear Research Reactor "ET-RR-1" is in operation since 1961. Considerations were taken with respect to the facility geographical location, the safety design, the access to vital areas and the State's assessment of the threat [7].

3. SYSTEM DESIGN

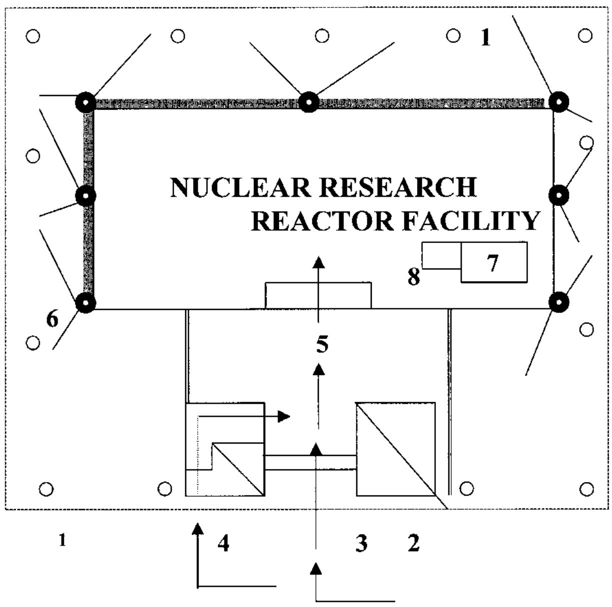
3.1. GENERAL

The basis of an effective physical protection system for a nuclear research reactor facility may be — mainly — the physical barriers, the guards system, the detection and assessment system, the communication system and the response system. Various factors should be considered in the design; the effect related to the site and physical environment, the tamper protection for the components of the physical protection hardware, the effects related to interferences (natural or man-made; e.g. electrical, electromagnetic, nuclear radiations,.etc.) and the redundancy for power supplies [8].

3.2. SYSTEM DESCRIPTION

The system for upgrading the physical protection of NMs and other radioative materials used or produced in an old nuclear research reactor (NRR) is schematically presented in figure 1. The system was designed to provide measures for external protection, guards, entry and access control, safety and protection for transport of NMs, and administrative/personnel control [1, 4].

A peripheral fence has been built arround the nuclear research facility as a second barrier. The first barrier is the fence of the Nuclear Research Center (NRR–AEA) where people may be allowed entry/exit through the main gate "point". The NRR facility fence is provided with a local security control center, with guards, communication equipment and direct contact with the main guard and security center. Also, the fence has television cameras allowing complete visibility of fence zone as shown in figure 1. In order to ensure functioning of the surveillance 24 hours per day, an illumination system operated through a universal power supply (UPS) was recommended.



1. Fence Perimeter & Illumination
2. Guards Local Center
3. Vehicle Entrance
4. External Personnel Entry Control
5. Facility Entry Control
6. Video Surveillance System
7. Inner Area
8. Intrusion Detection System

FIG. 1. Schematic diagram of the upgraded physical protection for an old nuclear research reactor facility.

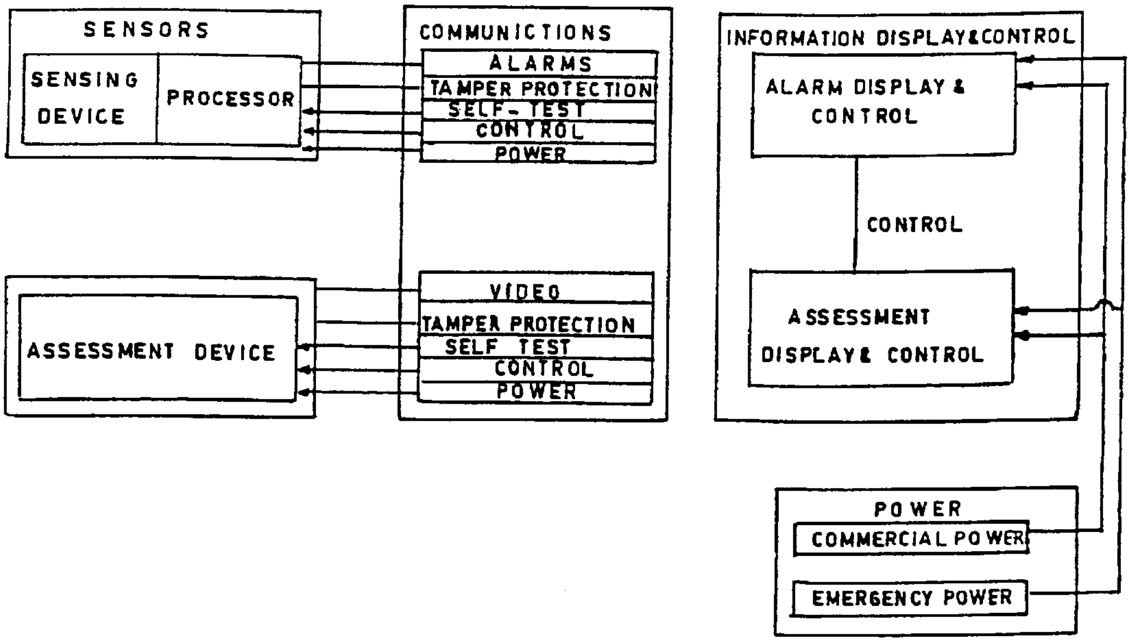


FIG. 2. Representation of an intrusion detection system hardware.

The access of personnel to the NRR facility is controlled through a personnel Entry/Exit port located near the local security guard where only authorized personnel [carrying a special card with a code number, or a special magnetic card] may be allowed entry to the NRR facility after registering and signing in an administration registration book.

The access control inside inner areas [4] (e.g. the reactor hall) is done under direct authority of the facility manager (assisted by radiation protection specialists) for a limited number of personnel involved in specific tasks. A closed circuit television system is used for surveillance inside the inner areas. The system can observe and locate any personnel inside the interior area from the reactor control room.

Various types of intrusion detection systems may be used in exterior or interior areas of the nuclear facility. In this work, an interior intrusion system has been investigated [9]. It is based on ultrasonic sensors. A block diagram of the system is presented in figure 2 [9]. It is designed to detect the movement of an intruder within the interior of a specific inner area inside the NRR facility. In order to allow authorized activities in that protected area, the intrusion detection system would interface with the entry control system of the facility physical protection regime.

4. PERFORMANCE

Performance of the upgraded system of physical protection of the old NRR facility in cooperation with the existing NM accountability system enhanced the ultimate goal of security of the NMs, other radioactive materials and the nuclear facility itself.

Development is going on in the direction of providing more specialized training for the concerned physical protection personnel and the use of more intelligent technology and equipment [10]. This could be realized through raised funds and technical cooperation projects with other states and the International Atomic Energy Agency.

5. CONCLUSION

It may be concluded that the process of upgrading the physical protection system of the old NRR facility is going on in the appropriate direction. Further development may still be needed to attain higher performance of the system.

REFERENCES

[1] UNITED STATES OF AMERICA, CFR-USA, Code of Federal Regulation, 10 CFR-Part 73, "Physical Protection of Plants and Materials", (Revised), Washington, USA (1984).

[2] MANGAN, D, Protection Prospective, JNMM Vol. XVI No 2,3 INMM, USA, (1988).

[3] WEIS, B.H., PELLAUD, B., Intensifying IAEA Activities in Physical Protection, Paper — Department of Safeguards, IAEA/SG, Vienna, Austria (1996).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, The Physical Protection of Nuclear Material and Nuclear Facilities, IAEA INFCIRC/225/Rev. 4 (Corrected), IAEA-Vienna, Austria (1999).

[5] NILSSON, A.B., Strengthening the Security of Nuclear Material Physical Protection, IAEA, Bulletin, Vol. 41, No.4, 32, IAEA, Vienna, Autsria (1999).

[6] BADAWY, I., HAMMAD, F.H., A Proposed National System of Nuclear Material Accounting and Safeguards, Proc. Al-Azhar Second Engineering International Conf., Vol. VII, 607, Cairo, Egypt (1991).

[7] TECHNOEXPORT, Physical and Thermal Calculations of BBR-C Reactor, Technoexport, FTT -2-12092/A-10-46-0256, Moscow, USSR (1956).

[8] UNITED STATES OF AMERICA, SAND-USA, Intrusion Detection Systems Hand Book, Sandia National Laboratories, SAND-76-0554, Albuquerque, NM, USA (1977).

[9] ABOU-EL-ELA, M. SHAHEEN H., ELSHANSHOURY A. BADAWY, I. An Intusion Detection System for Physical Protection of Nuclear Material in a Protected Area, Proc. Seventh Nat. Radio. Sc. Conf., H2, PP 1-11, Cairo, Egypt (1990).

[10] BRUCKER, D.G., Smart Technology-A Security Imperative, Proc. 32 nd INMM Ann. Mtg. Nuclear Materials Management, Vol. XX, 281, New Orleans, LA, USA (1991).

[11] BADAWY, I., An Integrated Nuclear Safeguards System for a Multi-purpose Medicum Power Research Reactor, Proc. AL-Azhar Fifth Engineering International.

QUESTIONS AND ANSWERS

J. Fechner (Germany): Could you elaborate on the contribution of response forces (e.g. police) to the PP of the research reactor since that provided by the operator will probably be insufficient to cope with attacks by the extremist groups known to exist in Egypt.

I. Badawy (Egypt): The site perimeter is guarded by armed forces ready for action.
O. Johnson (USA): How is the integrity and reliability of facility employees determined?

I. Badawy: This is done with the help of the national security system before allowing a worker to be hired.

PHYSICAL PROTECTION AT NUCLEAR POWER PLANTS IN SWEDEN

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Abstract. This paper will discuss the issue of physical protection from the view of power plant security manager.

INTRODUCTION

Just a glance back. There was a security need but no security before SKI promt was taken the command.

The SKI as a normative regulatory authority
The power plant managers trust at SKI competece in the area of physical protection.

Physical protection and reactor safety
The physical protection system is a part of the reactor safety and must be used in a comprehensive way.

Responsibility for an effective physical protection at the plants
There are responsibilities all the way from the managing director to the little man at the floor.

Security barriers and balanced protection in depth
Securtiy barriers build around the reactor like leaves at a head of cabbage.

Unarmed guards and response force by police force
The Swedish model with unarmed guards.

Experience from 25 years with physical protection at Swedish nuclear power plants
The need of general acceptance and co-operation.

INTRODUCTION

Twenty years ago there was a situation in Sweden there some reactors were in operation without a well-reasoned strategy for their physical protection.

Of course there had been a report, made by Swedish Power Board security department, but there conclusions seemed to bee too far-reaching and expensive.

The report was taken and discussed but not used for security improvement. At this time SKI prompt was taking command of the situation.

SKI made directions in what way the nuclear power plants had to build up there physical protection against a hypothetical, and secret, threat.

This lecture deal with the communication and co-operation between the nuclear power plants and the authority SKI and it will give you a piece of information how the authority demands will be received and answered by the Swedish nuclear power plants. Closely I would like to share a couple of experiences.

THE SWEDISH NUCLEAR POWER INSPECTORATE SKI, AS A NORMATIVE REGULATORY AUTHORITY

SKI directions for physical protection is a wall to wall concept. It includes all relevant aspects. It will supply people, as well as technical processes, at the nuclear power plants from a view of security needs. It is based on a physical protection over all threat definition.

The physical protection system was constructed to meet the authority directions in the late seventies. The concerned companies drew up their proposals for security solutions by themselves and showed the results to the authority. After discussions, and sometimes real changes, there always was acceptance from SKI and the security solutions were implemented.

In the physical protection concept there was, and will be, several controversial parts there issue needs dialog between the authority and the power plant management. During the last decade there has started a well-functioned communication. The parts will take concerned action by the way of preparatory informal dialog. After that there is a formal consideration before SKI stipulate new, or modified, security demands for the nuclear power plants.

As an example SKI has listened to the security managers, and the Swedish publics, attitude against weapons. In our culture the police force is responsible for maintaining order and public safety with weapons. Our guards are unarmed and we rely on the police force if there is a terrorist intrusion or another dangerous threat.

Today we have a confident teamwork. SKI and the security managers at the nuclear power plants feel very strongly the roles in the physical protection process. The authority points out the direction and the level. After that, the plant management have their possibility to carry out the directions in the best way depending on the very special facility conditions. Distinct routines for reports will ensure a mutual update of the physical protection conditions.

SKIs ambitions for physical protection give the nuclear power plants their security level. We trust the authoritys qualified analyse of threats in Sweden and in the surrounding world.

PHYSICAL PROTECTION AND REACTOR SAFETY

The physical protection is an important part of the reactor safety at the same time as it in some ways will have a negative influence on the reactor safety. The important point is to see the parts in a comprehensive view.

Long ago, when the physical protection systems were implemented there were two different offices at SKI who gave requirements without co-ordination. Physical protection demands led to reactor safety risks and reactor safety routines counteracted the intention of the physical protection. The SKI inspectors were right, in relation to their different missions but they were not co-ordinated. Circumstances like this was very frustrating for the plant management and specially for the security managers. Today this problem is history, but the experience is important.

Because there are no weapons at the plants we can not stop intruders immediately and that results in a delay philosophy with reactor safety system activities as a vital task in the physical protection until response force by the police take over and eliminate the threat. The operators competence and activities in case of an intrusion scenario are factors of finishing importance. The aim is to secure a constant control of the reactor and the reactor cooling what ever happens.

RESPONSIBILITY FOR AN EFFECTIVE PHYSICAL PROTECTION AT THE PLANTS

At each Swedish nuclear power plant there is a strictly responsible division, even at the physical protection area.

The managing director is responsible for the observance of the laws and the authority decree at an over-all level. The managers of operations are responsible for the physical protection effectiveness of the units and for the security investigation of the workers before they are allowed to get inside the shell protection.

Management and supervisors are responsible for the function of physical protection at there domains. In this will be included a settled security follow-up of subordinated personal.

Security manager is a staff-function. The security manager is responsible for making policies and instructions. He will check the physical protection effectiveness and advise the managing director and the organisation in security matters. The security manager is responsible for the co-operation and communication between the plant and SKI in physical protection issues.

The operating personal will, and have to, follow their instructions both in the ordinary every day job and if there will appear a threat.

All the employees share the responsibility of a well-functioned physical protection at the plants. Everyone have to keep the security directions and is expected to report risk observations and check unknown individual who stay at the plant area.

SECURITY BARRIERS AND BALANCED PROTECTION IN DEPTH

A very important part of Swedish nuclear power plant physical protection philosophy is their balanced security barriers which give a protection in depth.

The first barrier is a single fence around the site. The fence will not stop intruders but it is a necessary legal border.

The second barrier is a perimeter protection of double fences and isolation zones with sensors and continually watched over by TV-cameras, all around the nuclear power units. The double fences will delay intruder and the alarm equipment will indicate illicit access to prohibited area.

The third barrier is shell protection with intruder sensors around equipment witch needs for the safe reactor operation process. The shell protection is a strong construction which make it impossible for intruders without special tools to get inside and will delay intruders with all kind of tools.

The fourth barrier is the building sections with a lot of locked doors. Specially important equipment will be safe inside locked rooms with restricted access.

The fifth barrier will secure equipment which is vital by definition of SKI, and must be protected against sabotage. Shell protection around vital areas is made of very strong constructions and there are intrusion sensors all around the areas.

In addition there are security barriers around central control rooms and the alarm central.

Between the areas are checkpoints with guards and automatic access control by badges.

Mechanical safety will stop intruders and security equipment will give us information and initiate the response by guards and the police response force.

UNARMED GUARDS AND RESPONSE FORCE BY POLICE FORCE

Guards at the Swedish nuclear power plants will at first follow up on what is going on and sound an alarm if there is a threat against the plant. Early warning is important. We presume that the guards, with assistance of security equipment guaranties that we will not be surprised by intruders.

In Sweden there are no evidence for better security by armed guards. Our opinion is clear, armed guards will only rise the violence to a higher level and weapon will not improve the physical protection. We can also see some risks in using weapons at the plants. The guns can be fired off by mistake and in worst case the guns will be stolen and used against us by bandits.

We think that we by foresight and decent planning can manage the initial situation of an intrusion without armed guards. Together with the police we have prepared all the efforts and measures we need to secure the control of the reactors, the reactor cooling and the threat elimination.

Our experience of the police force organisation is good and we can relay on at their efforts when it comes to helping us if, just when we need their help.

EXPERIENCE FROM 25 YEARS WITH PHYSICAL PROTECTION AT SWEDISH NUCLEAR POWER PLANTS

Of course we have collected a lot of interesting experiences in physical protection at the power plants during 25 years. Here comes a short outline about two important observations.

General acceptance

Our experience shows that it is difficult to get general acceptance in security and safety matters which is based on threats who are not quite realistic and reliable. If there is no acceptance for the fundamental threat, the security routines will not work and sanctions will not help.

The challenge is to maintain security awareness by everyone depends on their acceptance of the threat.

The conclusion is; We need general acceptance because we want effective physical protection. For general acceptance we need a plain picture of realistic and reliable threat.

Even today, after 25 years with physical protection marketing, there are some individuals who do not accept the basic threat because they think it is excessive!

Co-operation

Our experience shows that internal and external co-operation is a fundamental condition when we want to obtain a good physical protection function. Our most important partner is the police force. All co-operation need preparations. Preparations need foresight and always a piece of time.

Conclusion

We need co-operation and it is important to map out suitable partners, be comfortable together, make plans and work together at practice exercises just to be ready to meet dangerous threats in the future.

QUESTIONS AND ANSWERS

M. Bahran (Yemen): Since the Swedish police may be exposed to radiation during PP training in hot areas or when intervening in response to an incident involving radioactive release, are they legally classified as radiation workers, i.e.subject to occupational exposure?

P. Warnström (Sweden): No, they don't train in radioactive areas very much and the level of radiation they receive would be very low. Nevertheless, our organization does a lot of training with the police.

K. Hirano (Japan): With your unarmed guard policy, what is your strategy for preventing hostage taking?

P. Warnström: Our organization is not prepared for it; the police handle hostage matters.

J. Koziel (Poland): In Poland, Sweden is regarded as a country that has given up its nuclear power programme. Has a PP barrier ever been broken down by anti-nuclear demonstrators?

P. Warnström: No. There have been peaceful demonstrations for the media but nothing of a violent nature.

S. Fernandez Moreno (Argentina): You mentioned that PP contributed to reactor safety. Could you give an example?

P. Warnström: I meant that good PP diminished the threat.

I. Ray (EC): Have you considered the possibility of terrorist intrusion from the air, for example by helicopter?

P. Warnström: No.

INTERNATIONAL OBLIGATIONS, STANDARDS & NATIONAL REGULATORY SYSTEMS

(Session 6)

Chairperson

C. PRICE
United Kingdom

Keynote Address

ONGOING EFFORTS TO STRENGTHEN THE INTERNATIONAL PHYSICAL PROTECTION REGIME

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Abstract. In the year 1999 there were 504 different fuel cycle facilities worldwide, out of these 250 were in operation (58 uranium mills, 31 conversion plants, 22 enrichment plants, 49 fuel fabrication plants, 67 interim storage facilities, 13 reprocessing plants and 10 MOX plants) [1]. At the end of year 2000 there were 438 power reactors operating [2]. Over 200 research reactors are shutdown but not decommissioned and over 200 research reactors are in operation [3]. Nuclear materials in these facilities and during transport could be potential target for theft or sabotage as well as these facilities could be potential targets for sabotage. This situation is not new and special care is taken by States to protect and safeguard nuclear material and fuel cycle facilities under their jurisdiction. Although the responsibility for establishing comprehensive system for the protection of nuclear material in a State rest with that State, it is also a matter of international concern. The IAEA involvement and guidance in this area is very important and is directed from safeguards and safety perspective.

INTRODUCTION

In the year 1999 there were 504 different fuel cycle facilities worldwide, out of these 250 were in operation (58 uranium mills, 31 conversion plants, 22 enrichment plants, 49 fuel fabrication plants, 67 interim storage facilities, 13 reprocessing plants and 10 MOX plants) [1]. At the end of year 2000 there were 438 power reactors operating [2]. Over 200 research reactors are shutdown but not decommissioned and over 200 research reactors are in operation [3]. Nuclear materials in these facilities and during transport could be potential target for theft or sabotage as well as these facilities could be potential targets for sabotage. This situation is not new and special care is taken by States to protect and safeguard nuclear material and fuel cycle facilities under their jurisdiction. Although the responsibility for establishing comprehensive system for the protection of nuclear material in a State rest with that State, it is also a matter of international concern. The IAEA involvement and guidance in this area is very important and is directed from safeguards and safety perspective.

HISTORY OF INFCIRC 225

The first IAEA recommendations on physical protection of nuclear material were published back in June 1972 as “Recommendations for the Physical Protection of Nuclear Material". These recommendations addressed only theft and were described as an essential supplement to the State System of Accountancy and Control (SSAC). Three years later, the first version of INFCIRC/225 was published under the same title and included threats of sabotage and plutonium dispersion and introduced three categories of nuclear material with corresponding three levels of protection. Up to now four revisions were made: in 1977, 1989, 1993 and 1999. The revision in 1989 followed the entry into force of the Convention on Physical Protection of Nuclear Material (CPPNM) in 1987 addressing the potential for sabotage and not only attractiveness of nuclear material to theft. Revision in 1993 was the result of the first Review Conference on the Physical Protection of Nuclear Material in 1992 and primarily considered categorisation of nuclear material along the Annex II of the CPPNM, as well as physical protection of irradiated fuel and nuclear material in waste. The last revision in 1999 with expanded title to cover Nuclear Facilities as well was significantly changed from previous versions [4]. It introduced more detailed recommendations to clarify the role of the national competent authority and of operators, introduced design basis threat and gave new emphasis on the protection against sabotage of certain nuclear facilities. Recommendations in INFCIRC/225 were developed by experts from Member States under the auspices of the IAEA and published by the Director General of the IAEA. They have not been submitted to the IAEA Board of Governors, and do not have formal status of an IAEA "Standard". They are voluntary for States to implement. Nevertheless INFCIRC/225 enjoys general recognition by States, and is used as a reference for physical protection requirements in bilateral cooperation agreements, in Nuclear Suppliers Guidelines for Nuclear Transfers and in two types of IAEA agreements: The Project and Supply Agreement and The Revised Supplementary Agreement for the Provision of Technical Assistance. Its recommendations are intended to be applied to the physical protection of nuclear material in use, storage and transport, whether domestic or international and whether for peaceful or for defence purpose. Recommendations relate also to sabotage of nuclear facilities and nuclear material. The recommendations are much more comprehensive than Annex 1 of the CPPNM

HISTORY OF THE CPPNM CONVENTION

The Meeting of Governmental Representatives to Consider Drafting of a Convention on the Physical Protection of Nuclear Material met in Vienna at IAEA in 1977, 1978 and 1979. Representatives of 58 States and one organisation participated. The Convention that was adopted in Vienna on 26 October 1979, signed at Vienna and at New York on 3 March 1980, obliges Contracting States to ensure during international nuclear transport the protection of nuclear material within their territory or on board their ships or aircraft. It entered into force on 8 February 1987 after 21 States deposited their instruments of ratification, acceptance or approval with the depositary — the Director General of the IAEA.

Pursuant to Article 16 of the Convention, the first Review Conference was held in Vienna from 29 September to 1 October 1992 and was attended by 35 States Parties. The Review Conference unanimously expressed its full support for the Convention and urged all States to take action to become party to the Convention. The Parties considered, in particular, that the Convention provides an appropriate framework for international co-operation in protection, recovery and return of stolen nuclear material and in the application of criminal sanctions against persons who commit criminal acts involving nuclear material. There are 69 State Parties to CPPNM as of 25. April 2001. Number of State Parties is growing steadily with some oscillations (figure 1).

OTHER INTERNATIONAL INITIATIVES

Since 1994 illicit trafficking is being highlighted by IAEA General Conferences resolutions, each successive year with broader scope. In the last one, GC(44)/RES/20 reference was made to all previous GC resolutions on the same issue, to Moscow and Denver G8 summits, to new revision of INFCIRC/225/Rev4(Corr) "Recommendations for the Physical Protection of Nuclear Material", to Safeguards agreements and Additional Protocols, to the 1998 Dijon Conference "International Conference on the Safety of Radiation Sources and the Security of Radioactive Materials", to UN General Assembly elaboration of an international convention on the suppression of acts of nuclear terrorism. Resolution invites all States to participate in the IAEA Illicit Trafficking Database Programme and appeals to States, that have not yet done so, to accede to the CPPNM, adopt relevant physical protection and safety standards and introduce and enforce appropriate measures and legislation to combat illicit trafficking in nuclear material and other radioactive sources. It also invites the Director General of the IAEA to report on the possibilities of further improving the international standards in this area.

Moscow G8 summit in 1996 produced Moscow Nuclear Safety and Security Summit Declaration stating among others, that the security of all nuclear material is an essential part of the responsible and peaceful use of nuclear energy. It reaffirmed the fundamental responsibility of nations to ensure the security of all nuclear materials in their possession and the need to ensure that they are subject to effective systems of nuclear material accounting and control and physical protection. It urged ratification by all States of the CPPNM and encourage the application of the IAEA Recommendations on the Physical Protection of Nuclear Material. It called on other governments to join G8 States in implementing the program for combating illicit trafficking in nuclear material. Commitment to 1996 Moscow Summit on Nuclear Safety and Security was reaffirmed at 1997 Denver summit and 1998 Birmingham summit. The 1999 Cologne summit stated inter alias that "strengthening the international non-proliferation regime and disarmament measures is one of our most important international priorities" and recognised the continuing need to protect and manage weapons-grade fissile material, especially plutonium. Similar conclusions are reflected also in the 2000 Okinawa G8 summit statement.

Comparing to some other related international agreements the membership of CPPNM is growing slowly despite the fact that appeals were made through the IAEA General Conference resolutions to States that have not yet done so to adhere to the CPPNM and despite calls from G8 summits (figure 2).

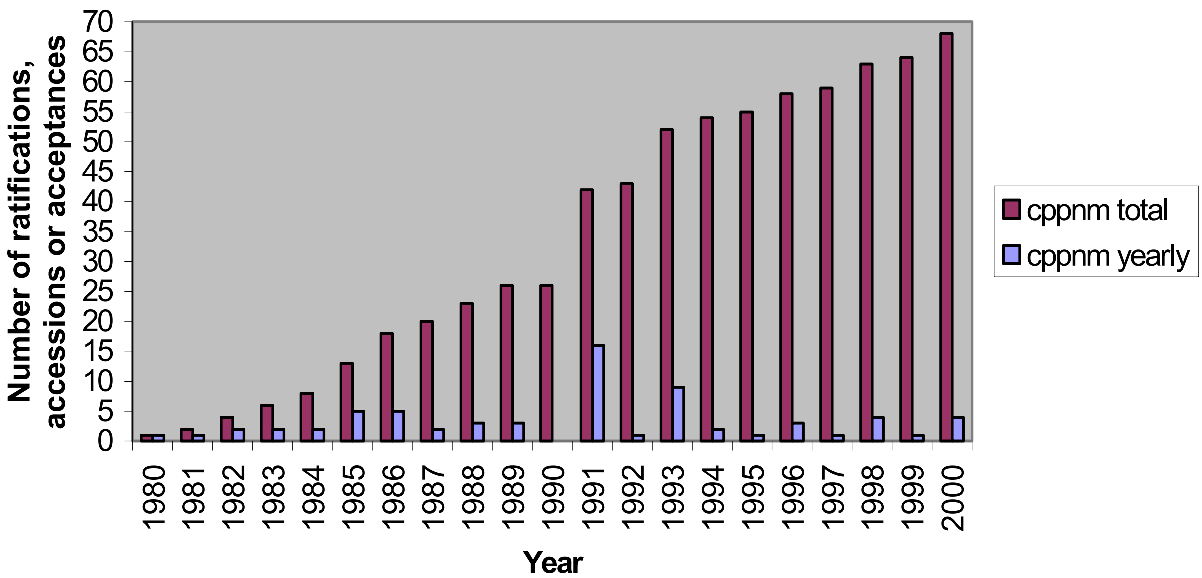

FIG. 1. Status of CPPNM.

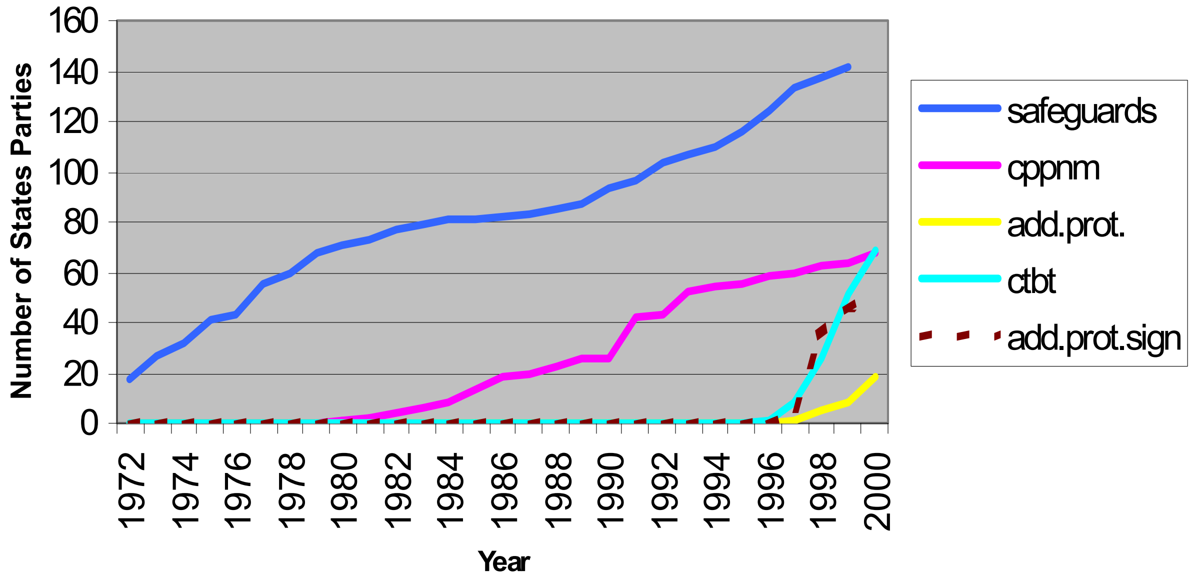

FIG. 2. Status of international agreements.

INITIATIVE BY THE DIRECTOR GENERAL OF THE IAEA

The Director General of the IAEA convened, in November 1999, an Informal Open-Ended Expert Meeting to Discuss Whether there is a Need to Revise the Convention on the Physical Protection of Nuclear Material (CPPNM), in light of the comments made at March 1999 Board of Governors meeting, and the recommendation of the Senior Expert Group that "Consideration should be given to the possible revision of the CPPNM to address issues of prevention of unauthorized possession of nuclear material and access to nuclear facilities". *The Director General requested the experts to provide their view on the basic question of whether there is a need to revise the Convention on the Physical Protection of Nuclear Material*. The Informal Open-Ended Expert agreed that a more detailed process should be established to further examine the issues that should be addressed prior to reaching conclusions on any future consideration of the need to revise the CPPNM decided to continue its work in the next 18 months in a series of Working Group meetings with the participation of the IAEA Secretariat. The Informal Open-Ended Expert Meeting agreed on the Terms of Reference for the Working Group. The Working Group was to prepare a report and make recommendations to be submitted to a further meeting of the Informal Open-Ended Expert Meeting. The Working Group met in February, June and November 2000 and in January 2001. In all, the Working Group considered 19 Working Papers, submitted by members of the Working Group. The result of each meeting of the Working Group was documented in an agreed *Chairman's Report.* The Working Group has addressed all tasks that were assigned to it and produced the final report that reflects broadly the progress of and the views expressed by the Working Group [5]. The tasks considered were:

ILLICIT TRAFFICKING IN NUCLEAR MATERIAL

"*The Working Group should make a careful analysis from all available official sources of all the information on illicit trafficking, including the work already underway and planned by the IAEA on its database, so as to refine and deepen the understanding of the nature and scale of the problem of illicit trafficking and specifically any possible implications for physical protection".*

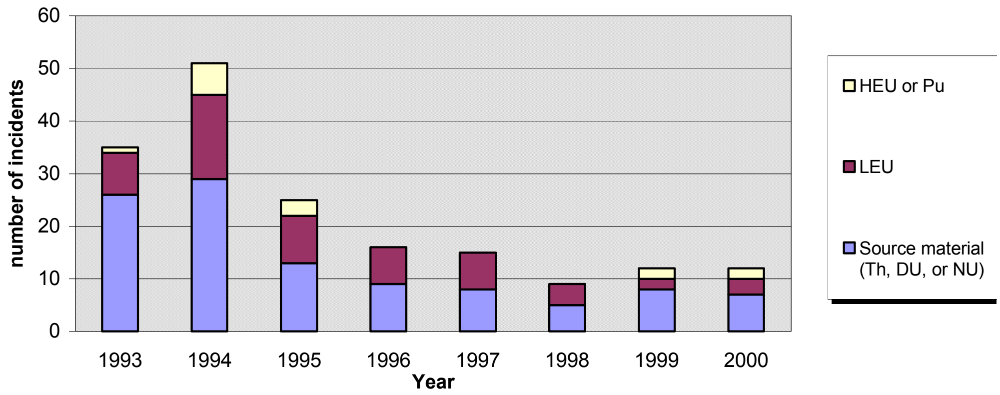

FIG. 3. Confirmed incidents with nuclear material by year and type.

Illicit trafficking in nuclear material has been a serious concern since the early 1990s, following a sharp rise in the number of cases. 68 States are now participating in the IAEA's Illicit Trafficking Database Programme. As the last revised official data shows, on 31 December 2000, the database contained a total of 345 cases that were confirmed by States, 162 of those cases involving nuclear material (figure 3). Most of the confirmed cases of illicit trafficking of nuclear material involve small quantities of nuclear material. Of the confirmed cases involving nuclear material, 4 have involved HEU in proliferation relevant quantities (figure 4).

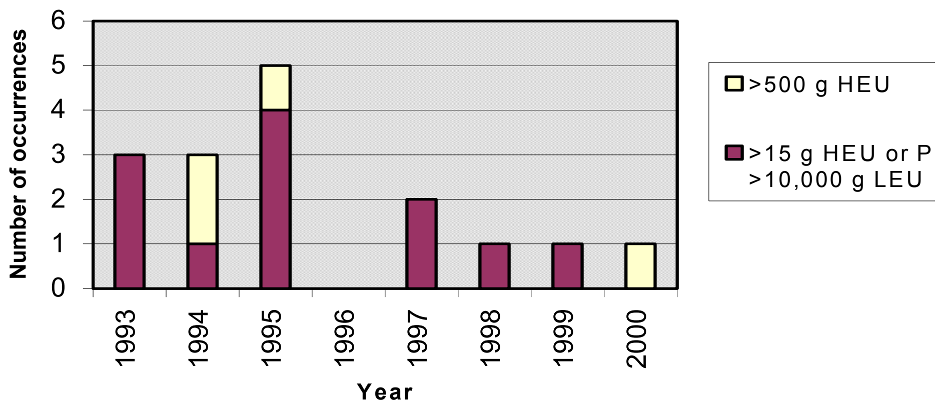

FIG. 4. Confirmed incidents involving relatively more significant amounts of nuclear material.

No confirmed cases have occurred for nuclear material in authorised official international transportation. The database on illicit trafficking has proved to be a valuable tool for monitoring the extent of illicit trafficking of nuclear material. A comprehensive analysis of the illicit trafficking events contained in the IAEA Illicit Trafficking Database would require more information, which may be available to national points of contact or other international organisations. The analysis of the reported cases of illicit trafficking in nuclear materials demonstrates a serious concern, which pointed to a need to improve the physical protection of nuclear materials. The analysis of the illicit trafficking in nuclear material, in itself, did not provide a sole rational to strengthen the Convention. Broadening the scope of the Convention, and thereby strengthening it, would contribute positively to preventing nuclear material becoming subject to illegal activities, including illicit trafficking.

IAEA SUPPORT AND ASSISTANCE ACTIVITIES IN THE FIELD OF PHYSICAL PROTECTION

"*Consider, with the IAEA's full participation, the IAEA's valuable support and assistance activities in the field of physical protection, so as to understand better their contribution to ensuring effective physical protection and to assist in targeting them as effectively as possible in the future*".

The implementation of INFCIRC/225/Rev. 4 (Corrected) is voluntary, hence the need to maintain its reference nature, in order to maintain the flexibility in its implementation. INFCIRC/225 is referenced in Bilateral Supply Agreements of several nuclear supplier States. There is no formal connection between INFCIRC/225/Rev. 4 (Corrected) and the Convention on the Physical Protection of Nuclear Material. Some States Parties to the CPPNM, because the implementation of INFCIRC/225/Rev. 4 (Corrected) is voluntary, or goes beyond the obligations that the State has committed itself to under the treaty, are confronted with a problem in establishing a legal and regulatory infrastructure that would allow a competent authority to implement INFCIRC/225/Rev. 4 (Corrected) in a flexible manner. The development of physical protection documents (as well as other physical protection programme activities) presently depends on ad hoc interaction between the IAEA Secretariat and the Member States, through the establishment of expert groups, as the need arises. An improved mechanism for interaction between the IAEA Secretariat and the Member States is desirable, as the work related to physical protection and other security issues becomes more substantial.

PHYSICAL PROTECTION OBJECTIVES AND FUNDAMENTAL PRINCIPLES

On the request by Working Group the Secretariat prepared a draft of Physical Protection Objectives and Fundamental Principles based on INFCIRC/225/Rev. 4 (Corrected). The physical protection objectives are to establish and maintain conditions to: protect against unauthorized removal of nuclear material in use and storage, and during transport; ensure the implementation of rapid and comprehensive measures by the State to locate and recover missing or stolen nuclear material; protect against sabotage of nuclear facilities and sabotage of nuclear material in use and storage and during transport; and mitigate or minimize the radiological consequences of sabotage. Twelve Fundamental Principles for physical protection as the basis for achieving the Physical Protection Objectives were identified. These principles cover *Responsibility of the State, Responsibilities during International Transport, Legislative and Regulatory Framework, Competent Authority, Responsibility of the License Holders, Security Culture, Threat, Graded Approach, Defence in Depth, Quality Assurance, Contingency Plans,* and *Confidentiality.* Only one Fundamental Principle is fully reflected in the CPPNM, four others are reflected to a limited extent and the remaining 7 are not reflected at all, which demonstrates the need to revise the CPPNM. The Physical Protection Objectives and Fundamental Principles should be applied in States' efforts to strengthen their systems of physical protection of nuclear material. A proper way to gain universal recognition and wide political commitment is an endorsement of the Physical Protection Objectives and Fundamental Principles in a General Conference Resolution. Hence, a political commitment could be secured in a shorter timeframe than the revision of the CPPNM. Since a General Conference Resolution is not legally binding, it needs to be supplemented by the incorporation of the Physical Protection Objectives and Fundamental Principles into the CPPNM. Furthermore, the establishment of the Physical Protection Objectives and Fundamental Principles as "Security Fundamentals", approved by the Board of Governors, would demonstrate an international consensus, and improve the hierarchy of IAEA documents for physical protection.

INTERNATIONAL PHYSICAL PROTECTION ADVISORY SERVICE

Some States have indicated the difficulty to implement recommendations that are voluntary, and a broadening the scope of the Convention could be a way to solve that problem and facilitate the solution of other problems identified during these missions.

TRAINING IN PHYSICAL PROTECTION, TECHNICAL UPGRADES AND OTHER SUPPORT AND CO-ORDINATED TECHNICAL SUPPORT PROGRAMME

These programmes are important elements in the IAEA's physical protection programme. The examination did not, in itself, indicate a need to strengthen the CPPNM.

SUPPORT PROGRAMMES OF ASSISTANCE IN THE AREA OF PHYSICAL PROTECTION OTHER THAN IAEA SUPPORT PROGRAMMES

"Undertake a voluntary survey of any programmes of assistance in the physical protection field (other than IAEA programmes) including assistance in training activities, with the aim of ensuring that any future assistance is targeted as effectively as possible".

The Secretariat had received input formally from seven States and informally from one State providing bilateral support to several other States in the physical protection area. The information indicated that a total of about 530 million US $ had been allocated by the States to provide support to other States for physical protection and nuclear material control. The support had primarily been allocated to States in Eastern Europe and in Central Asia. Impressive resources have been allocated by States to bilateral support in the area of physical protection and material control. This confirms the concern that the physical protection regime does not meet warranted level world-wide.

OTHER MATERIAL PERTINENT TO THE ISSUES UNDER CONSIDERATION, INCLUDING THAT OF WHETHER THERE IS A NEED TO REVISE THE CPPNM

"*Give consideration to any other material pertinent to the issues under consideration and any views expressed by members of the Informal Open/Ended Expert Meeting at its November 1999 meeting".*

RATIONALE FOR A REVISION AND CONSIDERATION OF WHAT PROBLEMS MIGHT BEST BE ADDRESSED BY POSSIBLE AMENDMENTS OF THE CPPNM

Some additional general facts that challenge the international physical protection regime were identified, e.g. an increased privatisation of the nuclear energy sector which may result in a different allocation of responsibilities between the State and the operator. During the last twenty years, there has been a significant increase in quantities of nuclear material used for peaceful purposes; the quantities of nuclear material under IAEA safeguards have increased six-fold (figure 5). In addition, the number of States with nuclear activities and the number of locations at which these activities take place, as well as the number of cases of transport of nuclear material domestically and internationally has increased significantly.

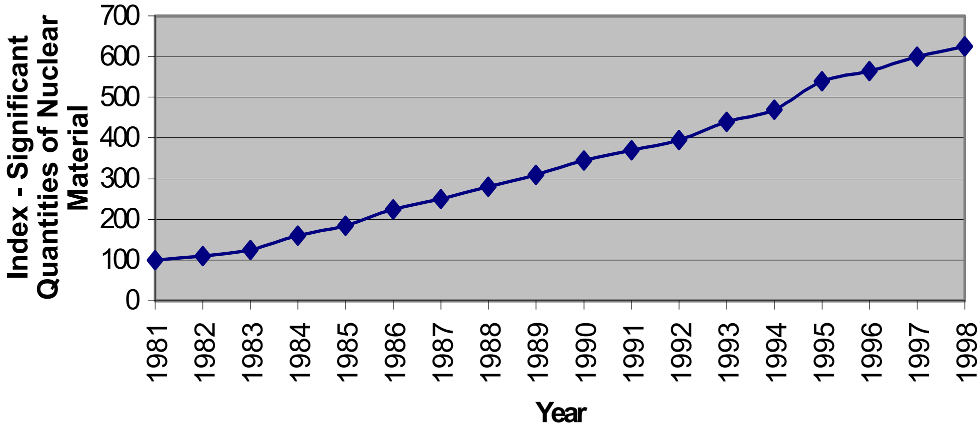

FIG. 5. Nuclear material under Safeguards, SIR 1999.

Threats involving theft of nuclear material constitute a clear proliferation risk, and sabotage of nuclear material and nuclear facilities may have radiological consequences for the public and the environment. The Working Group expressed the view that the risk imposed by criminal, including terrorist activities, both as regards theft of nuclear material and sabotage of nuclear material or nuclear facilities, needs to be taken seriously, and as far as possible, prevented. The content of INFCIRC/225/Rev.4 (Corrected), including its recent recommendations relating to the need to protect nuclear material and facilities from sabotage is considerably more comprehensive in its scope than the CPPNM. For some Member States, the revision of the CPPNM would facilitate the legislative process to adopt measures to improve their national physical protection regime. In addition, the many recommendations (ranging from national legislation, regulation and measures established and implemented at the Facility level) generated during IPPAS missions conducted so far indicate that the protection should be improved. The Physical Protection Objectives and Fundamental Principles would provide the necessary basis for introducing basic obligations in the CPPNM as to the national establishment and implementation of physical protection, while the necessary flexibility on the way to accomplish them on the national level, should be ensured.

The Working Group recognized that while a tool like the CPPNM can play a key line of defence in preventing illegal activities involving nuclear material, it has limitations in that it does neither cover nuclear material in domestic use, storage and transport, nor protection against sabotage.

The key dimensions of the proliferation risk, health of the public and protection of the environment, are of obvious relevance for the international physical protection regime. Given this relevance, all defence layers applied should be individually self-standing and optimised, without relying on compensatory measures provided by other lines of defence, however important these are. For example, if there are limitations in the current CPPNM, it cannot be concluded that there is no need to remove them based on the fact that a good international co-operation for assistance and support is in place.

The CPPNM cannot embody by itself all the provisions necessary to ensure the factual implementation of the desired level of defence; nevertheless it represents a major binding line of defence. It should cover all the situations and threats that involve the peaceful uses of nuclear material. The current CPPNM does not meet that requirement because domestic use and storage of nuclear materials, as well as protection against sabotage, are not included.

The views among members of the Working Group on the need to strengthen the international physical protection regime had narrowed down considerably during the work of the Working Group. Support was given to the idea to revise, to a limited extent, the CPPNM, and include in its scope domestic use, storage and transport and protection against sabotage. The preventive character of the CPPNM and its effectiveness should be improved as a prophylactic, rather than a reactive measure.

A revision of the CPPNM alone might not be the most important nor the only tool to strengthen physical protection world-wide. Efforts to strengthen physical protection world-wide should be focused and give specific answers to specific problems identified. A variety of solutions would be available for that purpose, ranging from short- to long-term.

CONCEPTUAL SUBJECTS TO BE CONSIDERED FOR A POSSIBLE REVISION OF THE CPPNM

The following conceptual subjects were identified for consideration *in the possible revision* of the CPPNM: Extension of scope to cover, in addition to nuclear material in international nuclear transport, nuclear material in domestic use, storage and transport, as well as protection of nuclear material and facilities from sabotage; Importance of national responsibility for physical protection; Importance of protection of confidential information; Physical Protection Objectives and Fundamental Principles, and Definitions.

The following subjects were *ruled out* from consideration for a possible revision of the CPPNM: There should *not* be a peer review mechanism included in the CPPNM; There should *not* be a requirement to submit reports to the international community on the implementation of physical protection; INFCIRC/225 should *not* be mandatory, e.g. through direct reference and also not through “due consideration”; There should *not* be a mandatory international oversight of physical protection measures; Nuclear material and nuclear facilities for military use should *not* be incorporated in the CPPNM.

ELEMENTS OF THE DRAFT CONVENTION ON THE SUPPRESSION OF ACTS OF NUCLEAR TERRORISM THAT ARE FEASIBLE FOR A POSSIBLE REVISION OF THE CPPNM

In considering possible revision of the CPPNM, it is important to continue to monitor progress in the on-going negotiations of a Draft Convention on the Suppression of Acts of Nuclear Terrorism, and to consider whether elements of that draft convention are feasible for a possible revision of the CPPNM.

Better implementation of the CPPNM, particularly Article 14 thereof

Very few thefts of nuclear material and none final outcome of the proceedings of prosecution of alleged offender have been reported according to the requirements of the CPPNM. To date, the IAEA has received communications only from 24 States Parties, pursuant to Article 14.1, providing information on laws and regulations that give effect to the CPPNM. All this shows that more attention is needed on the implementation of the CPPNM.

The "Due consideration" concept

The concept of giving "due consideration" to INFCIRC/225 would not be an acceptable option for a revised CPPNM, because it would introduce ambiguity and would not establish a transparent legal obligation. Imposing the recommendations of INFCIRC/225 as a binding obligation on State parties would not allow for flexibility with further development of INFCIRC/225.

PROCEDURE TO PERFORM A LIMITED AMENDMENT OF THE CPPNM.

The procedure to amend the CPPNM starts by a proposal for Amendment submitted by a State Party or Parties to the Director General of the IAEA as the depositary of the CPPNM. The Director General circulates the proposed Amendment to all State Parties and if majority of them agree to consider the proposed Amendment, the Director General of the IAEA invites all State parties to an Amendment Conference. The proposed Amendments to be considered by the Amendment Conference were only those that had been proposed and distributed to all States parties.

RESOLUTION BY THE GENERAL CONFERENCE TO STRENGTHEN THE INTERNATIONAL PHYSICAL PROTECTION REGIME

Support was given to the idea that a draft resolution, as one of many initiatives to strengthen physical protection world-wide, should be prepared and presented to the General Conference in 2001, endorsing the Physical Protection Objectives and Fundamental Principles. Such a resolution would be useful, as it would be a wide political commitment by all IAEA Member States and not only by those Party to the CPPNM. The proposed resolution should be considered as an *initial step* in conjunction with a decision to revise the CPPNM.

CONCLUSIONS AND RECOMMENDATIONS OF WORKING GROUP

Based on the results of examination of all issues that it had addressed in the process of answering the basic question, the Working Group ***concluded that there is a clear need to strengthen the international physical protection regime.*** In order to promote further the effective implementation and improvement of physical protection world-wide, and by this reduce the risk of theft or other unlawful taking of nuclear material or sabotage of nuclear facilities or nuclear material, that could have key dimensions of proliferation risk, health of the public and protection of the environment, and considering that different measures would be effective in different areas, for different audiences and in different time-frames, a spectrum[1] of measures, initiatives and actions is recommended. The recommendations to the Informal Open-Ended Expert Meeting reflect broadly the progress of the Working Group. Each recommendation received support. There was not universal commitment to each recommendation. The recommendations are:

STRENGTHEN THE CONVENTION ON THE PHYSICAL PROTECTION OF NUCLEAR MATERIAL

Strengthen the existing CPPNM by a well-defined amendment agreed in advance and tabled by State Parties to CPPNM which would cover well defined objectives, definitions, national

[1] It was impossible to single out only one measure that would, by itself, strengthen international physical protection world-wide.

responsibilities, protection of confidential information, domestic use, storage and transport of nuclear material, as well as protection against sabotage of nuclear material and nuclear facilities and reflect the Physical Protection Objectives and Fundamental Principles according to Working Paper 13. Such an amendment would clearly exclude nuclear material and nuclear facilities for military use, mandatory international oversight, periodic national reporting, peer reviews and mandatory use of INFCIRC/225. Invite the Director General of the IAEA to convene an open-ended group of legal and technical experts in order to prepare a draft amendment for such a revision of the CPPNM.

Make further efforts to encourage more Member States to join the CPPNM, and State Parties to fulfil their obligations of Article 14 of the CPPNM.

PREPARE A RESOLUTION BY THE GENERAL CONFERENCE

Drafting a resolution by Member States for GC(45) with the aim of strengthening the physical protection regime and specifically endorsing the Physical Protection Objectives and Fundamental Principles through a wide political commitment.

ENDORSE SECURITY FUNDAMENTALS

Invite the Director General of the IAEA to initiate the process of improving the logical hierarchy of physical protection documents to guide Member States in designing, implementing and regulating their national systems of physical protection. Establish, on the basis of Working Paper 13, "Security Fundamentals" to be endorsed by the Board of Governors following established practice.

Improve IAEA programmes by inviting Director General of the IAEA to establish a Standing Advisory Group on Security and to consider and implement within available resources the recommendations for the implementation of IAEA Programmes in Physical Protection.

FINAL REMARKS

Final meeting of Informal Open-Ended Expert Meeting will proceed shortly after this conference. It is to be hoped that the conclusions of this conference will help streamlining the important decision on how to answer the simple basic question of the Director General of the IAEA *of whether there is a need to revise the Convention on the Physical Protection of Nuclear Material* and how to strengthen the international physical protection regime.

REFERENCES

[1] Status of Regulations for Fuel Cycle Facilities in Member States, IAEA-J4-CS-50/99
[2] Power Reactor Information System, PRIS.
[3] Research Reactors Data Base, DRDB.
[4] The physical protection of Nuclear Material and Nuclear Facilities, INFCIRC/225/Rev4(Corrected), IAEA, June 1999.
[5] Final Report of the Working Group, Working Group of the Informal Open Ended Expert Meeting to discuss Whether there is a need to revise the Convention on the Physical Protection of Nuclear Material, 2 February 2001.

QUESTIONS AND ANSWERS

M. Maerli (Norway): Do you believe it would be beneficial to have an additional or expanded IAEA database on nuclear threats in general, where States could report incidents such as bomb threats or attacks on NPPs, in order to raise the general awareness of the problem and thereby support ongoing efforts to strengthen the PP regime.

M. Gregoric (Slovenia): The IAEA database is voluntary, and all additional information is valuable. Since different organizations are dealing with similar problems, co-ordination and exchange of experience with such organizations as Interpol and the WCO is also valuable.

P. Comella (USA): Referring to your comment on the insights that this conference may offer to the upcoming experts meeting, I stress — as several presenters have — that strengthening legal and regulatory infrastructures is a key to strengthening national systems of physical security of nuclear material and facilities. Moreover, if the CPPNM is to be revised, this should be done in accordance with the Working Group's recommendation for a well-defined amendment to the convention.

I. Othman (Syrian Arab Republic): As to a possible revision of the CPPNM to prevent unauthorized possession of nuclear materials, do we really need yet another legal instrument in addition to the NPT or could we concentrate on procedures and monitoring mechanisms?

M. Gregoric: The NPT does not cover everything required for effective PP. For this reason, we need and have other conventions and agreements, including the CPPNM. Now it's a question of whether we expand this convention.

S. Erickson (USA): I refer to the problem of returning recovered stolen nuclear material. Has any attention been paid to identification so that material can be properly returned?

M. Gregoric: Yes, the Working Group discussed the issue of identification in connection with the Illicit Trafficking Database Program and the difficulty of getting proper input data. Several organizations are dealing with this problem.

THE SAFETY AND SECURITY OF RADIOACTIVE MATERIALS

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Abstract. This paper is concerned with the IAEA's programme on the safety and security of radiation sources which is aimed primarily at protecting people's health. This programme finds its origins in the IAEA's statutory function for establishing safety standards and providing for their application. The International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources provides the basic safety requirements. In spite of the existence of such standards, serious radiological accidents continue to occur, some of these accidents involving 'orphan' sources, that is, they that are not under appropriate control. Concerns about this matter over led, in 1999, to the development of an Action Plan, which is aimed at enabling the IAEA to develop and implement activities that will assist States in maintaining and, where necessary, improving the safety of radiation sources and the security of radioactive materials over their life cycle. This paper describes the seven major topics of the Action Plan and the progress in the implementation of the various actions. These topics are: regulatory infrastructures; management of disused sources; categorization of sources; response to abnormal events; information exchange; education and training; and international undertakings. The findings of a Conference held in Buenos Aires in December 2000, while reinforcing the activities in the Action Plan, also identified further actions. One of these was that events where individuals are exposed to radiation because of breaches in radiation source safety or security without malice aforethought should be clearly distinguished from events where there is a criminal intent of exposing people to harmful effects of radiation.

INTRODUCTION

TWO COMPLEMENTARY PROGRAMMES

The International Atomic Energy IAEA has two complementary programmes dealing with the safety of radiation sources and the security of radioactive materials. One was initiated by the General Conference resolution in 1994 on the security of nuclear materials [1] and this is very much the subject of this Conference. The resolution itself was undoubtedly an expression of the concern on the matter of illicit trafficking that arose following the break-up of the Soviet Union. The other is an integral part of the broader programme of radiation safety, which, in essence, finds its origins in the initial statutory functions of the IAEA. This function is 'to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health and minimization of danger to life and property … and to provide for the application of these standards …'.

The objectives of the first programme are to improve Member State's ability to protect nuclear materials and other radioactive material from sub-national, terrorist or unlawful activities that could impose a non-proliferation threat, or that could endanger health and safety, and to provide Member States with the knowledge and tools for detecting and responding to such unlawful incidents. Specifically, with radioactive materials, the objective is to assist Member States in their efforts to prevent, detect and respond to illicit trafficking in such materials.

The statutory function regarding the establishment of safety standards and providing for their application has been taken very seriously by the IAEA since its inception, the first part being expressed particularly in the Basic Safety Standards. The Board of Governors first approved radiation protection and safety measures in March 1960 and the first basic safety standards in June 1962 [2]. Since then, revisions of these standards have been published, in 1967 [3], 1982 [4] and, most recently, in 1996 [5]. Such standards provide the basic requirements that must be satisfied to ensure safety for particular activities or application areas, and are supported by safety guides, which provide recommendations relating to the fulfilment of the basic requirements; safety reports, which provide practical examples and detailed methods that can be used to apply the standards or guides; and other supporting documents.

Recent concerns

In spite of the existence of such standards, radiological accidents still occur. One cause is undoubtedly because the standards have not been implemented effectively. In recent years, there has been a growing awareness of the potential for accidents with radiation sources, particularly those containing sealed radioactive sources. Some of these accidents have had serious, even fatal consequences. These accidents often have their origins in the inadequacy of security measures in the workplace and have involved members of the public or workers who inadvertently and unknowingly have come into contact with the sources. As sources may be transported across borders, the problems associated with radioactive sources in an insecure condition may not necessarily be confined to the State in which the sources were originally used. There are, for example, instances where sources have become mixed with scrap metal which has subsequently been exported to another State [6]. This has now become a matter of major international concern, because of the substantial international trade in scrap metal.

Sources that are not under appropriate control are now referred to as 'orphan'. These are taken here to mean sources that were never subject to regulatory control, but should have been, or sources that were subject to regulatory control but have been abandoned, lost, stolen, or otherwise removed without proper authorization. The number of such sources in the world is not known, but it is thought to be substantial.

The difference between this problem of 'orphan sources' and that of illicit trafficking in radioactive materials lies largely in the intent of the persons involved. Many of the measures for prevention, detection and response are however similar and it is these similarities that define the interfaces between the two complementary IAEA programmes[1].

The growing concern over the safety and security of radioactive sources reached a climax in September 1998, when an international conference on the topic took place in Dijon [7]. The conclusions from this were reported to the IAEA's General Conference almost immediately afterwards, and by resolution [8], the General Conference encouraged all governments 'to take steps to ensure the existence within their territories of effective national systems of control for ensuring the safety of radiation sources and the security of radioactive materials'.

In the same resolution, the Secretariat was also requested to prepare for the consideration of the IAEA's Board of Governors, a report on:

a) how national systems for ensuring the safety of radiation sources and the security of radioactive materials can be operated at a high level of effectiveness and

[1] There has been some confusion over these interfaces. Largely because detection systems do not distinguish the reason for the presence of radioactive material, the Secretariat adopted a general definition of illicit trafficking in radioactive materials, which was 'receipt, possession, use, transfer or disposal of radioactive material without proper authorization'. Clearly such a definition gives a much broader meaning to the term 'illicit trafficking' than is normally the case, bringing in many events where the presence of radioactive material is inadvertent or incidental. The Secretariat is in the processs of developing a working definition of illicit trafficking in radioactive materials which explicitly includes the criminal or malevolent intent component. Such a definition clarifies responsibilities and avoids the confusion that might otherwise occur.

b) whether international undertakings concerned with the effective operation of such systems and attracting broad adherence could be formulated'.

In response, the Secretariat asked a group of senior experts to prepare a report which was considered at the March 1999 Board meeting. The Board, in turn, requested the Director General to bring the report to the attention of national authorities by distributing it to all States, encouraging them, in particular, to:

a) establish or strengthen national systems of control for ensuring the safety and security of radiation sources, particularly legislation and regulations and regulatory authorities empowered to authorize and inspect regulated activities and to enforce the legislation and regulations;
b) provide their regulatory authorities with sufficient resources, including trained personnel, for the enforcement of compliance with relevant requirements; and
c) consider installing radiation monitoring systems at airports and seaports, at border crossings and at other locations where radiation sources may appear (such as metal scrap yards and recycling plants), develop adequate search and response strategies, arrange for the training of staff and the provision of equipment to be used in the event that radiation sources are detected, and take similar urgent actions.

In addition, the Secretariat was requested to prepare an *Action Plan*. The Director General was also requested to initiate exploratory discussions relating to an international undertaking, which might take the form of a convention or some other type of instrument providing for a clear commitment by and attract the broad adherence of States.

In May 1999, the Director General distributed the report to all States requesting them to transmit it to the relevant authorities in their countries and inviting them to submit their countries' views regarding the nature and scope of an international undertaking in the area of the safety and security of radiation sources.

The *Action Plan*, subsequently prepared by the Secretariat with the help of consultants, was submitted to the Board and General Conference in September 1999 [9]. The former approved it and the latter, through a resolution [10], endorsed it.

Objectives of paper

The objectives of this paper are to describe the *Action Plan*, the progress in its implementation, and the interrelationship with the other programme on the security of nuclear materials.

THE ACTION PLAN ON THE SAFETY AND SECURITY OF RADIATION SOURCES

The primary purpose of the *Action Plan* is to enable the IAEA to develop and implement activities that will assist States in maintaining and, where necessary, improving the safety of radiation sources and the security of radioactive materials over their life cycle. The actions are grouped into seven areas, one of which subsumes the obligation placed on the IAEA to undertake exploratory discussions into the possibility of an international undertaking. These seven areas and associated actions are discussed in turn below.

REGULATORY INFRASTRUCTURES

The BSS [5] are intended to place requirements on those who have been specifically authorized to use radiation sources; they have the primary responsibility for applying them. Governments, however, have responsibility for their enforcement, generally through a system that includes a Regulatory Authority and appropriate regulations. In addition, Governments generally provide for certain essential services for radiation protection and safety and for intervention in the event of an accident. The BSS are based therefore on the presumption that a national infrastructure is in place enabling the Government to discharge its responsibilities for radiation safety. Essential parts of a national infrastructure are: legislation and regulations; a Regulatory Authority empowered to authorize and inspect regulated activities and to enforce the legislation and regulations; sufficient resources; and adequate numbers of trained personnel. Clearly these are national matters, but the IAEA can assist States with establishing appropriate infrastructures.

Action: *to establish a service for advising States on the establishment of appropriate regulatory programmes.*

The Secretariat established in 2000 a Radiation Safety Regulatory Infrastructure Service for:

a) carrying out, at the request of States, assessments of the effectiveness of radiation safety regulatory infrastructures, identifying weaknesses and making recommendations for improvement; and
b) assisting, at the request of States, with the organization of radiation safety regulatory infrastructures and the associated regulatory programmes and advising on how to operate those programmes and on matters such as the functions of regulatory authorities, the application of international standards, and the drafting of regulations consistent with international standards.

During its September 2000 meeting, the Board of Governors encouraged Member States 'to avail themselves of the Secretariat's services relating to the development and review of regulatory infrastructures, and, in particular, to make use of the Radiation Safety Regulatory Infrastructure (RSRI) service recently established by the Secretariat'. So far, one Member State, the Republic of Ireland, has formally invited the Secretariat to provide the first type of service, involving a review of the regulatory infrastructure in that country.

MANAGEMENT OF DISUSED SOURCES

The disposal of redundant sources is a major problem in many States. Facilities for long-term storage may not exist and the original supplier may be unable or reluctant to take back such sources. Even where long-term storage facilities do exist, the disposal costs may deter their use. Because of this, some authorities now require disposal arrangements to be agreed prior to a source being supplied. However, such arrangements do not assist with sources that were supplied several decades earlier. A number of accidents has been caused by redundant sources languishing in stores that are not suitable for long-term storage. With time, the security arrangements degrade and corporate memory fades. The IAEA therefore needs to provide assistance to States in dealing with disused sources.

Action: *to prepare documents on particular aspects of the handling and disposal of disused radioactive sources.*

The Secretariat is currently preparing technical documents on:

a) the management of high-activity disused sources (a disused source is one that is no longer intended to be used for its original purpose) describing their proper handling, conditioning and disposal;
b) establishing procedures for conditioning and storing long-lived disused sources and equipment containing such sources; and
c) disused sealed source management involving storage/disposal in boreholes summarizing current practices involving the use of boreholes for the storage/disposal of disused sealed sources.

Action: to organize consultations and workshops on technical, commercial, legal and regulatory aspects of the return of disused sources to manufacturers and on the management of disused sources with long-lived radionuclides and of equipment containing such sources.

The Secretariat has initiated informal consultations with sources manufacturers about the return of disused sources to them. All the manufacturers contacted so far have expressed a willingness to attend meetings to elaborate various options and a strategy.

The Secretariat also intends to convene a Technical Committee meeting to consider possible strategies for the return of disused sources so that the radioactive material may be recycled and is planning workshops for the purpose of developing a strategy for the conditioning and storage of long-lived disused sources and equipment containing such sources.

CATEGORIZATION OF SOURCES

There is a wide variety of devices containing radioactive sources. Some of these, such as smoke detectors, are intrinsically safe with no appreciable likelihood of causing any significant dose. Such sources, once approved for supply, do not require further control. Other devices containing sources of high activity, such as those used in industrial radiography or radiotherapy, need to be carefully controlled throughout their useful life. Many of the serious radiological accidents have been caused by these devices. This wide range of hazard calls for a categorization of sources. The classification of the International Standardization Organization (ISO) [11] is not sufficient as it relates to performance under test conditions. A categorization of sources was therefore seen as an essential pre-requisite to establishing a graded approach to their management and control.

Action: to prepare a document on the categorization of sources on the basis of the associated potential exposures and radioactive contamination.

A Technical Committee developed a categorization of sealed radioactive sources, based on the following attributes: radiological properties, form of material, practice or activity, exposure scenarios and end-of-life considerations. Sources were ranked according to the harm they could cause, so that the controls to be applied can be made commensurate with the radiological risks which they present. The resulting categories, with examples, are:

a) Category 1 (high risk): industrial radiography sources, teletherapy sources, irradiators;
b) Category 2 (medium risk): brachytherapy sources (both high and low dose rate sources);
c) Category 3 (low risk): fixed industrial gauges with lower-activity sources.

This provides an indication of the priority which a Regulatory Authority should assign when establishing a regulatory infrastructure and trying to bring sources under regulatory control. It would also be relevant to decisions regarding, notification and authorization of use, security requirements and emergency preparedness.

The Board, in September 2000, authorized the Director General to issue the categorization and invited Member States to draw on it as appropriate. The categorization is now published [12]

RESPONSE TO ABNORMAL EVENTS

The IAEA has responsibilities under two Conventions concerned with nuclear and radiological emergencies, namely the Convention on Early Notification of a Nuclear Accident (the Early Notification Convention) and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (the Assistance Convention). It has well-developed emergency arrangements, although there is a need for them to be strengthened and kept under review. It has also developed guidance on preparedness and response to nuclear and radiological accidents [13-16]. These include arrangements for dealing with the discovery of an orphan source. The arrangements are largely concerned with planning for and implementation of response to identified events, although some coverage has been given to the locating sources [17], and some work has been done under the illicit trafficking programme on monitoring at borders [18]. So far however, the Secretariat has not developed comprehensive guidance for dealing with the regaining of control over sources using either active or passive search methods. The actions are therefore concerned with both the regaining of control and the upgrading of the arrangements for responding to incidents and emergencies.

Action: to prepare guidance on national strategies and programmes for the detection and location of orphan sources and their subsequent management.

This action was required to be started after the categorization of sources, the inference being that a graded approach should be adopted. The initial work was a systematic review of the orphan source problem which led to the identification of the areas in a model national strategy for locating orphan sources that need to be defined. It was concluded that sources get out of control through loss during use or (in the case of mobile sources) in transit, being abandoned or their control relinquished, and theft for scrap, particularly when the sources are inadequately stored. It was also recognized that theft for illicit trafficking purposes was a possibility. There may also be a ‘historical legacy’, because ineffective control systems were in place when the sources were used. Locations with a possible ‘historical legacy’ include hospitals and industrial and military sites. Since orphan sources may cross borders, be mixed with scrap metal, or be sent to a landfill site or incinerator for disposal, national strategies need to include the following elements:

a) actions to bring vulnerable sources, such as those in inadequate storage, under firm control;
b) programmes for investigating sites where the presence of abandoned sources is suspected;
c) detection systems at border crossings, scrap yards, landfill sites, incinerators, etc.;
d) intelligence gathering for cases of illicit trafficking; and
e) arrangements for responding to abnormal events, for example the finding of a source.

These elements are to be considered in a technical document which will define a model national strategy, and this is expected to be developed during 2001.

Action: to formulate criteria for the development, selection and use of detection and monitoring equipment at border crossings, ports of entry, ports of exit, and scrap yards and other facilities.

The criteria for monitoring equipment at such nodal points depend on the objectives. With orphan sources, the concern is with regaining control over those sources that might cause serious harm to people and therefore the emphasis should be on the detection of Category 1 sources, and the use of gamma monitoring equipment. Account may also need to be taken of the economic consequences resulting from contamination of recycled metal scrap, and, when this is the case, the range of sources of interest will be widened considerably, and again gamma monitoring equipment will normally be used. When there is need to search for illicitly trafficked material, particularly nuclear material, it is likely to be necessary to monitor for neutron as well as gamma radiation. In all cases, consideration will need to be given to the shielding provided by any material surrounding a source, any levels of residual contamination that can be accepted in material to be freely traded and the inherent statistical fluctuations in radiation measurement.

Both this and the previous action under this heading will be taken together because of their close association.

Action: to develop further national response capabilities for dealing with radiological emergencies.

TECDOC-953 [13] deals with the development of emergency response preparedness for both nuclear and radiological accidents. It is currently being revised and the new version will include the recovery and management of orphan sources involved in emergencies.

TECDOC-1162 [14] is a manual for emergency managers, first responders, on-scene controllers and radiological assessors and is intended to help States develop radiological emergency response systems and train personnel to respond effectively to emergencies.

Since radiological emergencies are sometimes recognized only after the appearance of medical symptoms, and delays in responding can lead to unnecessary exposure and even death, it is essential that medical professionals are able to identify radiation-related pathological conditions. Consequently, the Secretariat has published an information leaflet on 'How to Recognize and Initially Respond to an Accidental Radiation Injury'. In consultation with WHO it also intends to work on the development of a practical emergency response manual designed to help doctors and paramedics deal with radiation injuries. Already with WHO, the it has published 2 Safety Reports, one on the diagnosis and treatment of radiation injuries [15] and the other on planning the medical response to radiological accidents [16].

Action: to strengthen the IAEA's existing capabilities for the provision of assistance in emergency situations.

Under this action, the Secretariat has done a number of things related to its formal responsibilities under the Early Notification and Assistance Conventions:

- developed a revised version of the Emergency Notification and Assistance Technical Operations Manual (ENATOM) [19]. This provides guidelines to Member States, parties to the conventions, relevant international organizations, and other States on suitable mechanisms for interfacing with the IAEA within the framework of those conventions. The

latest version incorporates the concept of that emergency-related information should be reported even when there is no formal obligation to do so;
- developed, with other relevant international bodies, the first edition of the Joint Radiation Emergency Management Plan for the International Organizations [20];
- developed the IAEA Emergency Response Network (ERNET) [21]. This is intended to facilitate the provision of prompt assistance through the establishment and use of emergency response teams based in Member States;
- developed a revised Nuclear Accident/Radiological Emergency Assistance Plan for use by the Secretariat for its response to an accident or emergency.

It is noted that the Secretariat also operates the illicit trafficking database (ITDB), which is intended to record information on illicit trafficking events. This has its own reporting system and the Secretariat is currently setting up arrangements to ensure that there is an appropriate interaction between them and those related to the IAEA's obligations under the conventions.

INFORMATION EXCHANGE

Although awareness of the issues associated with orphan sources has grown, it is by no means universal and there may still be some reluctance to treat the matter seriously. This may be because the number of persons injured by them is small. Even within an accident state, the focus may be more on identifying the responsible parties or to the possible impact on plans to develop nuclear power — because of the difficulty that members of the public have in distinguishing between nuclear and radiological issues — than on determining the root causes and making appropriate changes to reduce the probability of similar accidents in the future.

It is therefore important that the Secretariat should spend some effort in drawing the attention of States to the issues and the importance of appropriate regulatory control.

Action: to organize an International Conference on the Control by National Authorities of Radiation Sources and Radioactive Materials and regional workshops on specific topical issues.

The Conference, hosted by the Argentina Government in Buenos Aires in December 2000, provided a forum for exchanging information and experience regarding the development of regulatory systems for ensuring safety and security of radioactive sources. It was directed at high-level officials, experts from national authorities, senior decision-makers and institutions which use sources. The Conference provided an opportunity for participants to present information on the system of regulatory control in their respective countries and to discuss how, if necessary, the situation might be improved. The conclusions are discussed below.

In addition, the IAEA is organizing several workshops on the safety and security of sources. The first was held in November 2000 for countries in Europe. Others will be held during 2001 — in Morocco and Thailand. These workshops are intended for users and manufacturers of sources and for regulators.

Action: to develop an international database on missing and found orphan sources or to modify an existing database so as to include such sources.

A Technical Committee has concluded that the most efficient mechanism whereby the IAEA might receive information on missing and found orphan sources and make it available to Member States is the reporting system established pursuant to the Early Notification and Assistance Conventions. This Committee has worked out a configuration for an international database, procedures for the reporting of data and rules regarding access to and the security of data and has designed a reporting form. It considered that only sources of Categories 1 and 2 (see above) should be covered.

Action: to develop and maintain the international database on unusual radiation events (RADEV) and make it available to Member States.

This database has now been developed and the aim of the Secretariat is make it available for use by Member States during 2001. It will contain summaries of reports giving the results of detailed reviews of serious radiological accidents and the lessons to be learned.

Since the accident in Goiânia, Brazil in 1987 [22], the Secretariat has prepared, with the agreement of the State concerned, reports on serious radiological accidents. The essential purpose is to clarify the causes and extract the lessons for dissemination to a wide audience. So far, the IAEA has published 8 such reports [22, 23, 24, 25, 26, 27, 28, 29], with another being prepared [30]. In addition, three reports on lessons learned from accidents which have occurred with industrial radiography sources [31], with industrial irradiators [32] and in radiotherapy [33] have been published. The information contained in these reports will be summarized in the database.

Data entered in RADEV to date	Number of Events
Total number of events	179
Orphaned sources	24
Persons exposed below dose limits	205
Execeed dose limits	44
Radiation ‘burns’	14
Amputations	8
Deaths	5

Action: *to develop a repository of information on the characteristics of sources and of devices containing sources, including transport containers, and to disseminate the information, with consideration of the advisability of dissemination through the Internet.*

The Secretariat’s aim is to produce a catalogue which contains information on radioactive sources and devices containing sources to facilitate their identification. Completion of the software design phase and inputting of available data will take place during 2001.

EDUCATION AND TRAINING

Professional education and training has been seen by the IAEA for many years as being an essential pre-requisite for the development of an appropriate competence within a Regulatory Authority and amongst those who advise users of radiation on appropriate protection measures. Nevertheless, there has been a recognition that its approach needs to be strengthened and streamlined. During the early 1990s, the General Conference, through resolution, reinforced this. This led to the publication in 1995 of a standard syllabus for post-graduate educational courses in radiation protection and the safety of radiation sources. An updated version is currently being published. Courses in English, Arabic, French, Russian and Spanish have been organized; courses in Chinese are also being planned. The Action Plan recognized the need for further work to be done in this area of education and training.

Action: to intensify post-graduate educational activities in accordance with General Conference resolution GC(XXXVI)/RES/584 on 'Education and training in radiation protection and nuclear safety' and to develop, in a systematic way, syllabuses and training material for specific target groups and specific uses of radiation sources and radioactive materials.

The Secretariat is currently designing shorter training events on specialized topics such as the establishment of regulatory infrastructures and emergency preparedness and response. It is also developing practice/task-specific modules, with lecture notes, guidance for lecturers, visual presentations, suggestions for practical exercises and sample test questions. The modules are intended primarily for the training of and use by trainers. The training modules on basic concepts, industrial radiography and diagnostic × rays are nearly complete. Distance-learning and computer-based training materials are also being developed.

Action: to strengthen, within existing resources, the role of regional training centres and to facilitate co-operation between such centres, on one hand, and national and regional authorities and professional bodies, on the other, with a view to encouraging the harmonization of training for protection against ionizing radiation, the safety of radiation sources and the application of the Basic Safety Standards.

The standardized material (see above) will provide also help to implement this action. In addition, a long-term programme for training at national and regional training centres is in preparation.

INTERNATIONAL UNDERTAKINGS

As indicated above, the request to the Director General to initiate exploratory discussions regarding the possibility of an international undertaking was subsumed within the Action Plan. The objective of such an undertaking would be to reinforce the commitment of States to establishing and maintaining an adequate infrastructure for the control of radiation sources.

Action: to initiate a meeting of technical and legal experts for exploratory discussions relating to an international undertaking in the area of the safety of radiation sources and the security of radioactive materials.

Two meetings of technical and legal experts were convened during 2000 and a draft Code of Conduct on the safety and security of radioactive sources was produced. It does not apply to the control of nuclear materials, or radioactive sources within military or defence programmes. It relies on existing international standards relating to legal and governmental infrastructure for radiation safety and the control of radioactive sources. Although addressed to States, it notes that States should emphasize to manufacturers, suppliers, users and those managing disused sources their responsibilities for the safety and security of radioactive sources.

The draft Code of Conduct, along with the chairman's report of the second meeting, was submitted to the Board and the General Conference in September 2000. The chairman's report noted a number of particularly difficult issues which the meetings discussed:

1. a proposal that the IAEA should provide the platform for an international registry, at least initially for radioactive sources in Category 1 of the Categorization of Sources [12] was felt to be premature, but could be further pursued by the IAEA's policy-making organs;

2. regarding the matter of import and export of radioactive sources, the meeting felt that the main responsibility for their safe management rested with the importing State, which should consent to import only if it had the technical and administrative capability needed to manage them in a safe manner, but no agreement on the obligations of exporting States in this regard was reached;
3. regarding the question as to whether unilateral declarations whereby States would undertake to take the necessary steps to implement the provisions of the Code should be submitted to the Director General, the meeting felt that the Code should be an incentive document which may or may not be complemented by binding legal undertakings. It also felt that the decisions about such undertakings was a matter for the IAEA's policy-making organs.

The Board of Governors took note of the draft Code and requested the Director General to circulate it to all States and all relevant international organizations. By means of a resolution, the General Conference also invited States to take note of the Code and to consider means of ensuring its wide application. The Code has now been published in the 6 IAEA languages — English, Chinese, Spanish, French, Arabic, Russian [34].

FUTURE DEVELOPMENT OF THE ACTION PLAN

The Conference held in Buenos Aires in December 2000 provided an opportunity to reflect on the effectiveness of the Action Plan and how it might evolve in order to address all the key issues. While many of the findings reinforced the activities already within the Action Plan, they also identified further actions that might have implications for it. These, in summary, are:

1. consideration should be given to the possibility of establishing a universal system for the labelling of radiation sources. The trefoil symbol itself does not provide a clear warning of hazard and an additional warning label, in the local language, would seem necessary to make the hazard immediately clear. This recommendation has surfaced in some of the accident investigation reports, but never has been acted upon;
2. whenever the management of disused sources is not possible within a country, the duty of the supplier to take back sources should be established at the time of purchase;
3. Governments should ensure that arrangements are made between regulatory authorities and facility operators for the detection and future handling of orphan sources, which tend to appear at facilities, such as scrap yards; and
4. events where individuals are exposed to radiation because of breaches in radiation source safety or security without malice aforethought should be clearly distinguished from events where there is a criminal intent of exposing people to harmful effects of radiation. This distinction has implications for border monitoring. It also indicates the need for close co-operation at the national and the international level between nuclear regulatory authorities and law enforcement authorities.

It is also worth noting the emphasis given in the findings to the need for States to develop national strategies for searching for and localizing orphan sources, including actions to bring sources that are in a vulnerable state, such as in inadequate storage, under proper control, programmes for investigating sites where the presence of abandoned sources is suspected, detection systems (at border crossings, scrap yards, foundries, steelmills, landfills and incineration plants), intelligence gathering (for illicit trafficking), arrangements for responding to abnormal events which do not necessarily constitute emergencies (eg the finding of a radiation source) and arrangements for dealing with users who have gone bankrupt.

These and the other findings were presented to the Board of Governors for considering at their March 2001 meeting. In response, the Board requested the Secretariat to assess the implications for the Action Plan and to submit proposals for adjustment to it for examination in September 2001. As a consequence, the Secretariat is convening an Expert Group and a Technical Committee meeting to assist with this task.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY IAEA, Measures against Illicit Trafficking in Nuclear Materials, GC(XXXVIII)/RES/15, IAEA, Vienna GC(XXXVIII)/RES/DEC/(1994).

[2] INTERNATIONAL ATOMIC ENERGY IAEA, Basic Safety Standards for Radiation Protection, Safety Series No. 9, IAEA, Vienna (1962).

[3] INTERNATIONAL ATOMIC ENERGY IAEA, Basic Safety Standards for Radiation Protection, Safety Series No. 9, IAEA, Vienna (1967).

[4] INTERNATIONAL ATOMIC ENERGY IAEA, Basic Safety Standards for Radiation Protection, Safety Series No. 9, IAEA, Vienna (1982).

[5] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY IAEA, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY IAEA, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, IAEA, Vienna (1996).

[6] AZUARA, J.A., "Main Issues in the Acerinox Event", Safety of Radiation Sources and Security of Radioactive Materials, Contributed Papers (Proc. Conf., Dijon, 1998), IAEA, Vienna (1999) pp. 45-51.

[7] Safety of Radiation Sources and Security of Radioactive Materials, (Proc. Conf., Dijon, 1998), IAEA, Vienna (1999).

[8] INTERNATIONAL ATOMIC ENERGY IAEA, The Safety of Radiation Sources and the Security of Radioactive Materials, GC(42)/RES/12, IAEA, Vienna, GC(42)RES/DEC/(1998).

[9] INTERNATIONAL ATOMIC ENERGY IAEA, Measures to Strengthen International Co-operation in Nuclear, Radiation and Waste Safety, GOV/1999/46-GC(43)/10, IAEA, Vienna (1999).

[10] INTERNATIONAL ATOMIC ENERGY IAEA, The Safety of Radiation Sources and the Security of Radioactive Materials, GC(43)/RES/10, IAEA, Vienna, GC(43)/RES/DEC/(1999).

[11] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, ISO 2919, Radiation Protection -Sealed Radioactive Sources- General Requirements and Classification, ISO/TC/85/SC2, ISO, Geneva (1999).

[12] INTERNATIONAL ATOMIC ENERGY IAEA, Categorization of Radiation Sources, IAEA-TECDOC-1191, Vienna (2000).

[13] INTERNATIONAL ATOMIC ENERGY IAEA, Method For The Development Of Emergency Response Preparedness For Nuclear Or Radiological Accidents, IAEA-TECDOC-953, Vienna (1997).

[14] INTERNATIONAL ATOMIC ENERGY IAEA, Generic Procedures For Assessment And Response During A Radiological Emergency IAEA-TECDOC-1162, Vienna (2000).

[15] INTERNATIONAL ATOMIC ENERGY IAEA, Diagnosis and Treatment of Radiation Injuries, Safety Reports Series No. 2, IAEA, Vienna (1998).

[16] INTERNATIONAL ATOMIC ENERGY IAEA, Planning the Medical Response to Radiological Accidents, Safety Reports Series No. 4, IAEA, Vienna (1998).
[17] INTERNATIONAL ATOMIC ENERGY IAEA, Methods to Identify and Locate Spent Radiation Sources, IAEA-TECDOC-804, Vienna (1995).
[18] BECK, P., DUFTSCHMID, K.E., SCHMITZER, C., "ITRAP-The Illicit Trafficking radiation Assessment Programme", Safety of Radiation Sources and Security of Radioactive Materials, Contributed Papers (Proc. Conf. Dijion, 1998), IAEA-TECDOC-1045, IAEA, Vienna (1998) 265-269.
[19] INTERNATIONAL ATOMIC ENERGY IAEA, Emergency Notification and Assistance Technical Operations Manual, EPR-ENATOM-2000, IAEA, Vienna (2000).
[20] INTERNATIONAL ATOMIC ENERGY IAEA, Joint Radiation Emergency Management Plan of the International Organiztions, EPR-JPLAN-2000, IAEA, Vienna (2000).
[21] INTERNATIONAL ATOMIC ENERGY IAEA, IAEA Emergency Response Network, EPR-ERNET-2000, IAEA, Vienna (2000).
[22] INTERNATIONAL ATOMIC ENERGY IAEA, The Radiological Accident in Goiânia, IAEA, Vienna (1988).
[23] INTERNATIONAL ATOMIC ENERGY IAEA, The Radiological Accident in San Salvador, IAEA, Vienna (1990).
[24] INTERNATIONAL ATOMIC ENERGY IAEA, The Radiological Accident in Soreq, IAEA, Vienna (1993).
[25] INTERNATIONAL ATOMIC ENERGY IAEA, The Radiological Accident at the Irradiation Facility in Nesvizh, IAEA, Vienna (1996).
[26] INTERNATIONAL ATOMIC ENERGY IAEA, The Radiological Accident in Tammiku, IAEA, Vienna (1998).
[27] INTERNATIONAL ATOMIC ENERGY IAEA, The Radiological Accident in Yanango, IAEA, Vienna (2000).
[28] INTERNATIONAL ATOMIC ENERGY IAEA, The Radiological Accident in Istanbul, IAEA, Vienna (2000).
[29] INTERNATIONAL ATOMIC ENERGY IAEA, The Radiological Accident in Lilo, IAEA, Vienna (2000).
[30] INTERNATIONAL ATOMIC ENERGY IAEA, The Radiological Accident in Samut Prakarn, IAEA, Vienna (Submitted for Publication).
[31] INTERNATIONAL ATOMIC ENERGY IAEA, Lessons Learned from Accidents in Industrial Radiography, IAEA, Vienna (1998).
[32] INTERNATIONAL ATOMIC ENERGY IAEA, Lessons Learned from Accidents in Industrial Irradiation Facilities, IAEA, Vienna (1996).
[33] INTERNATIONAL ATOMIC ENERGY IAEA, Lessons Learned from Accidental Exposures in Radiotherapy, IAEA, Vienna (2000).
[34] INTERNATIONAL ATOMIC ENERGY IAEA, Code of Conduct on the Safety and Security of Radioactive Sources, IAEA/CODEOC/2001, IAEA, Vienna (2001).

QUESTIONS AND ANSWERS

J. Schofield (UK): What information does the IAEA provide on the identification and categorization of sources according to their common uses and health hazard potential, in particular information that would be useful to front-line national agencies such as police and customs? Descriptions of standard containers and labelling would be useful to such agencies.

A. Wrixon (IAEA): The IAEA has categorized sources in order to provide guidance to regulatory authorities regarding priority for regulatory control of such sources. For front-line national agencies such as police and customs, a number of TECDOCs are being produced on the prevention of, detection of and response to illicit trafficking and inadvertent movement of radioactive material. The IAEA also intends to produce, under the Action Plan, an informational catalogue of sources and containment devices, and is also considering making the information available through the Web. A number of national bodies have produced broadsheets showing photographs of devices that might be encountered, particularly at scrap yards, which could also be useful for police and customs officers. The IAEA is considering producing brochures with such photographs for general distribution

ASSESSMENT OF THE THREAT FROM DIVERTED RADIOACTIVE MATERIAL AND "ORPHAN SOURCES" — AN INTERNATIONAL COMPARISON

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Abstract. Trafficking of nuclear and other radioactive material, radiological- and nuclear terrorism, and "orphan sources" have become potential threats to society. Representatives of nine countries in the Americas, Europe, and Asia formed a network to exchange information on the threat from diverted radioactive material and orphan sources. The results of the data analysis show that, despite international consensus documents and supporting legislation, in several cases major additional efforts are needed for strengthening the regulatory control and the technical capability of some states in order to assure continuing control over radioactive materials under their jurisdiction.

1. THREAT SCENARIOS

Multiple international activities have been undertaken to contain the trafficking of weapon-usable material in order to reduce the risk from the proliferation of such material. In addition, over the past decade the issue of unintended handling and transport of radioactive material has become increasingly important. Concurrent with the growing number of radioactive sources in industrialized and developing countries alike, the probability for losing control over such sources increases as well ("orphan sources"). This paper will describe the resulting threats to man and the environment, as well as the level of preparedness in selected countries. Based on an international survey further actions are recommended in the topic areas legislation and regulatory control, transport, detection and training.

1.1. UNINTENDED HANDLING AND TRANSPORT OF RADIOACTIVE MATERIAL

Worldwide the use of radioactive material is increasing in industry, agriculture, medicine and research. For example, over the past 50 years some 27 000 sources of ionizing radiation, of different activities and isotopic composition, have been imported by developing countries alone. In the future, the importance of ensuring control of radioactive material in general will increase further because over the past seven years several UN-organizations (FAO, WHO, UNIDO, WMO, UNESCO) have increased their efforts, jointly with the IAEA, to transfer advanced nuclear methods and techniques to developing countries [1]. Concurrent with the growing number of radioactive sources, the probability for losing control over them increases as well:

a) Exports of material contaminated with radioactive nuclides have been detected repeatedly in the past 20 years [1], e.g. from Mexico into the USA in 1984 (metal), from Central

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Asian republics to China in 1996 (waste), and from the USA to China in 1996 (iron/steel waste).

b) Internationally, 2,300 reports of radioactive sources found in scrap metal are recorded in the database of the US-Nuclear Regulatory Commission [2]. Without the knowledge of the vendor or buyer, internationally traded recycled metal scrap may be contaminated, i.e. radioactive metal products and by-products can be introduced into international trade without adequate control. In addition, such incidents can also have an off-site environmental impact due to atmospheric radioactive releases [3].

c) Even in a country with a high level of regulatory control, such as the United States of America (USA), an average of approximately 200 radioactive sources are reported lost, stolen or abandoned each year, thereby potentially exposing members of the public in an uncontrolled manner. In the USA every year one or two such sources escape detection and are subsequently melted in furnaces. This results in average costs to the steel mill operator on the order of US$ 10 million per incident. Internationally, at least 39 cases have occurred when radioactive sources were accidentally smelted with recycled metal [4, 5].

d) The Stanford-CISAC *Database on Nuclear Smuggling, Diversion, and Orphan Radiation Sources* (DSDO) shows a significant percentage of nuclear and other radioactive material reportedly going astray. According to the database, 220 confirmed cases had been reported to the IAEA by June 1998, involving persons attempting to sell illegally radioactive sources or nuclear material. However, since not all reported cases are confirmed by the IAEA, the actual number of such events may be higher still.

The IAEA has taken concrete steps in assembling data on such events over the past decade [6]. These input data obviously have to rely on cases as reported by the Member States. The largely varying degree of the regulatory control infrastructure of these countries enabling them to actually detect such events raises the question of the true number of such events occurring on a global scale (see this paper).

1.2. INTENTIONAL DIVERSION AND ILLICIT TRAFFICKING IN NUCLEAR MATERIALS

Internationally, customs officers and border guards are facing an increasing illicit flow of nuclear material [7]. These materials are often hard to detect, particularly in the case of alpha- and beta emitters, or even gamma emitters if well shielded. Furthermore, they can be marked in such a way to mislead the inspecting official during transport, either to distract, or to discourage the official altogether from further investigations in view of the costs associated with a more thorough radiation analysis.

1.3. RADIOLOGICAL- AND NUCLEAR TERRORISM

There is an increasing likelihood of *modern terrorism* becoming involved in the diversion of nuclear material [8]. Modern terrorism is characterised by the shedding of previous constraints, such as considering also the use of weapons-of-mass destruction on innocent victims as prime targets. Events in the recent past are indicative of such a tendency, e.g. the use of the nerve gas sarin by the Aum-sect in the attack on passengers of a subway in Japan, or the attempt by the group of Osama bin Laden to acquire the capability to build a crude nuclear device.

Clandestine nuclear weapons production has had so far a low success rate, primarily due to the control of fissile material. However, *nuclear terrorism* should not be discounted as a possibility in the future for the following reasons:

a) *Increased availability of weapon-grade material*. Approximately 3 million kg have been produced to date [9] and excess stocks are growing as disarmament continues. Relaxing security at nuclear facilities could open up opportunities for unauthorised transfer and diversion of material.
b) *Increasing stockpiles of Pu from the civilian nuclear power production* and proven usability of such material for weapon purposes according to US-tests [10]. In 1999 the international stockpiles of commercial-grade Pu amounted to 802 to 1037 t, in addition to the 242 to 267 t of weapon-grade Pu stockpiled worldwide [11].
c) *Facilitated access world-wide to technological know-how* concerning the construction of crude nuclear weapons ((yield in the lower kiloton range is likely) due to the declassification of previously classified material, presentations in the open scientific literature and enhanced flow of electronic information[12]. For example, in 1998 the statement was made publicly available that neptunium and americium can be used for a nuclear explosive device, overcoming e.g. heat and radiation properties of americium with “a relatively low level of sophistication” [10].
d) *The present non-proliferation strategy* has not prevented several nations from progressing in their efforts to develop nuclear weapons (e.g. Israel, Pakistan, India, Iraq, North Korea, South Africa).
e) It is unlikely that the comparatively *low level of safeguards at nuclear medical- and research installations* (e.g. research reactors with HEU) — as compared to nuclear weapons-storage areas –will represent a deterrent to modern terrorists with an adequate logistical infrastructure to gain access to such materials in the future.
f) *Co-operation between organised crime and modern terrorism* is likely to become a more common feature in the future, since organised crime is making increased efforts to link with personnel from armed forces (e.g. in Russia). It has already an international network in place for smuggling a wide range of goods, which can easily be adapted for profit making in a field less covered by law enforcement than drug trafficking (e.g. cigarette smuggling networks were used by Iraq in its clandestine nuclear programme for obtaining high-tech components).

Modern terrorism is also interested in instilling fear and instability in a complex society. A useful approach, from a terrorist perspective, could be *radiological terrorism*, i.e. the use of non-fission radioactive material (e.g. Cs-137, Sr-90, Co-60) in acts of violence. Such material is subject to considerably less control and available worldwide in research centres and institutions for nuclear medicine. Such material could be used in combination with conventional explosives to cause large-scale environmental contamination. Alternatively it could be introduced into the central ventilation system of major civilian structures (e.g. airport, medical centre, subway, office complex, shopping mall) potentially causing radiation exposure of inhabitants and users. Such a potential future terror scenario emphasises low-tech terror of “mass-disruption” rather than “mass-destruction”. Thereby, modern terrorists can challenge the capability of Governments to exercise control of the situation even by simply causing widespread low-level environmental contamination without actually inflicting lethal radiation exposures. It cannot be excluded that widespread mental health disorders would follow such an act of terrorism, making early and ongoing psychiatric treatment essential for affected communities [13].

2. PROJECT “HAZMAT”

Over the past decade illicit trafficking of nuclear material was repeatedly acknowledged as a public safety and a non-proliferation issue at high-level political summit meetings in Naples, Halifax and Moscow [14]. In 1996 a programme was released for preventing and combating illicit trafficking in nuclear material to ensure increased co-operation among the participants of the Moscow Nuclear Safety and Security Summit. This programme was aimed at comprising all aspects of prevention, detection, exchange of information, investigation and prosecution in case of illicit nuclear trafficking. In this context all other governments were called upon to join in implementing this programme. Subsequently the IAEA General Conference adopted resolution GC(4)/RES/18 on “Measures against illicit trafficking in nuclear materials and other radioactive sources”. In a further step the IAEA Secretariat expressed its concern that in a number of areas the scope of the Convention on the Physical Protection of Nuclear Material is too narrow and that a revision is desirable [15].

As part of a larger programme “HAZMAT”[1], addressing also biological and chemical hazardous materials, the objective of this component of the HAZMAT-study was the investigation of the level of preparedness to reduce the threat from diverted radioactive material in 9 countries in the Americas, Asia and Europe. In this context the term “radioactive” is used to comprise both special nuclear fissile material and non-fissile radioactive sources. Assessment of the threat of losing control over radioactive material was done with the use of a flow-chart, describing the subsequent stages of a given threat scenario (figure 1). The scheme describes the unintended handling of radioactive material and the subsequent transport of contaminated material (e.g. scrap metal contaminated by a radioactive source unknown to the trader; scenario UT — “Unintended Threat”), and the intentional diversion of radioactive material and subsequent transport of the material with the intent to commit a criminal action (e.g. radiological terrorism; scenario IT — “Intentional Threat”).

In both threat scenarios control over nuclear and other radioactive materials is best acomplished directly at the source, i.e. at the user or the storage site of the material. Once the material is outside this control regime — either unintentionally (e.g. loss) or intentionally (e.g. theft) — it is increasingly more difficult to re-gain control by having to intervene during transport or at any subsequent stage.

A questionnaire[2] with over 120 questions was developed, addressing the different means of control and intervention in the four fundamental topic areas: legislation and regulations; control; transport; detection.

The data were supplied by the members of the international network forming the “HAZMAT Working Group” (HWG). The country representatives are affiliated with research centers, universities, or Governmental agencies in altogether nine countries. The countries were selected in order to cover a wide range of economic development and involvement with nuclear technology:

a) ***Austria:*** 2 nuclear research centers with 2 nuclear research reactors; radioactive sources are widely used in research, medicine and industry (about 10 000 occupationally exposed persons; status: 2000), GDP = US$ 27 920 (per capita, 1997);

[1] Work performed within the framework of the International Project “An International Approach to Reducing the Threat from Diverted Hazardous Materials” at the IIS-European Forum, Stanford, CA, USA.

[2] Copies of the questionnaire are available upon request at fjs@stanford.edu

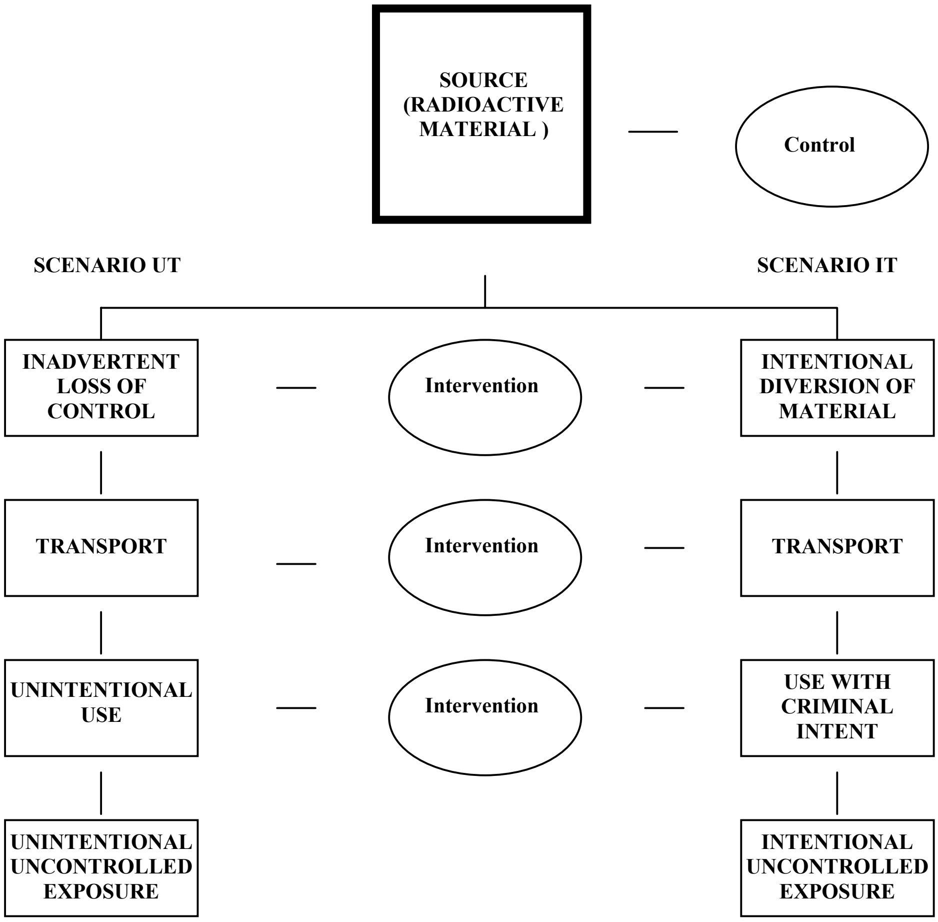

FIG. 1. Flow diagram for different controls and interventions for potentia diversions and subsequent transport of radioactive materials (UT = unintended threat; IT = intentional threat). The term "radioactive" is used to comprise both special nuclear fissile material and non-fissile radioactive sources.

b) ***Bangladesh:*** 1 nuclear research center with 1 nuclear research reactor; 40 licenses issued for various uses of radioactive materials (status: 1999), GDP = US$ 360 (per capita, 1997);
c) ***Brazil:*** uranium mining, milling and fuel production; 1 nuclear power reactor, 4 research reactors; scene of the largest radiological accident on record (Goiania, 1987); 32 licenses for user of fissile material and 2792 licenses issued for users of 4661 radioactive sources (status: 1998), GDP = US$ 4790 (per capita, 1997);
d) ***China:*** complete nuclear fuel-cycle and nuclear weapon-state; 3 nuclear power reactors, 13 research reactors, 68 659 licensees use 59 328 radioactive sources (total activity: 5.10^5 TBq), GDP = US$ 860 (per capita, 1997);
e) ***Germany:*** complete nuclear fuel-cycle capabilities; 20 nuclear power reactors and 15 nuclear research reactors; 11 457 licensees of radioactive material (status: 1998), GDP = US$ 28 280 (per capita, 1997);
f) ***Kazakhstan:*** key role in the nuclear industrial-military complex of the former Soviet Union; nuclear weapons-test sites; uranium mining, milling and fuel production; 1 fast breeder reactor (designated for decommission) and 3 nuclear research reactors, GDP = US$ 1350 (per capita, 1997);
g) ***Poland:*** 8 nuclear research centers and 1 nuclear research reactors; 6 Material Balance Areas and 2500 licensees use about 20 000 sources (1999), GDP = US$ 3590 (per capita, 1997);

h) ***Romania:*** 1 nuclear power reactor, 2 nuclear research centers and 2 nuclear research reactors; 500 licensees use about 200 radioactive sources and fissile material, GDP = US$ 1410 (per capita, 1997);
i) ***Switzerland:*** 5 nuclear power reactors and 3 research reactors; 1 nuclear research center; 2500 licensees use 80 radioactive sources, 10 licensees are authorized to use fissile material, GDP = US$ 43 060 (per capita, 1997).

At the occasion of a closed meeting at Stanford University in June 2000 the situation in each country was reviewed in a series of plenary discussions. In mid-2001 the detailed and nation-specific results of this meeting will be made available to the competent national regulatory authorities in the format of a “White Paper” with limited circulation. In view of the confidentiality of some of the national data only generic observations will be presented in this paper.

3. RESULTS

3.1. LEGISLATION AND REGULATORY CONTROL

All participating countries request managerial, logistical and technical procedures from domestic owners and users of radioactive and fissile material as part of their inventory control and accountancy. However, the mode of establishing the inventory control and accountancy shows significant differences[3]:

a) All countries have established a *national database for fissile material* and its users. Two countries do not have a *central register for the radioactive material* on their territory: in one case this information is available on a regional basis only, in the other case these data are available only at the facility level.
b) The history of *site-specific incidents*, non-compliance with national regulations, and enforcement actions are recorded in a central database in all but one country. In one case neither information is available at any level.
c) All countries exercise *routine inspection programs* or other regulatory mechanisms to periodically contact and/or inspect all license holders, thereby checking that the material is secure and in the assigned location.
d) *Unlicensed radioactive material* is known to have existed in 50% of all countries; in one country regulatory authorities are also aware that some fissile material had never been specifically licensed.
e) In 30% of the countries some radioactive material was removed from authorized storage sites or licensed end-users without proper authorization (*scenario UT*) during the period 1990-2000.
f) 25% of the countries do not have registration procedures in place for *“orphan” radioactive sources*; 60% do not have any long-term strategies for the detection and relocation of such sources; in 25% of the countries orphan sources have originated from defense activities (e.g. abandoned military areas), respectively from uses in medicine and industry. The majority — but not all — have made provisions with regard to storage and proper disposal of orphan sources once located.
g) There is a great variability of *economic incentives* in place by different countries in order to discourage long-term storage of disused radioactive materials at the user’s premises: most favor a fixed period license, whilst long-term storage fees is the least favored approach.

[3] All information refers to participating countries only.

h) 50% consider the *available resources* as insufficient, but do not foresee any long-term budgetary increases to ease the situation either.

4. RESULTS

4.1. CONTROL OF RADIOACTIVE MATERIALS

All participating countries claim to make significant efforts to maintain adequate control over the site and the radioactive material used or stored. Adherence to IAEA standards and recommendations are frequently referred to as a basis for establishing more or less comprehensive systems to prevent the loss of control of materials. However, in view of the lack of data provided on some topic areas (e.g. physical protection) it is difficult to judge the actual degree of compliance and control. Nevertheless, the situation can be summarized as follows**:**

a) All facilities in each country maintain *lists of radioactive materials* stored and used at a specific installation. It cannot be judged on the basis of the information provided at what intervals this information is updated.
b) All countries follow the *cradle to grave concept*, i.e. the history of the radioactive material is tracked until it is returned to the supplier or managed as waste. This includes mandatory authorization related to the domestic transfer between installations.
c) None of the countries reported specifically on the range of *levels of physical protection* implemented at different domestic facilities: either it was considered a national security issue outside even the scope of the confidentiality agreement, or irrelevant since “only high standards were tolerated”. For nuclear fissile material all but one country referred to the “concept-in-depth” as being applied in physical protection; none provided any explicit reference adhering to the IAEA INFCIRC 225/Rev. 4.

4.2. TRANSPORT OF RADIOACTIVE MATERIAL

National legislation concerning the transport of radioactive material is in place in all participating countries. Export controls for nuclear material, radioactive sources, and installations containing such sources are requested as part of national legislation or “Atomic laws”. The transport of radioactive material takes place in accordance with international rules and regulations, and IAEA recommendations. In some countries the regulatory requirements depend upon the country of destination and the transit country; others require special arrangements if the total source activity exceeds 1,000 TBq. Generally, restrictions apply for mailing radioactive sources. The following has been noted:

a) The *preferred method of shipment* of radioactive material is by road, followed by rail. Few countries ship by air, only one country by sea.
b) All countries have *control measures* in place upon completion of the transport phase, e. g. requests for notification about arrival at the foreseen destination.
c) No shipment of radioactive material is considered to be outside the scope of the *regulatory framework* (e.g. return shipment of sealed radiation sources to the supplier of the source in another country). All countries have security- and control procedures in place during the domestic transport of radioactive material, including over-night stops within the country. This applies also to trans-boundary transport.

4.3. DETECTION OF RADIOACTIVE MATERIAL

Once initial control has been lost over nuclear and other radioactive material the success of re-gaining control depends *inter alia* on the adequacy of the radiation detection system installed inside the country and at its borders, and the training of the members of the security forces and customs officers in charge.

In case of threat scenario UT such detection systems have to overcome frequently the problem of registering ionizing radiation originating from bulk material, e.g. from metal contaminated inadvertently with a high activity gamma-emitting source; or to locate a lost radiography source in the environment. This may appear to represent a relatively easy meteorological task. However, it should be noted that gamma radiation, being a product of the decay of many naturally occurring radionuclides, is not evidence of illegal activity by its mere existence. Threat scenario IT can be far more demanding to meet, since it may involve the need to detect radioactive material purposely placed inside shielding. This applies particularly for alpha/neutron emitting weapons-usable material hidden in a container. Such a task requires a degree of sophistication in terms of detection equipment and know-how usually unavailable at strategic checkpoints (airports, border crossings, harbors). In this context the survey in this study showed the largely varying degree of actually being able to detect diverted radioactive material in different countries:

a) All but one country consider to have adequate *technical/scientific expertise* at universities, research facilities, Government institutions and in industry to detect, identify nuclear and other radioactive material under laboratory conditions. Few are able to provide the same service under field conditions.
b) The number of *radiation monitoring installations* and portable equipment available at national check-points ranges from zero in one country, to over 120 fixed installations, 1000 hand-held and 250 radiation pagers in another.
c) Three types of *instrumentation* are available at checkpoints: radiation–pagers worn on the belt and hand-held portable monitors for search operations (both usually simple gamma detectors); stationary portal monitors (typically gamma detectors).
d) 80% of the countries are lacking specific *Investigation Levels (IL)* above which a vehicle- or rail transport, or a pedestrian would be stopped and closely investigated. Even countries with defined IL have taken different approaches, with definitions ranging in case of e.g. pedestrians from IL = twice background to IL = 10 microsievert/h.
e) No country has radiation monitoring capabilities at *“green borders*”; i.e. natural borders without defined border crossings are not subject to routine radiation control.
f) The *number of alarms*, seizures of radioactive material, proposals for sale, and fraud cases ranges from zero (in a country without any monitoring system), to 17 000 alarms and 133 denied entries (out of 84 million vehicles passing national check-points in 1999) in a country with a highly developed border control system.
g) *National training courses,* addressing the prevention, detection, and the response to the loss of control over radioactive material, are conducted in all but one country. The frequency of such courses is typically 2-3 times per year.
h) The *syllabus* of all training courses offered has a high degree of uniformity and provides information on the nature and effects of radioactivity, properties and applications of radioactive material, monitoring and detection principles, protection, safety, and security requirements, as well as “hands on”-type exercises and drills.
i) The *target groups* are mostly customs officers, border guards and security forces. Multi-IAEA training course to improve co-operation between customs and other agencies are held by 50% of the countries.

5. CONCLUSIONS AND RECOMMENDATIONS

The *legislative- and regulatory framework* for exercising control of nuclear and other radioactive material is in place in all participating countries, ready to be applied with generally well defined regulatory and procedural requirements. However, there is definitive room for improving further the enforcement of control in some countries due to the limited resources and manpower available. The actual enforcement of the necessary stringent control is often a major problem due to inadequate finances, lack of equipment and trained staff, a problem several countries have called attention to. Moreover, there is a need for a further development and harmonization of national legislation to adapt to new security threats posed by the illicit trafficking of radioactive material, nuclear- and radiological terrorism. Also the topic area “orphan sources” needs more attention by the legislature in some countries, both in terms of searching for such sources as well as ensuring their safe disposal and storage. In this regard it should be considered unacceptable for a country to lack the central overview on how much radioactive material is in use or stored on its territory. It is encouraging that all countries have adopted the cradle to grave-concept for registered sources, irrespective of the social infrastructure and economic status. The lack of information on the national approaches to physical protection does not allow to make any reliable assessment with regard to the probability of material diversion due to insider and outsider threats.

Transport of nuclear and other radioactive material is generally in compliance with international standards in all countries participating in this study. Comprehensive control mechanisms are established for both domestic and international transport.

The *detection capabilities* for nuclear and other radioactive materials differ widely among the participating countries. Under laboratory conditions all countries have a basic technical/ scientific infrastructure to assess the type of radioactive sources and fissile material, and the activity of seized or suspect material of unknown origin. However, the capability to do this also under field conditions is comparatively severely limited. None of the countries provide radiation detection systems for border guards as an operational routine at “green borders”.

The type of equipment currently available and the special working conditions for customs officers and border guards limit their capabilities to detect hidden radioactive, and in particular fissile material. In many cases their control is reduced to determining whether or not radioactive material is present, i.e. excluding the possibility to ensure that radioactive content stated in the accompanying documentation coincides with the actual radioactive material transported. Three factors are prohibitive to a more detailed investigation: the limited amount of time available for a pedestrian-, container- or vehicle check; the pending bureaucratic effort associated with an isotopic analysis; the resulting costs.

The present situation requires additional R&D efforts in radiation detection systems to address the complex control tasks security forces and customs are facing in their daily routine, such as:

a) Detector systems capable of locating neutron sources at larger distances (e.g. using directional thermal neutron detectors);
b) Large-area thermal neutron measurements without the bulky and sometimes unreliable gas-tube technology based He-3 detectors (e.g. instead with an optically based scintillation detector);
c) Hand-held portable germanium spectrometers, for improved sensitivity and provision of some directionality (e.g. CsI(Na)) detectors featuring a Compton suppression shield);

d) Detection of traces of nuclear material on surfaces, packages, and within vehicles (e.g. using long rang alpha detection methods);
e) Locating nuclear material and providing information on its shape (e.g. with a gamma-ray imaging spectrometer);
f) Inexpensive portable neutron- and gamma detector of variable shape and size (e.g. inflatable radiation detectors based on mylar foil);
g) Remote gamma- and neutron monitoring of shipping containers with minimal access (e.g. using superheated-liquid dosimeters).

In addition there is a need to evaluate the cost-effectiveness of the different conventional vs. the new and advanced detection methods available in the near future.

In the area of *training* an internationally coordinated effort is needed to increase the number of trained members of security forces and customs, requiring in particular:

a) Provision of increased funding for national and regional training courses;
b) The creation of an International Advisory Board, reviewing the content of the currently taught training courses, specially in view of the future use of new and advanced equipment;
c) Increased efforts to conduct domestic inter-IAEA training courses.

REFERENCES

[1] STEINHÄUSLER, F., WIELAND, P., Radiological emergencies due to unaccounted sources or failures of the control system in developing countries, IAEA-GOCP, "Ten Years Later", Vienna (1998).
[2] GONZALES, A., Timely Action — Strengthening Radiation Safety and Security, IAEA Bulletin, Vol. 41/3 (1999).
[3] AZUARA, J. A., Main issues in the Acerinox Event, Proc. Conf. "Safety of Radiation Sources and the Security of Radioactive Materials", IAEA, Dijon (1999).
[4] LUBENAU, J.O., YUSKO, J.G., Radioactive materials in recycled metals, Health Phys. 68 (1995) 440.
[5] LUBENAU, J.O., YUSKO, J.G., COOL, D.A., Radioactive contamination of recycled metals, Proc. IRPA 9 Int. Congr. on Radiation Protection, Vol. 3, Vienna (1996) 291.
[6] NILSSON, A., Measure to prevent illicit trafficking in nuclear and other radioactive materials: The IAEA Security Material Programme, Proc. Dijon (1999).
[7] INTERNATIONAL ATOMIC ENERGY IAEA, Int. Conf. on the "Safety of Radiation Sources and the Security of Radioactive Materials", Dijon, France (1999).
[8] BREMER MAERLI, M., Relearning the ABCs: Terrorists and weapons of mass destruction, The Non-proliferation Review (Summer 2000).
[9] ALBRIGHT, D., O'NEILL, K. (eds.), The challenge of fissile material control, Institute for Science and International Security, ISIS-Report, Washington, D.C. (1999).
[10] GIBSON, W.G., Letter to M. Pankratz/Los Alamos National Laboratory (1999).
[11] COCHRAN, T.B., PAINE, C.E., The amount of plutonium and highly-enriched uranium needed for pure fission nuclear weapons, Nuclear weapons Databook, Natural Defence Council (NRDC), Inc. (1995).
[12] SERBER, R. The Los Alamos Primer: the first lectures on how to build an atomic bomb. University of California Press (1992).
[13] DiGIOVANNI, Jr., C., Am. J. of Psychiatry (1999).
[14] INTERNATIONAL ATOMIC ENERGY IAEA, INFCIRC/509 (1996).
[15] INTERNATIONAL ATOMIC ENERGY IAEA, GOV/1999/8, paragraph 40 (1999).

QUESTIONS AND ANSWERS

M. Bahran (Yemen): Do you have any idea about not only the quantity but also the activity of international holdings of radioactive sources.

F. Steinhäusler (Austria): Participating countries are either hesitant to provide this information to the public or actually not in possession of it themselves. The latter group is the larger one in this study.

S. Fernandez Moreno (Argentina): You mentioned that no State indicated that it applied the recommendations contained in INFCIRC/225/Rev. 4. Was the questioned posed to them about nuclear material or radioactive material in general?

F. Steinhäusler: The questionnaire asked specifically about the application of the recommendations for nuclear fission material.

THE DECLARATION REGIME: AN EFFICIENT TOOL TO IMPROVE CONTROL AND PROTECTION OF NUCLEAR MATERIALS IN FRANCE

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Abstract. The French regulatory system related to the protection and control of nuclear materials is based on detailed and comprehensive regulations. A declaration regime has been set out with respect to small owners of nuclear materials in the industrial, medical and research fields. This requires every operator to declare annually its activities and inventories of nuclear materials, the identification of senders and receivers, and the changes to the inventory expected in the coming year. Specific arrangements regarding physical protection of nuclear materials are also required. The Institut de Protection et de Sûreté Nucléaire (IPSN) ensures on-site inspections carried out by sworn inspectors under the authority of the Ministry for Industry.

1. INTRODUCTION

France has developed a comprehensive fuel cycle from mine to reprocessing plants, and is also a nuclear weapon state which has signed the Non Proliferation Treaty. Beside these civil and military activities, nuclear materials have been used since tens of years in several fields including industrial, medical applications and research activities.

Considering its nuclear situation and conscious of its national and international responsibilities in terms of national public security and nuclear non proliferation, the French government set up a national safeguards system under the authority of the Ministry for Industry whose mission is to ensure protection and control of nuclear materials and to ensure protection of the facilities against malevolent actions. This national system deals with nuclear materials held by small users in the abovementioned activities.

2. REGULATORY FRAMEWORK

The French regulatory system related to protection and control of nuclear materials is an original system based on detailed and comprehensive regulations, taking into account in a specific way the small users of nuclear materials.

The major regulatory texts concerning the small users of nuclear materials are the following:

Law n°80-572 of 25 July 1980, on the protection and control of nuclear materials.

The basic aim of this law is to prevent and, if necessary to detect without delay the disappearance, loss, theft or diversion of fissile, fusible or fertile materials, or equipment containing these materials regardless of their chemical or physical form, ores excepted. The law of 25 July 1980 relies on three main principles:

- Licences are required by anyone to undertake activities in the following fields: import, export, storage, use and transport of nuclear materials. At this stage, no categorization regarding nature and quantity of nuclear materials is done.
- The operator is responsible for the implementation of nuclear materials physical protection, control and accountancy measures, under the control and inspection of national authority.
- Implementation of a penalty system, as punishment for different malevolent actions concerning nuclear materials.

Decree n°81-512 of 12 May 1981. This decree defines in greater details the way in which the law of 25 July 1980 should be applied. It also precises the different types of nuclear materials considered in the French regulations:

- plutonium,
- enriched uranium with 20% or more of uranium 235,
- enriched uranium with less than 20% of uranium 235,
- natural and depleted uranium,
- thorium,
- tritium,
- deuterium,
- lithium 6.

Three regulatory regimes are established, according to the nature and quantity of nuclear materials involved, as presented in Table I:

Table I. Categorization of nuclear materials according to articles 8 and 9 of decree of 12 May 1981

	Plutonium and ^{233}U	Uranium = 20% ^{235}U	Uranium < 20% ^{235}U	Natural and depleted uranium, thorium	Deuterium	Tritium	Lithium 6
Licensing	>3 g	>15 g ^{235}U	>250 g ^{235}U	>500 kg	>200 kg	>2 g	>1 kg ^{6}Li
Declaration	<3 g >1 g	<15 g ^{235}U >1 g ^{235}U	<250 g ^{235}U >1 g ^{235}U	<500 kg >1 kg	<200 kg >1 kg	<2 g >0,01 g	<1 kg ^{6}Li >1 g ^{6}Li
Exemption	<1 g	<1g ^{235}U	<1 g ^{235}U	<1 kg	<1 kg	<0,01 g	<1 g ^{6}Li

- **licensing**: for the most sensitive materials in significant quantities, a licence is granted to operators by the Ministry for Industry.
- **declaration:** below defined quantity thresholds of held nuclear materials, no preliminary licence is needed but a simple annual declaration of undertaken activities.
- **exemption:** no specific requirements for the operator but the quantities of nuclear materials held must be very limited.

Operators under the declaration regime are called « declarants ».

Order of 14 March 1984. This order stipulates technical arrangements related to the control, the accounting for and the physical protection of nuclear materials, under the declaration regime.

Typically, the declaration regime applies to quantities of depleted uranium or thorium, greater than 1 kg and not greater than 500 kg.

It is worth noting that most of nuclear materials are also radioactive materials and that other regulations apply; radiation protection regulations, environmental protection regulations.

3. ACTIVITIES OF DECLARANTS

Nuclear materials are found in activities beside the civil and military fuel cycles. These activities concern the medical, industrial, research fields, and in some rare cases, artistic uses. These uses are described below for the main type of nuclear materials, by decreasing order of importance, as far as number of operators and quantities detained are concerned:

Depleted uranium

The most important uses of depleted uranium (DU) are as radiation shielding material, against radiation from radioactive sources used in the medical and industrial fields. Industrial gamma radiography using sealed radioactive sources of tens of gigabecquerels of iridium 192 or cobalt 60 is the main field of use of DU in France, in terms of number of devices and companies concerned.

The second field where large quantity of DU is used is medical radiotherapy. Telegammatherapy devices containing sealed sources of cobalt 60 with activities of hundreds of terabecquerels include radiological shielding, collimation systems and trimmers made of DU. Some low dose rate and high dose rate brachytherapy equipment also use DU as shielding material.

Moreover, DU is used as balance weights in aerospace applications such as aircraft control systems. It has been used in oil-well drilling in the form of sinker bars.

Thorium

Tungsten inert gas (TIG) welding needs thoriated tungsten electrodes to be used for welding metals such as stainless steel and titanium. Thorium has been widely used in alloys with magnesium by aerospace industry. Disarmed airplanes in air museums may contain some equipment with such alloys. These applications are the most important with respect to declarants in France, today.

Thorium is also found in laboratories as chemical product (thorium oxide, nitrate, acetate) used as reference standard and for analyses. Suppliers of such chemicals are often submitted to the declaration regime but rarely the users.

Thorium is also a concern for some « historical » radioactive waste.

Natural uranium and low enriched uranium

The main use of natural uranium is as laboratory chemical products, such as uranyl oxides, acetate and nitrate, which are used as reference standards, molecule labeling and analyses. It shoud be noted that depleted uranium is also used as a source of uranium element in these chemicals. Main suppliers of these chemicals are commonly submitted to the declaration regime. Most of the time, quantities held by final users are under the declaration threshold.

Concerning low enriched uranium, this nuclear material is not encountered in France among small

Tritium

Due to its radioactive properties, tritium has been widely used for radioluminescent devices: radioluminescent « exit » signs, radioluminescent paints and bulbs used in the watch and aerospace industries. Only companies manufacturing and supplying such devices are concerned by significant quantities of tritium with regard to French regulation thresholds.

It is worth noting that purchase of radioluminescent watches by the general public is commonly exempted from control.

Rare uses in the medical and research fields, as radiotracer and for synthesis of labelled molecules, may lead owners to have stock of tritium above the declaration threshold.

Highly enriched uranium and **plutonium** are very rarely encoutered among small users of nuclear materials in the industrial, medical and research fields.

To provide some figures concerning 1999, about 250 declarants were identified in France, most of them holding depleted uranium. It shoud be noted that the trend is to a reduction of the quantity of depleted uranium held by declarants in France for the following reasons. The two main applications of DU: industrial gamma radiography and telegammatherapy are facing competing techniques. Gamma radiography is more and more replaced by industrial × radiography, using an electrostatic × ray generator. Telegammatherapy units are replaced by linear particle accelerators which are now preferred by radiotherapists. Both of the replacement techniques do not use sealed radioactive sources and, as a result, do not need internal shielding made of DU.

4. REGULATORY REQUIREMENTS RELATED TO THE DECLARATION REGIME

4.1. ANNUAL DECLARATION

A declaration must be established by the operator every year, before the 31^{st} of January. Declarations are sent to the Département de Sécurité des Matières Radioactives (DSMR) of the Institut de Protection et de Sûreté Nucléaire (IPSN), acting as technical support body of the national authority. The DSMR gathers and centralizes data within the national boundaries.

The declaration contains the following data:

For the initial declaration and after each modification of the declarant status:

- identification data (company’s name, address...) and the name of its owner and operator who are legally responsible;
- type of activities concerned and localization of nuclear materials.

In each annual declaration:

- stock of nuclear materials held at the 31^{st} December of the previous year;
- stock variations occurred during the previous year, including the identification of senders and receivers;
- the stock and inventory changes of nuclear materials expected for the present year.

The latter informations are particularly important to identify new operators which have received nuclear materials the previous year, or sent materials to already known operators; or to identify declarants whose stock of nuclear materials may reach the licensing threshold.

These data should be provided for each category of nuclear materials defined in Table I. The order also sets the units to be used for each category of materials.

4.2. ACCOUNTING OF NUCLEAR MATERIALS

Declarants must set up a local accounting system based on an inventory book. This book allows to gather chronological records of the various types of inventory changes that occur at the facility, for instance reports on materials produced and consumed. The model of book is not stipulated by the order. A paper copybook or a computerized system comply both with this requirement.

The operator must keep records of all supporting documents with respect to transactions involving nuclear materials as justifications of the inventory changes, at least five years.

4.3. PHYSICAL INVENTORY

The inventory is the most elementary means to reveal a possible loss of control of nuclear materials. Before fulfilling its annual declaration, the operator must carry out a physical inventory to ensure that the quantities of nuclear materials, which should be present as reflected in the accounting system, are effectively present in the facility.

It is also recommended to the operator to periodically check the physical presence of the nuclear materials in the place where it is expected to be, especially when the device containing the materials is not frequently used.

4.4. PHYSICAL PROTECTION AND SURVEILLANCE

The declaration also has to describe the main features concerning facility layout related to surveillance and physical protection of materials.

With respect to physical protection requirements, nuclear materials should be kept under lock and key, and keys should be accessible to authorized personnel only.

Alarm and guards are not mandatory, but in some special cases, an alarm system has been required by the authority.

It should be noted that these requirements are very often the same than those set by national authorities dealing with sealed radioactive sources.

4.5. SOME EXPERIENCE FEEDBACK

In the case of operators using gamma radiography devices, several regulations regarding licensing of sealed radioactive sources users, radiation protection of public and workers, and environmental protection, require physical protection measures in order to prevent theft of radioactive sources and to ensure their protection against fire or other damages. Usually, the arrangements made by the operator for the protection of devices containing both a radioactive source and nuclear materials comply with the requirements related to physical protection of depleted uranium.

This is not the case for empty devices whose radioactive source has been removed and for the accessories such as directional and panoramic collimators, transfer casks, trimmers, which contain DU and are not submitted to other regulations. Inspections carried out at the declarants facilities allow to make them sensitive to that point in order they ensure the same level of physical protection to all devices containing DU, both used, useless or damaged.

Several thefts involving nuclear materials have taken place during the past years, due sometimes to the lack of surveillance of vehicles transporting gammagraphy equipment, even for very short periods without surveillance.

As a result, gammagraphy operators should not store and leave without surveillance gammagraphy equipment inside vehicles, as the risk of theft is significant.

In the medical field, trimmers may have been removed from the radiotherapy unit, and special attention should be paid for their control and protection. Furthermore, shaping blocks made of DU, could have been delivered with the units in the past. Very often, these blocks have not been used by the medical personnel, because of their radioactivity, and they could have been out of control. These items, containing a few kilograms of DU, have to be looked for and inventoried by the operators, labelled and kept under lock and key.

As a general principle, when possible, operators are invited to return unused and damaged equipment to the manufacturer.

5. ENFORCEMENT OF THE DECLARATION REGIME REQUIREMENTS

5.1. CENTRALIZED ACCOUNTANCY OF NUCLEAR MATERIALS

As abovementioned, declarants have to send every year an annual declaration of their stock and inventory changes of nuclear materials related to the previous year. The DSMR gathers all the declaration forms fulfilled by declarants. Data are processed into the centralized national accounting database managed by the DSMR. Declarants are identified in this centralized database by a unique ID number. General information regarding the company (name, adress, phone numbers, contacts...) and data concerning quantity and quality of nuclear materials involved, are recorded.

The DSMR also carries out consistency checks between information provided by declarants and data concerning quantity, quality and inventory changes of nuclear materials owned by licensed companies, submitted to the authorization regime.

5.2. ON-SITE INSPECTIONS

Enforcement of the declaration regime requirements is also ensured by on-site inspections, carried out by sworn and accredited inspectors under the authority of the Ministry for Industry.

It is worth noting that, during the inspection, information is provided to the declarant to recall requirements of national regulation related to control and protection of nuclear materials, and the links between this regulation and others concerning radiation protection, radioactive sources management, etc.

Experience feedback shows that this information is an essential element in the prevention of breaches in the system of control and protection of nuclear materials. Indeed, by lack of knowledge, legal users may make some mistakes in the control of the nuclear materials or may neglect their management duties as defined by the national regulation system, and in so doing lose control of the nuclear materials they possess.

The inspectors carry out verifications on:

- the compliance with the regulation, and particularly with the requirements of the order of 14 March 1984, of the arrangements made by the operator;
- the local accounting system, which indicates, at any time, location, quality and quantity of nuclear materials held at the facility and the inventory changes;
- the book-keeping records;
- the exhaustiveness of physical inventory. It is worth noting that inspectors use portable detection equipment, adapted to the nature and the quantity of the radioactive materials to be detected.
- the arrangements made by the operator to ensure the physical protection of nuclear materials.

After the inspection completion, the inspectors send a report to the Ministry for Industry, proposing corrective actions from the operators, if needed.

The DSMR carries out more than 30 inspections at declarants facilities every year.

6. CONCLUSION

Even if the nuclear materials held by declarants are of low sensitivity as far as proliferation is concerned, a total absence of regulations on the low quantities concerned might lead to an increased attractiveness for unauthorized uses.

It is important to highlight the importance of on-site inspections, which allow to verify the compliance of the physical protection arrangements made by the operator and the exhaustiveness of physical inventories of nuclear materials. In this way, every year, tens of items and tens of kilograms of nuclear materials (mainly depleted uranium) are put back into a controlled environment.

Moreover, on-site inspections allow to bring comprehensive information to the operators concerning the regulatory requirements to be implemented.

The declaration regime is a balanced approach between exemption and licensing. Moerover, good practices in terms of control, accountancy and physical protection of nuclear materials held by declarants reduces the occurrence of incidents related to losses or thefts of equipment or products containing nuclear materials and, as a result, contributes to an improvement of public confidence and acceptance in the French nuclear industry as a whole.

QUESTIONS AND ANSWERS

Y. Volodin (Russian Federation): Does IPSN determine the frequency of inventories and verification of nuclear material as well as carry out inspections of quantities and categorization of NM?

L. Pillette-Cousin (France): Many fields of activity are concerned (medical, industrial, research) and the quantities of NM kept by smallholders vary widely. The problem areas vary accordingly, so every year IPSN defines a panel of "representative" operators in these areas in order to carry out inspections.

M. Ohlsson (Sweden): The operator checks the inventory of NM annually and so does the IAEA during the annual verification. Does this mean the work is duplicated?

L. Pillette-Cousin: The operator is responsible for its inventory. However, feedback from inspectors has shown that operators don't always have comprehensive knowledge about the NM in their facility. That is why inspectors verify the completeness of the operator's inventory.

REVISING NATIONAL PHYSICAL PROTECTION REGULATIONS FOR NUCLEAR FACILITIES

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Abstract. Physical protection regulations in Sweden are based on and developed from a design basis threat. SKI as the regulator is in the process of transforming the regulations from the present detailed individual requirements to generally applicable regulations which are clear and transparent.

1. BACKGROUND

During the build up of the nuclear power program in Sweden in the late seventies the Swedish Nuclear Power Inspectorate, SKI early recognised the need for physical protection measures at nuclear facilities. It took SKI a couple of years to arrive at a suitable concept for protection which then led to the publication of regulations requiring operators to take proper measures. The requirements to take measures for physical protection are formalised as one of the conditions to operate a certain facility i.e. a license condition.

The regulations are based on and developed from a defined threat i.e. a design basis threat (DBT). Furthermore one of the foundations of the regulations is a well-established security concept. Moreover the present regulations are by nature very detailed. In the light of the new supervisory policy of SKI, to clearly put the full responsibility on the licensee to take appropriate measures, the objective is to have transparent regulations laying out general functional requirements that the licensee has to meet. The licensee should then have the obligation to show SKI how the regulatory requirements are met.

With this background and a general requirement to modernise regulations there is now a need to rewrite also the physical protection regulations.

2. DIRECTIVES TO SKI

SKI is the competent nuclear regulatory body in Sweden and therefore responsible for the supervision of nuclear activities. In the directives to SKI, the Government specifies performance goals. One of these goals is that nuclear facilities and nuclear material under Swedish jurisdiction must be given adequate protection against terrorist attacks, sabotage and theft.

Furthermore SKI should establish regulations that are clear and transparent. The requirements in the regulations should be sufficiently general so that the licensees' responsibility for safety and security is not negatively affected or assumed by SKI. Moreover SKI should through activity-oriented supervision control how the licensees meet the requirements.

3. CHALLENGES

In the process to transform from the present detailed individual requirements to a general applicable regulation we have identified a number of issues that poses a challenge to SKI as the regulator.

First of all the new regulation should apply to all major nuclear facilities in Sweden such as power reactors, research reactor, fuel fabrication plant and interim spent fuel storage facility. This calls for a careful analysis in order to ensure that no gaps or loopholes are left and that overlapping requirements are not introduced.

To transform from detailed to general functional requirements is a very delicate act of balance. On one hand the message must be sufficiently clear so that the licensee understands the requirements. On the other hand the requirements must be general enough for the licensee to take his responsibility for safety and security and be free to find the solution to meet the requirements. There could be a conflict between the need for clarity and the need to keep the regulations general enough.

Furthermore the international physical protection recommendations, published in INFCIRC/225/Rev4, were recently revised to better reflect modern requirements. Even though these are only recommendations and not binding requirements we feel that Sweden has a moral obligation to adhere to them since Swedish experts have been actively involved in the development and revision of the recommendations. The present regulations are almost fully in line with the latest revision of the recommendations and therefore only minor adjustments are needed in the revised regulations.

Another challenge to SKI as a regulatory and supervisory authority is the deregulated electricity market. We are aware that the minute we start the process to rewrite regulations we also open the Pandora's box i.e. licensees will challenge our proposed regulations. Since all measures, existing and new, cost money we are tasked with the challenge to put forward requirements that are both relevant and understandable. The aim is to end up with regulations that are accepted by licensees.

4. FORMAL PROCESS

The starting point of the process was the review of the existing DBT. This is the responsibility of SKI. The work is being done in close co-operation with e.g. the police and the intelligence community. We have found it to be a lengthy process mostly due to the fact that input is needed from several organisations. Nevertheless the revised DBT forms the basis for the coming work.

SKI has established an internal process, that is a part of our Quality assurance system, for the development and revision of regulations.

The process can be divided into the following formal steps:

- Development or review of the existing design basis threat, to be co-ordinated with other national authorities.
- Proposed regulations, first draft.
- Review of the internal regulatory group at SKI.
- Comments from relevant offices within SKI.
- Proposed regulations, second draft.
- Information to the Director General and the Board of SKI.
- Request for informal comments from operators, police authorities and other relevant bodies.
- Meeting with interested operators and other relevant bodies to review comments

- Proposed regulations, final draft.
- Formal request for comments from operators, police authorities and other relevant bodies.
- Proposed regulations presented by the Director General to the Board for approval.
- Regulations in force.

As shown above the process is quite lengthy but it gives the opportunity to include external comments into the final regulations both in an informal and formal request for comments. Furthermore SKI has created an internal regulatory group through which all proposed regulations must pass. The objective is to ensure the quality and consistency of all regulations.

It should be noted that not only written comments but also a joint meeting with operators/licensees follow the request for informal comments. During this meeting comments will be discussed in more depth than during the formal request for comments. It is our experience that the informal part of the dialog with the parties concerned is very fruitful and therefore important. We have found that there is a greater possibility that the final regulations will meet acceptance by the licensees given that they have had the opportunity to influence them. SKI has had good experiences using this process in developing regulations during the last years.

5. ENSURING ACCEPTANCE

In order to ensure a successful implementation of new or revised regulations it is of outmost importance that the regulations will receive acceptance from concerned parties. To achieve this we are involving both licensees and the police (local and central) in the formal and informal process. Furthermore we believe that both the logical structure and the way the regulations are introduced are important for ensuring acceptance of them. Therefore we are planning to invite licensees and police representatives to a workshop when the regulations will come into force.

6. CORNERSTONES IN THE REGULATIONS

The basic requirements concerning physical protection of nuclear facilities are already laid down in the SKI regulation 1998:1 concerning safety in certain nuclear facilities. There the term “Physical protection” is defined as technical, administrative and organisational measures with the aim to protect facilities against unauthorised intrusion, sabotage or other such impacts which can result in a radiological accident as well as at preventing the unlawful possession of nuclear material or nuclear waste. From the definition it is clear that there are **two objectives**

1. to protect against a radiological accident i.e. part of **conventional safety,**
2. to protect against theft i.e. part of **nuclear non-proliferation.**

Furthermore nuclear facilities concerned must have a documented plan for physical protection. Before the facility may be taken into operation a safety review of the plan shall be carried out as well as evaluated and approved by SKI. A safety review shall also be carried out of any modifications to the plan, which affect the physical protection system. Before they may be applied SKI shall be notified of the modifications and SKI can decide whether additional or other measures are needed.

For the revised regulations an unchanged security concept is foreseen. The concept consists of the following:

- facilities are guarded by an unarmed guard force,
- defence in depth is achieved by multiple protection barriers,

- so called engineered systems, consisting of particular reactor/facility safety systems, are applied for protection purposes,
- administrative measures such as instructions, emergency plans are important for security,
- the armed outside response force is set up by the regional police authority.

It is important to note that the security concept relies on the function of all its components. It is the combined function that forms a reliable physical protection system.

7. LESSONS LEARNED

The following experiences and lessons learned can be shared from the work that has been carried out so far. When time is running and you are running behind your time schedule it can sometimes be tempting to take shortcuts and jump ahead in the established process. It is our experience that the final result i.e. the regulation in force, will always be better if you follow the process. Furthermore it is advisable to involve "non-experts" in the work since they will look at your work with "fresh eyes" and most probably ask the important questions that will improve the quality of the regulations. Finally it is very important to be realistic in your planning of the project to write or revise regulations. It is an extensive and time-consuming task that involves both colleagues and external organisations. My advice is to estimate the time needed and then double it!

QUESTIONS AND ANSWERS

L. Moore (USA): Since SKI relies on the police to a great extent for the PP of nuclear facilities, what influence does SKI exercise on the police in terms of funding and inspection to ensure that they provide the capabilities that SKI regulations require?

S. Isaksson (Sweden): SKI and the police are separate authorities with no formal links. We do not audit the police in any way but we work in close co-operation with them.

THE FINANCIAL IMPLICATIONS OF CERTAIN TYPES OF CROSS-BORDER POLLUTION: THE POLLUTER-PAYS PRINCIPLE

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Abstract. Favorable Paris Convention regulations: absolute liability, exclusive liability, channeling of liability to the operator in case of nuclear damage, financial security, limited maximum liability, single legal forum, ten-year time limit. Difficulties of application for certain types of cross-border pollution not covered by the Paris Convention: so-called orphan sources (stolen, lost, or abandoned sealed sources or confiscated contaminated metallurgical scrap). Benefits of the polluter-pays principle: identification of the polluter, identification of the holder of the polluted materials, responsible parties held accountable, financial reparations. Analysis of the polluter-pays principle already recognized in numerous international texts on environmental law.

1. INTRODUCTION

In the United States in 1957 and then in Europe in 1960, a special régime for third-party nuclear liability was developed for the first time and integrated into law and convention (the Price-Anderson Act in the United States and the Paris Convention in Western Europe). As underscored by the Paris Convention's guiding principles, this unique set of regulations governing nuclear liability was needed because ordinary common law was not well suited to dealing with nuclear energy's particular problems. Indeed, if ordinary law were applied, several different people might be held liable for the damage caused by a nuclear incident, and the victims would likely have great difficulty establishing who was, in fact, liable.

To summarize briefly, the Paris Convention is characterized by the operator's absolute (fault does not have to be established) and exclusive liability (this is channeling) in case of nuclear damage. As a result of these clear principles, the operator who internalizes his risks maintains adequate insurance coverage or other financial security and benefits from limited aggregate liability. Likewise, claims for damages are presented before a single legal forum (unity of jurisdiction) within ten years (rather than the thirty years accorded under ordinary common law) after the nuclear incident.

If the Paris Convention's special régime ensures adequate compensation for victims of nuclear incidents occurring in a nuclear installation (or during transport of nuclear materials) and causing damages to the environment of the country within which the incriminated installation is located, as well as beyond its borders, the fate of victims of certain specific types of cross-border pollution, whose consequences are not entirely covered by the implementation of this convention, remains unclear.

Thus, this presentation will address the legal and financial ramifications of so-called orphan sources (for example, stolen, lost, or abandoned sealed sources or confiscated contaminated metallurgical scrap) for which the polluter-pays principle could prove to be a valuable tool.

The international conference organized by the IAEA in Dijon, in September 1998, allowed us to consider the financial consequences of the detection and seizure of illicit radioactive materials[1]. The seminar organized by the United Nations Economic Commission in Prague, in

[1] Proceedings Series Safety of Radiation Sources and Security of Radioactive Materials — IAEA Vienna 1999 p. 362; IAEA-TECDOC-1045/CN-70/11 — September 1998; IAEA Safety Standard Series Draft Safety Guide Preventing, Detecting and Responding to Illicit Trafficking in Radioactive Materials N S 61 — 1998-12-29.

May 1999, provided an opportunity to analyze the practical application of current regulations to the movement of metallic substances contaminated by radioactivity[2]. This international Conference organized in Stockholm by the IAEA, affords us an opportunity to reflect more deeply on the financial implications of certain types of cross-border pollution and the polluter-pays principle.

2. SIGNIFICANCE OF CROSS-BORDER POLLUTION

Failure to respect the regulations governing radioactive substances is apt to affect the territory of two or more nations. This is what the OECD calls "cross-border pollution" or a "transfrontier accident". The evolution of this concept of long-distance pollution (more than 30 kilometers beyond a border) is a result of the ability to detect pollution at greater distances. Consequently, the law's basis for intervention must be the phenomenon itself and not just the geographical area in which it is produced.

According to a generally recognized principle, States exercise sole jurisdiction over their own territory. When acts originating in one State cause damage or potentially threaten the sovereignty of another State, a conflict between those States arises. Thus a State is strongly tempted to argue its right to absolute sovereignty over its own territory. But the State whose territory sustains the financial consequences of pollution has no less a right to demand reparations.

First of all, it is naturally up to the various parties involved to prevent cross-border pollution and, failing that, to make provisions for reparations.

There are numerous situations in which no claim or legal proceeding is likely to be pursued. The financial damage sustained may not appear, at first glance, to be sufficiently serious. The determination of liability may not be properly handled. As a result, claims for damages would lack a solid legal basis and thus have little chance of success. Finally, legal action might be opposed in the interests of political order. States that can, by turn, appear to be either polluters or victims of pollution stand united. International responsibility is then difficult to invoke, even when pollution results from a lack of knowledge about conventional obligations.

If the pollution is serious enough to cause significant damage, there are likely to be many injured parties in both the public and private sectors. That being the case, any number of liable- and injured-party combinations would be possible. Depending on the nature of the parties involved, the situation could fall under the jurisdiction of either national or international law. In some cases, after exhausting internal avenues of recourse, a case could be taken to an international court. In addition, several commercial enterprises could be implicated in varying degrees without its being possible to determine their actual level of responsibility.

Finally, issues of the pollution's origin and of unidentified responsible parties obviously raise the question of indemnification. Metallurgical scraps contaminated by previously uncontrolled radioactive sources well illustrates the difficulties encountered. The same problem is posed by agricultural products coming from a third country affected by the provisions of the July 27, 1999, (EC) regulation no. 1661/1999.

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[2] UN/Trade/Steel/SEM.2/AC/7 du 5/07/99, p. 4 and Trade/Steel/Sem.2/4.

3. ANALYSIS OF THE POLLUTER-PAYS PRINCIPLE

Identification of the polluter must first of all determine who caused the pollution, be that the producer or the party actually in possession of the source of pollution. Once the responsible party has been identified, the question of form of indemnification arises. Compensation may be in-kind reparations or the payment of a sum of money to the public authorities charged with handling the matter.

The level of payment must be determined. The polluter may only be required to pay for the measures that need to be taken in order to achieve an acceptable level of pollution (the standard Polluter-Pays Principle). The polluter might also pay a sum needed to cover the social damages resulting from an acceptable level of pollution (the extended Polluter-Pays Principle). Originally, the polluter-pays principle only covered the cost of preventive measures related to administrative demands (surveillance, inspection, authorization régimes, etc.) and the cost of curative measures. The current tendency is to expand the costs charged to the polluter in order to internalize costs more completely.

Recognition of the polluter-pays principle fulfills four main functions. The economic integration function aims, first of all, to ensure that the rules of free competition are respected. In order not to upset the market's rules, subsidies must not be accorded to businesses that do not respect the norms of safety and security.

The redistributive function of the principle rests on the idea that the polluter must assume the costs of pollution prevention and control established by public authorities.

Through its preventive function, the polluter-pays principle can contribute to the reduction of pollution. From an economic point of view, polluters must be motivated to reduce pollution by making the cost of polluting outweigh the benefits derived therefrom. Application of this principle must motivate the polluter, within the framework of a self-regulatory system, to assume responsibility for taking the measures needed to reduce the pollution he creates.

Finally, the curative function can guarantee full compensation for damages sustained and hasten the payment of damage claims by ascertaining the responsibility and liability of the holders (receivers) of these polluted materials.

Application of the polluter-pays principle can, however, encounter a certain number of obstacles.

The Rio Conference's declaration on environment and development recognizes the polluter-pays principle in principle 16. However, this United Nations declaration expressly states that ***the implementation of this principle must not distort international trade and investment.***

Despite what appears to be its constraining nature, implementation of the polluter-pays principle may be moderated by invoking an Act of God or the intervening act of a third party (*la force majeure*) and, to a lesser extent, necessity. An Act of God is a situation in which an unforeseen event, beyond one's control, makes it impossible to meet one's international obligations. No one can be expected to do the impossible. On the other hand, necessity is a situation in which one is able to meet one's obligation but at a cost requiring heavy sacrifices that surpass common practice. Recourse to necessity can amount to same thing as invoking extenuating circumstances.

4. CONCLUSION

The neighboring States affected by cross-border pollution must first of all be notified with utmost urgency so that they, too, can analyze the financial consequences of the losses sustained and take the necessary protective measures. International collaboration is then necessary in order to evaluate the facts gathered and communicated. International assistance must also allow us to identify the principal parties, especially in cases involving several parties located in different States. The consultation principle must be recognized, with a view toward allowing the injured parties to follow the compensation process. Finally, international cooperation should facilitate the recovery of damage claims.

The logic of indemnification often runs up against with the difficulty of allocating pollution clean-up costs to the responsible parties. The polluter-pays principle, however, is not intended as a substitute for the normal criteria of liability in the nuclear sector. It has a highly symbolic value. It also better takes into account the financial costs of pollution. Its recognition in texts in the nuclear field could constitute a guiding principle that would contribute to more appropriately assigning responsibility to the various parties involved.

The opinions expressed herein are the author's alone and require further collective consideration.

REFERENCES

[1] THE POLLUTER-PAYS PRINCIPLE RECOGNIZED IN IMPORTANT INTERNATIONAL TEXTS

OECD

recommandation du Conseil du 26 mai 1972, sur les principes directeurs relatifs aux aspects économiques des politiques de l'environnement sur le plan international — *C(72) 128 (final) OCDE, 1972;* recommandation sur la mise en œuvre du principe du pollueur-payeur — *C(74) 23 (final) OCDE, 1974*; recommandation du 5 juillet 1989 sur les pollutions d'origine acidentelle lièes aux substances dangereuses — *C(89) 88 (final), OCDE 1989*; recommandation relative à l'utilisation des instruments économiques dans la politique de l'environnement — *C(90) 177 (final), OCDE, 1991.*

EC

- livre blanc sur la responsabilité environnementale présenté par la Commission COM(2000) 66 final du 9.2.2000;
- premier programme d'action en matière d'environnement (1973-1976) — *JOCE n° C 112 du 20/12/73, p. 6;* recommandation 75/436/Euratom/CECA/CEE du 3 mars 1975 relative à l'imputation des coûts et à l'intervention des pouvoirs publics en matière d'environnement *(JOCE n° L 19 du 25/07/75);* second programme d'action (1977-1981) interdisant l'octroi de subventions aux pollueurs *(JOCE n° C 139 du 13/0/77);* troisième programme (1982-1986) définissant un rôle d'incitation pour réduire la pollution et promouvoir les technologies propres *(JOCE n° C 46 du 17/02/83);* quatrième programme (1987-1992) adoption d'instruments économiques *(JOCE n° C 328 du 7 décembre 1987).*
- déchets: directive 75/439/CEE concernant les huiles usagées; directive 94/62/CE sur les emballages et les déchets d'emballages; article 15 de la directive-cadre 75/442/CEE reconnaissant la responsabilité du détenteur; proposition de directive concernant la responsabilité civile pour les dommages causés par les déchets *(JOCE n° C 251 du 4 octobre 1989, p. 3);*

- traité de la communauté européenne *(article 174 § 2 modifiant l'ancien article 130 R §2 suite à la ratification du traité d'Amsterdam);*
- résolution 592 du 24 avril 1975 de l'Assemblée parlementaire du Conseil de l'Europe;
- déclaration sur la sécurité et la coopération en Europe à la suite de la conférence d'Helsinki du 10 juillet 1992;
- commission économique pour l'Europe des Nations Unies (art. 2.5.b du traité d'Helsinki du 17 mars 1992);
- convention de Londres du 29 décembre 1972 sur la prévention de la pollution des mers résultant de l'immersion des déchets (protocole modifié de 1996);
- protocole du 17 mai 1980 relatif à la protection de la mer Méditerranée contre la pollution d'origine tellurique (préambule du protocole d'Athènes modifié le 7 mars 1996 à Syracuse);
- accord du 9 juillet 1985 de l'ASEAN sur la conservation de la nature et des ressources naturelles (art. 10,d);
- convention de Londres du 30 novembre 1990 sur la préparation, la lutte et la coopération en matière de pollution par les hydrocarbures;
- accord portant la création de l'espace économique européen (art. 73);
- convention du 7 novembre 1991 relative à la protection des Alpes (art. 2 –1);
- convention de Paris du 22 septembre 1992 pour la protection du milieu marin de l'Atlantique;
- convention d'Helsinki du 17 mars 1992 sur la protection et l'utilisation des cours d'eau transfrontières et des lacs internationaux;
- convention d'Helsinki du 9 avril 1992 pour la protection du milieu marin pour la zone de la mer Baltique;
- convention de Lugano du 21 juin 1993 sur la responsabilité civile résultant de l'exercice d'activités dangereuses pour l'environnement;
- accords de Charleville-Mézières du 26 avril 1994 sur la protection de l'Escaut et de la Meuse;
- convention de Rotterdam sur la protection du Rhin;
- déclaration de la conférence de Rio du 3 juin 1992 — principe 16.

[2] FRENCH REGULATIONS

- loi n° 95-101 du 2 février 1995 relative au renforcement de la protection de l'environnement;
- loi du 15 juillet 1975, concernant l'élimination des déchets — art. 2;
- loi sur l'eau du 3 janvier 1992 sur le principe de gestion équilibrée des ressources hydriques -art. 2;
- code rural reconnaissant le principe de protection de la nature au titre de l'intérêt général — art L 200-1;
- code de l'urbanisme énonçant le principe d'une gestion économe de l'espace art. L 110

OF JUSTICE.

[3] RECOGNITION BY THE EUROPEAN COURT

- CJCE, 10 mars 1983, inter-huiles, aff. C-172/82, Rec p. 555, point 18 et CJCE, 29 avril 1999, Standley, aff. C-293/97.

RADIOACTIVITY IN SCRAP RECYCLING: MONITORING, DETECTING AND REGULATORY ISSUES

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Abstract. The results of 3 and a half years of metal scrap monitoring performed by more than 150 factories (steel mills, aluminium refineries, foundries and scrap-collecting factories) situated in the province of Brescia, are presented. Monitoring is carried out in compliance of Italian law and regional ordinance, although the latter is no longer valid. Actions following detection of radioactive material are also described. No radioactive source of high activity, which might have constituted a serious radiological and environmental hazard has been found, but the high number of sources and contaminated materials detected in metal scrap is evidence that many are not correctly disposed of and are out of control.

1. INTRODUCTION

The province of Brescia is the main important metallurgic hub in Italy. 7 million tons of metal scrap (steel, brass, copper, aluminium, etc.) are recycled every year in more than a hundred foundries and 13 steel mills. Approximately one third of the scrap used is imported. Unfortunately, in the recent past — since 1990 — numerous cases of contamination have occurred in Brescia, involving two steel-mills, one aluminium refinery and the associated facility, some plants producing copper alloys, one authorized and one unauthorized landfill, the goods-stations in Brescia and in a nearby town, and a scrap-collecting factory. None of the incidents caused significant exposure and/or contamination of the workers, but nevertheless they did cause concern among the population living close to the plants and among the foundry workers. The damage in terms of recovery costs, shutdown and market loss was significant.

2. REGULATORY ISSUES

2.1. NATIONAL LAW AND REGIONAL REGULATION

Article 157 of the Italian Law on Radiation Protection [1], passed in 1995, made it mandatory for users and traders to monitor metal scrap and art. 142 of the same law established the penalty for non-compliance. Unfortunately the expected decree on specific applications and methods was not — and has still not been — issued, leading to a general lack of compliance. After the latest incident at a steel plant in Brescia, in May 1997, due to the melting of two different sources (^{60}Co and ^{137}Cs), the Lombardy Region issued an urgent ordinance [2] ordering smelting plants and scrap-collecting factories to check for the presence of contaminated materials in metal scrap prior to use. The Lombardy Region also defined a protocol for the monitoring of metal scrap from arrival at the factory to completion of the melting process.

The protocol required:

a) radiation measurements outside each truck, wagon or container with fixed detection systems positioned at the entrance gate or with portable detectors;
b) radiation measurements and visual inspection of the metal scrap after unloading;
c) gamma spectrometry of test castings, slag and furnace ash dust.

The protocol also specified the characteristics of the instruments to be used at each stage of the control process. In many cases the monitoring systems were sensitive enough to detect contaminated materials with very low activity and shielded radioactive sources.

The regional ordinance is no longer in force, but the steel firms and foundries that established control procedures still comply with it. Although a national protocol defines the procedures for controlling metal scrap transported by ships at seaports, the general decree mentioned above which allows full application of art. 157 has not yet been issued. So the level of compliance differs in Lombardy and other Regions. According to our sources, more than 150 plants in the Province of Brescia perform the required monitoring, the smallest of them using hand-held instruments, and also the visual inspection required by the regional ordinance. The industrial association, with the technical support of experts belonging to instrument manufacturers and universities, handled most of the training of the operators. Emphasis was placed on teaching workers to recognize labels, signs and shapes of sources. Pictures of the most commonly used and no longer used sources (smoke detectors, lightning rods, industrial source holders, etc) were distributed.

2.2. ACTIONS FOLLOWING DETECTION OF RADIOACTIVE MATERIAL

According to Italian Law, any discovery of radioactive material must be reported to the Police and, according to the past regional ordinance, to the local Health Authority. When an alarm level has been exceeded, the firm, following the procedures and instructions given by a Qualified Expert in Radioprotection, unloads the truck or wagon and identifies the source or contaminated object (piece of metal, part of a pipe, luminescent dial, etc.) which caused the alarm. The source or object is isolated and sequestered by the Judicial Authority, which delegates its categorization and the initial investigation to our office. In the presence of the sender the source is categorized and it is verified whether Italian law applies to that specific situation. Disposal of the source or object will be allowed at the end of the entire legal procedure. In only a few cases were the objects found to be below the activity and concentration limits established by Italian law. The consequences in both legal and financial term can be serious for the sender of the material.

3. CURRENT SITUATION

3.1. LOCAL SITUATION

As reported, more than 150 local firms (steel mills, foundries and scrap recyclers) comply with the law. Many of them perform checks at the different stages of the smelting process, not only on incoming loads. A firm in a nearby town, which recycles furnace ash dust, checks all incoming lorries for radioactive contamination and reports any abnormal cases to the local Authority. In 1995 these checks led to the discovery of ^{137}Cs contamination of dust in a steel mill, which ceased activity a few months later. In 1998 the checks performed at the gate of one of the biggest steel plants revealed ^{137}Cs contamination of soil from a scrap-collecting factory. This latest incident probably occurred in the late 80s or early 90s, but the exact time and source of contamination are not known.

3.2. RESULTS OF SCRAP MONITORING

Between June 1997 and December 2000 local firms reported 267 cases of detection of radioactive contamination, half of them reported by steel mills. Subsequent procedures led to the finding of 636 radioactive objects (Table I). In Table I the words "contaminated materials" indicate all types of contaminated object not specifically identified as a source.

Table I. Radioactive objects found in scrap loads between 28/5/97 and 31/12/2000

Radioactive objects (number)	Radioactive isotopes	Maximum estimated activity (MBq)	Total estimated activity (MBq)
Radioactive sources (29)	^{226}Ra	740	2239
	^{137}Cs	516	
	^{85}Kr	370	
	^{241}Am	240	
	^{90}Sr	166	
	^{60}Co	55	
Lightning rods (32)	^{226}Ra	40	448
	^{241}Am	40	
Smoke detectors (28)	^{241}Am	2	36
	^{226}Ra	1	
„Radium Trikkur“ [1] (10)	^{226}Ra	5	16
Luminescent dials (169)	^{226}Ra	1	22
Contaminated materials (368)	^{60}Co	19	200
	^{137}Cs	10	
	^{226}Ra	5	
	^{232}Th	2	
Total number 636			≈3 GBq

About 50% of the radioactive materials found in metal scrap comes from Italy or, at least, the last trader is Italian. Only 6% comes directly from non-EU countries, including Switzerland, while France with 14% and Germany with 20 % are the main "suppliers" of contaminated items among EU countries.

According to the type of source, lightning-rods come mainly from France (18 out of 32) and "Radium Trikkur" from Germany (6 out of 10).

Depending on the type of production, 60% of the contaminated objects were found in iron scrap, 20% in brass scrap and 20% in aluminium scrap. In steel-mills contaminated materials are normally detected at the entrance gate before being unloaded, while in other smelting plants contaminated items are often found by monitoring systems installed on the conveyor-belts where the scrap is more spread out.

It is worth noting that the detected objects shown in Table I come from about half of the 13 steel mills operating (there were 24 in operation a few years ago) and from 1/6 of the foundries in the province. We have not received any reports of discovery of contaminated material by scrap recyclers.

[1] For Radium water treatment.

It may also be interesting to compare the number of incidents with the tons of scrap used. Table II shows the number of radioactive objects detected, subdivided by year and referring to the quantities of scrap melted by three steel mills and one aluminium refinery. Approximately one contaminated object is expected to be found in every 70,000 tons of iron scrap and in every 3,000 tons of aluminium scrap.

Table II. Radioactive objects detected in three steel mills and one aluminium refinery

Year	Iron scrap (tons)	Radioactive objects found (number)	Aluminium scrap (tons)	Radioactive objects found (number)
1997	2,455,000	39	-	-
1998	2,806,000	62	100,000	42
1999	2,655,000	44	130,000	65
2000	3,065,000	22	140,000	32
Total	10,981,000	167	370,000	139

4. FINAL CONSIDERATIONS

The monitoring of scrap before it enters the production cycle does not guarantee complete protection against accidental melting, but it certainly decreases the probability of such an event occurring. In our opinion it is a means for discouraging the incorrect disposal of old sources, but it needs to be extended to all countries interested in these activities, and it has to be performed systematically, using similar methods and instruments of comparable sensitivity. It is important to remember that although metal scrap imported into Italy from non-EU countries had official certification, some radioactive sources were found by the receivers.

Monitoring also prevents the contamination of slag and dust (mainly due to ^{137}Cs, ^{226}Ra and ^{241}Am), by-products often used in other industries or disposed of in waste facilities. Although the checking of test castings and by-products cannot prevent contamination of the plant and machinery, it allows immediate detection of the incident and actions to control the spread of contamination. In the incident that occurred in 1997, which was detected a week later, it was possible to bring back the contaminated steel, which had already been sold, and to store the contaminated dust safely at the plant.

Although no highly radioactive sources constituting a serious radiological hazard were found, the high number of sources identified — small radioactive sources, scrap contaminated by NORM (Naturally Occurring Radioactive Material) and natural or depleted uranium — is proof that many are out of control and have not followed the correct disposal procedure out of ignorance or fraudulently.

REFERENCES

[1] DECRETO LEGISLATIVO 17 marzo 1995, n 230- Attuazione delle direttive Euratom 80/836, 84/467, 84/466, 89/618, 90/641 e 92/3 in materia di radiazioni ionizzanti. Supplemento Ordinario alla Gazzetta Ufficiale della Repubblica Italiana n.136 del 13 giugno 1995– Serie Generale (1995).

[2] ORDINANZA DEL PRESIDENTE DELLA REGIONE LOMBARDIA 20 giugno 1997- N.57671- Ordinanza finalizzata alla definizione delle modalità temporanee di attuazione della sorveglianza radiometrica, prevista dal d.lgs 17 marzo 1995, n 230, su rottami o su altri materiali metallici di risulta destinati alla fusione. Bollettino Ufficiale della Regione Lombardia-Serie Ordinaria-N.29–14 luglio 1997 (1997).

BIBLIOGRAPHY

PROCEEDINGS OF THE INTERNATIONAL CONFERENCE "The Radioactivity in the Metal Scraps Recycling Industry: Consequences and Solutions". Brescia (1998).
RISICA S., DI CIACCO P. (Eds) "Problemi di radioprotezione connessi con l'importazione di rottami metallici". Rapporti ISTISAN 96/24 (1996).

QUESTIONS AND ANSWERS

C. Englefield (UK):Would you agree that beta/gamma detection systems are not the answer to the problem of alpha emitters that might be in scrap metal, and that therefore another approach must be developed?

R. Gallini (Italy): I agree, it is a problem and is perceived as a risk. In my country we don't have the experience required to solve it and currently nothing is being done currently in this regard.

N. Kravchenko (Russian Federation): Are there any requirements for exporters of scrap metal to ensure radiation safety in EU countries?

R. Gallini: No. In the shipment documents, liability in general is with the sender. There is no specific reference to radiation.

C. Schmitzer (Austria): In monitoring at borders for radioactive contamination of metal in scrap, is there an accepted action or intervention level or an indication on exempted amounts or concentration of radioactivity?

R. Gallini: This used to be the case, when the regional ordinance listed three different action levels expressed as dose rate but this is no longer in force. I think it is fundamental to reintroduce set levels.

J. Tikkinen (Finland): How do you define the country of origin of radioactive scrap? Scrap metal may have gone through a long chain of dealers and across borders.

R. Gallini: We are aware of this and are often unable to determine the actual origin of the scrap. The shipper of the source (i.e. the last dealer) is considered responsible and this is the only information concerning origin that can be found in the shipping documents.

ILLICIT TRAFFICKING-
INTERNATIONAL ISSUES AND RESPONSES
(Session 7)

Chairperson

S. MAGNUSSON
Iceland

Keynote Address

NUCLEAR SMUGGLING: ADAPTABILITY, ORGANIZED CRIME AND UNDERCOVER OPERATIONS

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INTRODUCTION

In the early and mid 1990s nuclear material smuggling propelled itself onto the agenda of intelligence and law enforcement agencies in Western Europe and the United States. Hardly a week went by without a startling new claim about the inadequacy of security at Russian nuclear material stockpiles, the possibility of organized crime groups supplying terrorists or rogue states with sufficient material to make at least one nuclear weapon, and the inability of authorities in the former Soviet Union (FSU) or in the West to stanch the continued trafficking of materials. At the same time, skeptics argued that much of the trafficking involved radioactive junk rather than weapons-grade material, that the demand side of the market had been artificially created by western undercover police, intelligence agents, and journalists posing as potential buyers in what was an attempt at sensationalism, and that the market was populated by amateur criminals, who were easily entrapped, rather than by professional smugglers who were likely to be much more elusive.

The debate reached a peak in 1994 and has since declined. In spite of the seizure of a sample of uranium-235 (enriched 76%) seized by a border guard in Bulgaria in May 1999, and 920 grams of enriched uranium-235 (30%) seized in Georgia in April 2000, the radioactive and nuclear material trafficking issue has lost considerable salience. There are two possible explanations for this. The first is that the problem has indeed become less significant. An alternative is that it has changed forms and direction in ways that attract less publicity, but that might in fact be equally or more disturbing. To determine which of these propositions is more compelling the first section of this paper examines the changes in trafficking patterns. Based on a database of over 700 incidents that have taken place since May 1991 and been identified in the open sources, the discussion focuses on trends since 1995 and suggests not only that that there has been a major shift to southern routes, but also that this shift has a logic or rationale that is highly disturbing. In effect, the adaptability of the traffickers makes the problem even more serious. This sobering conclusion is reinforced by the second section of the paper examining the extent of organized crime involvement in nuclear material trafficking. The analysis challenges the conventional wisdom that there is little, if any organized crime involvement — especially if the full ramifications and manifestations of organized crime are taken into consideration. Nuclear material trafficking is an activity involving high risks and modest, or even uncertain, profits. While this might impose some inhibitions on organized crime involvement in the nuclear material market, these inhibitions do not necessarily amount to a prohibition — and can easily be shed when opportunities arise.

The third and final section of the paper focuses on the responses to what — if the argument here is accepted — is a serious and enduring problem. It looks at the potential uses (and dangers) of undercover operations targeted at nuclear material trafficking. In effect, the analysis identifies the menu of possible undercover operations according to their purpose, scope, benefits, costs, and risks. It also seeks to assess the prevalence of undercover operations in the cases of nuclear material trafficking that are in the public record. (In addition, the analysis in this section seeks to offer a finely granulated assessment of the utility of undercover operations according to the structure of the operation and, in particular, the precise role (buyer, seller, middleman, etc.) of the undercover agents in the transactions. It does this by juxtaposing the menu of possible undercover operations with the major stages identified in the Nuclear Smuggling Pathway Model developed by James Ford and Richard Schuller.[1] This facilitates a more disaggregated approach to undercover operations, and in particular, provides an opportunity to consider risks and benefits of such operations in relation to different stages of the theft and trafficking process. From this it should be possible to distill best and worst practices and to identify the conditions under which, and the forms in which, undercover operations are most likely to maximize positive results (greater knowledge and understanding of the market, disruption of specific trafficking efforts, and deterrence through increased sense of risk) and minimize negative results (the inadvertent creation of incentives to traffic nuclear materials or political embarrassment).

1. CHANGING PATTERNS OF SEIZURES

In considering seizure data and the changing pattern of incidents, a good dividing point is 1995, since this splits the ten-year period of data collection into two five-year parts. Although this is somewhat arbitrary, it does provide two distinct periods for comparison that are roughly comparable in duration. Accordingly, Table I shows the seizures broken down by region and year for the period from May 1991 to December 1995. Table 2 covers seizures for the period from January 1996 to December 2000.

In considering this data the following observations are worth emphasizing:

- The decline in the overall number of incidents. The most obvious explanation for this is that there has been a decrease in the size and intensity of the market for illicit nuclear materials. There are several alternative explanations, however, including the possibility that amateur smugglers have been deterred from involvement and that the professionals have become more skillful and adept at avoiding detection.
- The major decline is in Germany and Central Europe. There were almost no seizures in Germany during the period from July 1995 to February 1999, which is all the more striking because of the major seizures in 1994. The only two seizures were not significant. Furthermore, there were only seven seizures outside Germany in the rest of Western Europe during this time (although one of them clearly involved Italian organized crime groups). There are several possible reasons for the diminished importance of Western Europe in nuclear material trafficking. One is that the 1994 undercover operations highlighted the risks of this route, especially compared to southern routes where both levels of vigilance and the effectiveness of law enforcement are much lower. Another is that traffickers realized that the market for nuclear materials is not in Western Europe. The demand for these materials is much more likely to come from the Middle East, South Asia, and North Korea. Accordingly, the move away from Western Europe can be understood as a more realistic approach to trafficking than in the early and mid 1990s when Austria, Switzerland, Italy and Germany were the major conduits, and at least interim, destinations.

[1] James L. Ford and C. Richard Schuller, *Controlling Threats to Nuclear Security: A Holistic Model*, (Washington, D.C.: National Defense University, 1997).

Table I. Seizures by country, region and year (May 1991-December 1995)

Region	1991	1992	1993	1994	1995	Total
Russian Federation	2	5	18	26	19	70
Baltics	0	0	3	3	6	12
Balkans	4 (1R)	4 (1R)	6 (6R)	12 (7R)	5 (3R)	31 (18R)
Central Asia	0	0	0	0	2	2
Middle East	0	0	0	1	4	5
Asia	0	0	4	1	2	7
Central Europe	1	10	10	6	5	32
Western FSU	0	5	2	2	10	19
Western Europe	4	20 (11G)	12 (8G)	14 (10G)	2 (1G)	52 (30G)
South Asia	0	0	0	2	2	4
Turkey And Cyprus	0	0	2	4	3	9
Caucasus	0	0	0	0	1	1
Africa	2	1	2	2	3	10
South America	0	0	1	0	0	1
Total	**13**	**45**	**60**	**73**	**64**	**255**

Table II. Seizures by country, region and year (January 1996-December 2000)

Region	1996	1997	1998	1999	2000	Total
Russian Federation	6	14	5	4	9	38
ltics	5	4	1	0	1	11
Balkans	11 (4R)	3 (2R)	1	2	6 (4R)	23 (10R)
entral sia	3	4	0	6	7	20
Middle East	1	0	1	1	0	3
Central Europe	2	6	3	0	0	11
Western FSU	6	3	2	5	5	21
Western Europe	5 (1G)	3 (1G)	4	1	1 (1G)	14 (3G)
ırkey And Cyprus	4	3	2	3	1	13
Caucasus	1	2	2	2	2	9
South Asia	0	4	6	0	3	13
Asia	2	1	4	2	2	11
Africa	2	4	0	1	0	7
South America	0	0	1	0	0	1
Total	**48**	**51**	**32**	**27**	**37**	**195**

- The number of seizures increases greatly in the second time period in areas south of the Russian Federation. Thus, the routes can be said to have shifted from west to south. In comparing the data from 1995–1997 to 1998–2000 the shift from west to south becomes even stronger, with most cases (about 60%; excluding the Russian Federation, 75%) in 2000 moving south. Additionally, most seizures in the Russian Federation in 2000–2001 were made in the southern border regions, the Far East and Moscow. In sum, stolen nuclear and radioactive material is no longer traveling through Germany and West Europe), it is going south — through the Caucasus, Central Asia and the Balkans. This use of southern rather than western routes is not entirely surprising given that the Middle East (including the Gulf region) is where the most likely end-users are concentrated. Nevertheless, it represents a major shift in the locus of trafficking activities from the first period to the second. Southern routes accounted for about a sixth of nuclear trafficking seizures in the first period and accounted for around a quarter in the second period. What makes this shift all the more striking is that law enforcement and customs along these routes are generally less sophisticated, not as well equipped, and more susceptible to corruption than their counterparts in Western Europe. The increase is even more striking when it is also kept in mind that seizures in the Balkans declined during the second period in absolute numbers. There are several possible reasons for this including the implosion in Albania, followed by the developing conflict over Kosovo, which made the Balkans route as dangerous for nuclear material trafficking as it was for drug trafficking.

Skeptics can still argue, of course, that the seizure pattern is meaningless since the trafficking during the last five years has rarely involved fissionable or weapons-grade material. Moreover, although arrests and seizures provide a partial glimpse of the phenomenon, it is uncertain how representative that glimpse is. This makes assessments based on seizure data somewhat hazardous at best. On the other hand, when there is an increase in seizures in countries and regions where law enforcement and interdiction capabilities are not fully developed, then a logical implication is that there is much more going on than is visible. Moreover, the southern routes are all the more dangerous because they lead towards the ultimate end-users — rogue states and terrorist organizations such as the Osama bin Laden terrorist network. The implications are sobering. The opportunities are available, the smuggling routes and expertise are in place. The only thing that is missing during the last five years is a seizure of a significant amount of weapons-grade material *en route* south. Given the limited interdiction capabilities along the southern routes, however, this is hardly surprising. It is certainly not grounds for complacency. Gloomy as this conclusion might be, it is reinforced by an assessment of the role of organized crime in nuclear material trafficking. The next section provides such an assessment.

2. THE ROLE OF ORGANIZED CRIME

a. Patterns of Organized Crime Involvement in Nuclear Material Trafficking

There are several difficulties in any effort to determine the precise level of organized crime involvement in nuclear material trafficking. Part of the difficulty is that the reports are often sketchy, and do not always specify whether those involved in an incident have any formal affiliation with a known criminal organization. This is compounded by uncertainty over precisely what constitutes organized crime. For some traditionalists the term refers only to traditional mob-style groups operating on the basis of a strict hierarchy, codes of secrecy and readily resorting to violence. It is argued here, however, that organized crime can take many different forms. This is particularly so in the FSU where there are strong symbiotic relationships between organized crime and government officials, where organized crime has infiltrated key institutions such as the military, and where the lines between public and private activity are particularly blurred.

An interesting case that appears to point to official complicity in nuclear material trafficking concerns a seizure of 1.2 kilograms of uranium-235 in Turkey in January 1996. Interrogation of the traffickers revealed not only that they allegedly intended to sell uranium-235 to Libyan buyers, but even more significantly, that they had bought the material in Georgia in 1994 from Taraci (or Taradze), the security chief of Georgian President Eduard Shevardnadze.[2] Although these allegations were not proven, they had some plausibility as the accusation was corroborated by several of the traffickers.

Indeed, whatever the precise details of this case, it is clear that there is a problem of collusion between the political and administrative elites and criminals. Traditionally respected institutions such as the military have also become corrupt, developing their own "mafia in uniform" and working through close links with organized crime.[3] Who controls whom in these collusive relationships is not always evident. Nevertheless, the relationships are deeply entrenched and make it difficult to combat organized crime.

Another closely related issue is the use of commercial companies. Again there are significant relationships between organized crime and commercial companies in the FSU. An episode that clearly reveals this — and is an overt and incontrovertible case of organized crime involvement in nuclear material trafficking — concerns a shipment of beryllium seized by police in Lithuania in 1993. The beryllium shipment originated from the Institute of Physics and Power Engineering in the city of Obninsk, and was obtained through a bogus purchase order in early 1992. The export of the beryllium was handled by a series of front companies or trading firms, connected in some way or another to organized crime in the Russian Federation. The initial payment and receipt of the material was handled by Yuri Alexeyev, a suspected racketeer from Yekaterinburg, through his Moscow karate club Karate-Do. The involvement of the club was inherently suspicious not only because it was such an anomaly, but also because martial arts practitioners and other "sportsmen" provide much of the "muscle" for organized crime. The beryllium was transported to Moscow then Yekaterinburg and passed from a trading company called AMI to another trading company, the Urals Association for Business Development (UADS), which reportedly had connections with organized crime in the Sverdlovsk region, particularly the "Tsentralnya" organization in Yekaterinburg. The beryllium was then purchased by VEKA, a Lithuanian firm, and was subsequently flown to Lithuania where it was stored in a bank vault in Vilnius before being seized by police in May 1993. Although it was never sold, it appeared that a Zurich buyer with Korean connections was interested in purchasing the material.[4]

As well as the cases in which organized crime is involved, directly or indirectly, through front companies or unscrupulous entrepreneurs, there have also been incidents in which known members of criminal organizations have been arrested while in possession of radioactive materials. The prime example of this was a seizure in October 1994. Of the 12 people arrested, the majority had previously been in trouble with the law; some of them might have

[2] *FBIS Report: Arms Control and Proliferation Issues*, "Article Describes Activities of 'Nuclear Mafia'," FBIS-TAC-96–007 (Internet).
[3] Graham Turbiville, "Organized Crime and the Russian Armed Forces," *Transnational Organized Crime,* Vol. 1, No. 4 (Winter 1995), pp. 57–104.
[4] Tim Zimmermann and Alan Cooperman, "The Russian Connection," *U.S. News & World Report*, Vol.119, 23 October 1995, pp.56–67.

been members of one of Moscow's major criminal organizations, the Solntsevo group. The group had a strict hierarchy: bosses (led by known criminal Yuriy Kazaryan, director and founder of "TOO Interattraktsion" (which was engaged in experimental-design work on equipment and technologies for the creation and operation of joint enterprises), who had reportedly developed methods for smuggling strategic materials out of the Russian Federation to other countries, sought out buyers, and set the price for the materials; a kind of counter-intelligence and security service, which saw to it that the "goods" remained safe and sound; and the "dividers," who "packaged" the uranium in small batches for sale.[5]

It is not only Russian organized crime, however, that reportedly has been involved in nuclear material trafficking; there has also been at least one instance in which the Italian Mafia was involved. In February 1998, Italian police arrested 14 members of the Italian Mafia on charges of attempting to sell uranium fuel rods. Among those arrested were four Sicilians (including Salvatore Tringale, allegedly a "Mafia boss" of the Santapaola clan from Catania), two Calabrians (Giuseppe Zampaglione and Domenico Russo), an unidentified man from Catania, and seven Romans suspected of belonging to the Magliana gang. In a related case, two Portuguese men (Belarmino Vilarino, a businessman who had resided for ten years in Avola and was suspected of involvement in money laundering, and Carlo Monteiro from Guinea Bissau, an "owner of an international transport company"), and Pietro Bellia, a Sicilian from Belpasso, believed to be a leading figure in the Santapaola clan, were arrested and charged with "the export and transit of armaments." Allegedly they were trying to sell a "25-kilogram bar of uranium-235," from Zaire, together with an indeterminate quantity of "red mercury." It was reported that the group had access to five more bars of uranium. Monteiro stated that "he had acted upon the request of the Russian secret services, which were interested in recovering a quantity of red mercury that had been stolen in the Soviet Union in 1989."[6] Reportedly, the police believed those arrested were part of a transnational network operating between the Democratic Republic of the Congo (formerly Zaire), North Africa and Europe. The Italian connection was also evident in a bizarre episode in which Italian intelligence agents posing as buyers of nuclear materials and focusing on "a factory outside St Petersburg" were offered a Raphael, entitled *The Madonna of the Hay* that had disappeared in the 1920s.[7]

Nor is organized crime involvement in nuclear material trafficking limited to Western Europe. Other possible routes for nuclear material trafficking include Afghanistan and Pakistan. The Pakistani frontier city Peshawar is notorious as a haven for smugglers of all kinds. It is a place where, according to one report, "antiquities smugglers run a sideline in nuclear merchandise" and where traffickers move from product to product with considerable ease and confidence.[8] Other parts of the two countries also serve as bases for nuclear material traffickers. For example, in April 1997, Munawar Shah, a "notorious smuggler, wanted in several international cases of drug trafficking and gun-running," was arrested in Rawalpindi, allegedly in possession of two kilograms of heroin, and a "few samples of uranium." It was further

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[5] Grigoriy Sanin and Nikolai Kopeykin, 'Rossiiskim uranom torguyut optom i v roznitsu', *Sevodnya*, 19 October 1994, p.7.

[6] *Daily Report: West Europe*, "Background to Uranium Seizure Reported," FBIS-WEU-98-080, 21 March 1998 (Internet); *Daily Report: West Europe*, "Anti-Nuclear Trafficking Operation Reviewed," FBIS-WEU-98-106, 16 April 1998 (Internet); *Daily Report: West Europe*, "Alleged Smugglers of Nuclear Material Arrested," FBIS-WEU-96-177 (Internet); *Reuters*, "Uranium Smugglers Held in Italy," 1 July 1996; *Agence France Presse*, "Three Men Arrested for Trafficking Radioactive Substances," 1 July 1996; Peter Shadbolt, "Contraband Uranium Passed through Italy," *United Press International*, 1 July 1996.

[7] Richard Owen, "Lost Raphael seized during Mafia 'sting'," *The Times (London)*, 20 February 1999.

[8] Tim McGirk, "A Year of Looting Dangerously," *Independent on Sunday*, 24 March 1996, pp.4–8.

reported that the Anti-Narcotics Force (ANF) found documents which suggested that Shah had "links with international gangs of arms smugglers operating from Central Asian states, Saudi Arabia and Europe." According to an ANF official: "several other members of the same gang, allegedly headed by Munawar Shah, had earlier been arrested with huge quantities of heroin in Islamabad and Karachi." During an interrogation by the ANF, Shah reportedly confessed that he had "brought samples of uranium from Afghanistan."[9] If it is for sale, and a profit can be made in selling it, then the product becomes almost irrelevant.

This appeals to another category of people — former KGB and Special Forces personnel, who have the requisite skill and knowledge to identify critical materials, to obtain access (directly or indirectly) and to act as brokers. Alexander Victorovich Kuzin and Karl Friedrich Federer, both of whom allegedly had intelligence backgrounds were reportedly involved in several incidents of nuclear material trafficking in the early 1990s. Kuzin, who operated out of Vienna and through companies in Italy was implicated in a number of incidents in Europe. Other former intelligence agents seem to have been active elsewhere, either as genuine brokers or as fraudulent dealers and scam artists. It was not always clear which they were. In August 1994, for example, it was reported that Macau authorities believed that "a substance purporting to be... red mercury," had been transferred to a Hong Kong ship by former special services operative, Igor Deordienko and Vladimir Rippin, "a former KGB agent who served in Afghanistan and Beijing."[10] Deordienko was involved in a range of criminal activities and controlled some of the prostitution in Macao. Although it seems a large jump from prostitution to nuclear material trafficking, if one considers the possibility that he was also involved in trafficking in women for commercial sex, the leap becomes less implausible. After all, a product is a product.

The implication of all this is that there is a small but not insignificant number of seizure and arrest incidents in which members of organized crime, or individuals and companies that can be readily located within criminal networks, have been involved in nuclear material trafficking. The difficulty is working out how representative the sample really is. Suffice it here to argue, that when it comes to black markets and organized crime activities, it is generally the unlucky or incompetent criminals who get caught. If this is the case, then the conventional wisdom about the non-involvement of organized crime in nuclear material trafficking requires serious reappraisal.

b. A Typology of Criminal Organizations

Against this historical background and with sufficient sensitivity to the pervasiveness of Russian organized crime, it is possible to identify nine different kinds of criminal group that have been, or might be, involved in nuclear material trafficking:

- *opportunistic amateur groups*. The most pervasive but least important category consists of individuals and small groups that, either because of greed or necessity, decide to seek opportunities in the theft and export of nuclear materials. Such groups are opportunistic rather than composed of career criminals. They might be prompted into action by

[9] *FBIS Report: Narcotics*, "'Notorious Smuggler' Caught with Heroin, Uranium Samples," FBIS-TDD-97-107, 17 April 1997 (Internet); *FBIS Report: Narcotics*, "Court Refuses to Extend Drug Smuggler's Remand," FBIS-TDD-97-120, 30 April 1997 (Internet).

[10] Brian Freemantle, *The Octopus: Europe in the Grip of Organized Crime* (London: Orion, 1996), pp.29-32; Paolo Biondani, "Uranovaya oxota," *Literaturnaya Gazeta*, 11 March 1992, p.15; Jamie Dettmer, "The Changing Face of Terrorism," *The Washington Times*, 25 October 1994, p. A8; Hedley Thomas and Darren Goodsir, "Nuclear Materials Smuggled Near HK," *South China Morning Post*, 1 August 1994, p.1.

economic crisis, by friendships with workers in nuclear installations who have access to the materials, by family relationships with such workers, or by proximity and access to nuclear material stocks. Generally these small groups will operate at a low level of sophistication. Even if the insider connection gives them some knowledge about the material and the initial access, it is unlikely that they will develop very sophisticated smuggling techniques. Methods of concealment and deception are likely to be poor or nonexistent, and the odds are considerable that in the search for a buyer they will draw attention to themselves. These opportunistic criminals are amateurs rather than professionals and have been among the most obvious components in the market.

- *predatory criminal organizations*. This category consists largely of criminal groups that essentially engage in small-scale criminal activities such as localized extortion, car theft and the like, and that do not have links with corrupt officials. These organizations are more like street gangs than fully fledged organized crime groups, although the more successful ones tend to become more sophisticated and gradually develop links with the business, political, and administrative elites. To the extent that predatory criminal organizations become involved in nuclear material trafficking it is likely to be at a fairly low level of sophistication. Thefts of material would generally be small and fairly crude — either done through direct entry into a facility or through coercion or bribery of insiders — and they are more likely to obtain access to radioactive junk than to fissionable material.
- *ethnically based smuggling organizations*. Turkish and Chechen networks fit this category. One important aspect of smuggling is that although law enforcement tends to weed out the less efficient and effective, at least some groups develop quite sophisticated methods of concealment and deception. Moreover, smuggling groups can readily move from one product line to another with great ease and speed. In a few incidents of trafficking of nuclear materials involving Turkish groups, at least some members of the group had previously been involved in antiquities theft and smuggling. Once the infrastructure, routes, and methods (including bribery of officials) are in place, the product itself becomes almost irrelevant. Moreover, nuclear material has certain attractions: it is not too difficult to obtain, is relatively small and easy to transport, is easy to disguise or conceal, and, if a suitable buyer, has been arranged provides rapid, immediate, and large profits.
- *sophisticated transnational criminal organizations*. The more substantial Russian organized crime groups are often network-based criminal associations that encompass a wide range of smaller groups and engage in a wide variety of criminal activities. Perhaps the premier example of this kind of association is the Solntsevo group. One of Moscow's and the Russian Federation's premier criminal organizations, Solntsevo is well entrenched with several layers of strong leadership, a well-established structure and a high level of professionalism. It acts as a kind of umbrella organization for over 300 individual crime groups and has a wide diversity of criminal activities and an extremely entrepreneurial approach to organized crime. Solntsevo dominates the southwestern districts of Moscow, but the proceeds of its criminal activities have been invested in real estate, land, and large commercial enterprises in a variety of locations. A key figure is Semeon Mogilevich, based in Budapest, who is widely regarded as a major organized crime figure with interests that extend from Moscow, Samara, and Crimea to Hungary, Britain, and Israel. Moreover, this empire includes an extensive network of legitimate, semi-legitimate and simple front companies. Companies linked to Mogilevich include Arbat-International, YBM Magnex, the British company Arigon, and the Israeli Empire Bond. In the Russian Federation itself, the Solntsevo organization reportedly controls the University and

Cosmos hotels; several casinos; the Solntsevo car exchange; all non-food markets in the Southwest District of Moscow; and commercial transportation to and from Vnukovo airport. In addition, Mogilevich is believed to control freight passing through Moscow's Sheremetyevo International Airport. The Solntsevo organization has protected itself through bribing local police investigators and prosecutors. The group's control over transportation resources, its capacity to corrupt officials, and its transnational links provide three of the requisites for effective participation in the nuclear smuggling business.[11]

- *The "comrade criminals"*.[12] Some criminal organizations in the FSU have close links with officials and have become key components of the competing administrative financial criminal oligarchies that are one of the dominant forces in the Russian Federation today and that operate at local and regional levels as well as nationally. Indeed, in most of the countries of the FSU there is a seamless web between the legal and the illegal that is reinforced by the lack of clarity between public and private activities: little is done to prevent conflicts of interests for those in political power, who typically use public office for private gain. An "iron triangle" has developed among the oligarchs and businessmen, organized criminals, and political and bureaucratic elites all of whom are working together in a symbiotic relationship that has become one of the most dominant characteristics of the Russian Federation in the first years of the twenty-first century.[13]. The fusion of crime, politics, and business has been evident in cities such as St Petersburg where the Tambov organized crime group with its 300 to 400 "soldiers" and its own telephone monitoring and surveillance services, is believed to control hotels, the oil market, the retail trade in gasoline and the production and sale of liquor. Vladimir Kumarin, widely recognized as a leader of the Tambov gang is also vice president of the St. Petersburg Fuel Company which controls over two-thirds of the retail gasoline market in the city, and has received a string of municipal contracts largely because of its political links. In addition, the group has long had protectors in the St. Petersburg Legislative Assembly.[14] When the problem of nuclear material trafficking is considered against this background, it would be foolish indeed to assume that nuclear cities, nuclear installations, nuclear storage sites, or nuclear laboratories, are immune from the process of fusion between organized crime, the political elites, and economic managers.
- *Criminal-controlled businesses*. Organized crime infiltration of and control over licit business has become the norm rather than the exception in the Russian Federation and other states of the FSU. Criminal groups have even targeted charitable organizations such as the Afghan War Invalid's Foundation, and various sports foundations that were given tax-free status and became active in the import-export business. An important variant on the criminal-controlled business concerns firms that are ostensibly (and in some instances perhaps even predominantly) licit but with their origin in criminal activities and with a residual tendency to resort to violence and corruption to protect and promote their activities and to deal with competitors. The 21st Century Association is perhaps the most well-known enterprise that at least some observers believe fits into this category. Companies such as Nordex can also be considered here. Such companies have several

[11] For a good discussion of Mogilevich and Solntsevo see Jeffrey Robinson, *The Merger* (London: Simon and Schuster UK, 1999) pp. 159–173

[12] Stephen Handelman, *Comrade Criminal* (New Haven: Yale University Press, 1995)

[13] The authors would like to thank Gregory Baudin-O'Hayon for the term "iron triangle" as used here.

[14] The analysis of St Petersburg draws in large part on William A Cook and Gregory Baudin-O'Hayon, " A Chronology of Russian Killings" in *Transnational Organized Crime*, Vol. 4 No. 2 (Summer 1998) pp. 117-201. See also Mikhail Nenarokov, "Ex-Police Chief on Tambov crime Gang" *Moscow Rossiyskaya Gazeta*, 28 April 2000.

advantages when it comes to trafficking in nuclear materials: they have well-established trade links, existing institutional forms and affiliations, and established financial channels that can be used to move funds and process payments. All of these characteristics can help provide cover for a variety of illicit activities including trafficking in weapons and nuclear materials. Companies that are involved in the trade in arms or the export of strategic metals are also perfectly placed to enter this trade. They have the necessary contacts to provide export licenses, the knowledge of which officials are susceptible to bribery in return for favors, and the cover of apparently legitimate trade and financial activities.

- *Networks of former intelligence agents*. Although it is important not to see organized crime in the Russian Federation as dominated by ex-KGB agents, it is clear that former intelligence and military operatives do play a large part in some organized crime activities. These former agents are specialists in violence — something that is integral to the world of organized crime — have knowledge about and access to nuclear facilities, and have transnational linkages that can be critical in determining where the demand is, and for which particular materials. They are also likely to be particularly adept in providing sophisticated methods of concealment, in protecting shipments, and in obtaining the necessary financial transfers required for payment. Although they are almost certainly among the more sophisticated and therefore least visible participants in the nuclear material black market, there have been some cases where their involvement has been detected or at least suspected.
- *Traditional mafia organizations*. Although the preponderant organized crime involvement in nuclear material trafficking has come from the states of the FSU themselves, there have been a few cases of foreign organized crime involvement, especially by Italian Mafia organizations. This is not surprising: the linkages between Italian organized crime and criminal groups in the FSU provides many opportunities for Mafia involvement. Italy's location also makes it an alternative, if higher risk route, than Turkey, Central Asia, and the Caucasus.
- *hybrid trafficking networks.* The above categorization is neither exhaustive nor rigid. Nor are the categories mutually exclusive. On some occasions various kinds of groups will work together. This is why it is also important to include hybrid trafficking networks that are dynamic and fluid rather than fixed or static and often bring together different kinds of participants in what are essentially alliances of convenience. In some cases, where collaboration is harmonious, successful, and profitable, it is likely to be repeated. In other instances, however, the network will simply dissolve as the participants move on to other criminal endeavors with other partners. This suggests that there are hybrid trafficking networks that might merge some of the characteristics of the other types of organizations, but that deserve attention in their own right. The inclusion of this group makes the analytic and intelligence tasks more complex and more formidable, but is indispensable to understanding the phenomenon of organized crime and the links to nuclear material trafficking.

c. Perpetrators and Pathways

The biggest variable in nuclear material trafficking pathways is perhaps the degree of sophistication with which the activity is carried out. This is evident in the method of acquisition of the materials, which can range from smuggling of small amounts by relatively low-level workers, to large-scale diversions by those in management positions. In some cases the impetus will come from the insiders themselves, particularly in cases of extreme economic hardship. In other cases, the activity will be initiated by outsiders who require insider assistance in the acquisition of the materials, and obtain it through bribery and corruption, physical intimidation or blackmail. It is possible to conceive of elaborate schemes for physical removal of nuclear materials from the premises. In most cases, however, the more elaborate the scheme and the larger the amount of material involved, the more people have to be recruited and the greater the danger of discovery. The exception to this is where there is high-level management involvement. This can involve relatively few people and be based on manipulation of paperwork that provides a pretext for movement of the material that can, in turn, allow for its subsequent diversion.

The importance of sophistication is even more obvious in the trafficking process. At the lowest level are opportunistic amateur criminals who cooperate with insiders and predatory gangs, which coerce insiders. In neither case do the would-be traffickers usually know what to do with the material once they have obtained it. As a result the chances of being caught in a frantic and overt search for a buyer are quite considerable. At a somewhat higher level of sophistication are smuggling organizations, often ethnically based, and experienced at avoiding detection. In some cases these groups have developed their expertise through trafficking in products such as drugs, arms, stolen art and antiquities, rare fauna and flora, and in moving illegal aliens and women for the commercial sex trade. As a result, they know which mistakes to avoid, which routes are low-risk, and which customs posts are ineffective or susceptible to corruption. Such expertise makes it more difficult to detect their activities.

This task becomes even more formidable with transnational criminal organizations that have a wide array of legitimate and front companies, providing an extensive infrastructure to support their activities. Such groups have the clout to coopt or coerce insiders, including those with wide-ranging responsibilities. In addition, they can provide excellent coverage for shipments of stolen materials. Perhaps the biggest question marks concerns their relationship with potential buyers. Given the extensive reach of an organization like Solntsevo, however, this should not be an insuperable problem. Nevertheless, one of the key issues is whether or not sophisticated transnational criminal organizations would steal and divert material in the hope of finding a buyer, or only when a buyer is already lined up and has provided some kind of financial advance. Another possibility is that stolen material might be taken out of the FSU by one criminal organization and then sold to another group that would in turn sell it to an end-user. The known linkages between Russian and Italian organized crime, especially their willingness to develop joint ventures and the pre-existence of effective trafficking networks and money laundering relationships, suggest that cooperation in the area of nuclear material trafficking is a distinct possibility.

There is obvious overlap between the sophisticated transnational criminal organizations and the criminal-controlled companies. But the criminal-controlled businesses are so pervasive in the Russian Federation that it seems necessary to consider them in their own right. One of the difficulties of identifying trafficking activities by these businesses is that many of them are involved in the import-export sector and, therefore, have ready-made cover for their illicit activities, whether moving the material or receiving the payments. Their familiarity with export licensing, their ability to corrupt border-guards and customs officials, their capacity to hide illicit cargo in licit goods, and their foreign links are all resources that could readily be exploited for nuclear material trafficking.

Much the same is true of the "Comrade Criminals," officials who are closely linked to criminal organizations. Many of the Russian Federation's most prominent officials have close links — either personal or through jointly owned companies — with known criminals or with businessmen such as Lev Cherny, Boris Berezovsky, and others with reputations for unscrupulous and, in some case, illegal dealings. Moreover, this pattern is repeated not only in Moscow but at lower administrative levels such as region and oblast. Close links between local government officials, and criminals could all too easily translate into collaboration in the smuggling of nuclear materials. Management officials at the various nuclear installations face the same hardships — and the same temptations — as others in authority, and might be willing to use their position for personal gain. Alternatively local officials could find themselves compromised in some way by organized crime and then have little alternative other than collaboration. With high-ranking and middle-ranking officials involved, the diversion of nuclear materials is more likely to be a disguised diversion — with some apparently legitimate cover — than a crude theft. It could also involve more material, all of which would be transported and exported under cover of legitimate documentation.

This survey does not do justice to all the possibilities summarized in Table 3. It does, however, highlight the main variations that can occur and accentuates the fact that dealing with the problem is all the more formidable because of the mix and match quality of the range of possibilities. There are many different permutations of hybrid networks. They can include a mix of businessmen, officials, organized crime figures, and former intelligence agents — or any combination of people who fall into these categories. They can operate at different levels of the supply-chain, and act with a degree of sophistication and an expertise in concealment, that they could prove very difficult to detect, let alone apprehend.

d. Implications

Although this is "a first cut" at the issue of organized crime involvement in nuclear material trafficking, its implications are sobering. Not only is there a greater diversity of actors than generally believed, but many of them have considerable skill, resources, and ingenuity, and could mount a trafficking operation that would be difficult to detect. Moreover, the potential links among different kinds of actors offers diverse modes of theft or diversion and gives the trafficking process itself an infinite variety of forms. The difficulties of monitoring are increased enormously as a result. Nevertheless, the analysis also suggests that there are several things which might be done to enhance the process of monitoring and detection:

There urgently needs to be a much broader analysis of the risk related to Russian nuclear installations and facilities. At the moment, the risk tends to be analyzed largely in terms of physical security. Is it or is it not secure from intrusions and from theft by the employees. Important as these considerations are, more attention could be paid to the location of the plant in relation to the geography of organized crime in the FSU. In those cases where nuclear facilities are located in regions where organized crime groups are particularly strong, well-entrenched, and have symbiotic links with the local and regional elites then the risk assessment needs to reflect this. In effect, the problem concerns not simply the installations but also their environment in terms of the strength of organized crime and its capacity to influence either low-level employees or high-ranking officials at the facilities.

A broad range of potential indicators needs to be considered. The problem of observables is a formidable one as it is with any kind of sophisticated trafficking in illicit products. If the traffickers are experienced, and have commercial companies particularly in the import-export sector, then the challenge of identifying illegal transactions in the midst of the plethora of legal commercial transactions is enormous. This places a premium on prior knowledge about the company itself — whether or not it is a front for organized crime, whether it has a reputation for engaging in dubious or illegal activities, and the location of its major trading

Table III. Perpetrators, Pathways and Indicators

Type of group	Method of acquisition	Trafficking methods	Indicators and Observables
opportunistic amateurs	- link with insiders through friendship or family connection	- generally very primitive with little concealment	search for buyers
predatory criminal organizations	- intimidation or bribery of insiders - breaking in and stealing the materials	- unsophisticated transportation of small amounts	- links with insiders - search for buyers
ethnically based smuggling organizations	purchase from insiders or from brokers	- good concealment and deception - follow southern routes including Turkey, and via Afghanistan and Pakistan	- trafficking in diverse illegal goods - search for buyer
sophisticated transnational criminal organizations	Bribery high-level contacts intimidation or blackmail management diversion of materials	- hide within legal shipments - front companies - metals trading - import-export firms - arms dealers - fruit exports	- false invoices - circuitous routes - destination of shipments - change in life-styles of managers - money flows
Criminal-controlled businesses	Bribery high-level contacts intimidation or blackmail management diversion of materials	hide within legal shipments front companies metals trading import-export firms arms dealers	false invoices circuitous routes destination of shipments change in life-styles of managers money flows
Comrade Criminals	management diversion of materials	hide within official government shipments and exports or various front companies	"official" export shipments to potential proliferants
Networks of former intelligence agents	blackmail of insiders	- sophisticated fronts - security of transportation - links to customers	- destination of shipments - money flows
traditional Mafia organizations	purchase through brokers or obtain from indigenous criminal organizations which use bribery or intimidation for access	use of front companies	- links among organized crime groups from different countries -established patterns of cooperation - suspicious financial flow
hybrid trafficking networks	insider who can be involved only in theft and diversion or part of a continuing criminal network	series of choices at each stage that would generally be sophisticated.	Criminal links with businessmen and with former intelligence agents

partners — and this can be an important stimulus for closer surveillance of its activities. Such surveillance might even result in the interdiction and disruption of a particular trafficking venture. Similarly, a trafficking group that is not particular about the products it moves or which has a diversified or multi-product profile could be a prime candidate for involvement in nuclear material trafficking, and once again bear closer scrutiny than those that typically tend to specialize in one product. Another possible indicator is lifestyle changes for people in the nuclear industry itself. These could include vacations outside the FSU, a wave of new purchasing activities of luxury items, new houses, and new cars. The problem with this is that it will probably appear only after a successful theft and trafficking incident. Nevertheless, it does bear some attention — and suggests that cross-linkages of various different kinds of information on organized crime and nuclear material trafficking might be particularly useful and productive in generating a fuller range of possible indicators.

Closely related to this, there is a need for more effective data-fusion. Although there are several databases in the public domain of seizure incidents; wherever possible, these should be cross-referenced with those companies, individuals, officials, and major crime figures who populate the world of organized crime in the FSU and elsewhere. Indeed, nuclear material trafficking is an area in which the development of link analysis, using sophisticated software tools such as i2's *Analyst's Notebook* can be helpful in identifying critical nodes and crime-corruption connections that could feed into nuclear material trafficking networks, greatly facilitating the process.

Finally, there is a continuing need for undercover operations in this market and, even more controversially, to combine them, on some select occasions, with controlled deliveries. Buy and bust operations only give a small glimpse of the supply chain, whereas a more permissive — but still carefully monitored controlled delivery approach might make it possible to obtain a much fuller picture, including a far better sense of the identity of the possible end-users.

III. Undercover Operations and Nuclear Material Trafficking

a. The Nature and Purpose of Undercover Operations

There are several kinds of undercover operations that can be used for a variety of different purposes ranging from knowledge discovery to disruption. In terms of purpose, it is possible to distinguish among:

- Operations geared primarily towards the acquisition of knowledge of the dynamics, operations, and scope of the nuclear material black market. Among the things that undercover operations could help to discover are: the nature and extent of the networks of traffickers; the modes of transportation and the methods of concealment; the ways in which traffickers attempt to link up with buyers; the kinds of prices that prevail for certain kinds of materials. Such operations can include the use of informants, infiltration of criminal organizations, trafficking networks, or even groups of thieves or potential thieves within a nuclear facility. Perhaps the most far-reaching undercover operation designed to acquire knowledge about the nuclear material trafficking business is the controlled-delivery. This allows the process to be traced from plant to final customer, if indeed there is a final customer, as opposed to brokers along the way. If done well a controlled delivery would reveal the nature of the trafficking network and possibly the customer. Several operations of this kind would help to reveal the extent to which networks operating in the market for illicit nuclear materials are directed networks (where there is vertical integration among the stages of the operation) or transactional networks (in which there is not central direction or vertical integration, but simply a series of largely independent brokers who are knowledgeable about — and willing to deal with — other participants in the market, and thereby make the market function very effectively, even in the absence of direction). Controlled deliveries would also help to determine price levels. This is one area in which — at least if the open literature is any guide — there is still inadequate knowledge.

- Undercover operations designed to have disruptive or deterrent effects on the nuclear material black market. The aim here is to introduce mistrust into the market and make it difficult for trafficking networks to operate with confidence, especially in relationship to potential buyers. To achieve this, publicity about successful undercover operations is essential to convince potential traffickers that this is not a risk or cost-free activity. The usual assessment of undercover operations is that they have encouraged potential suppliers to enter the market. However, if there is known to be a real risk of arrest and seizure, then it is more likely that potential entrants will be discouraged.
- Undercover operations that are oriented towards interdicting a specific criminal operation (rather than having any larger purpose) and intended simply to ensure that a particular product does not reach the intended customer, or any other potential customer. In effect, intelligence or law enforcement agents become surrogate buyers in the hope of pre-empting real buyers. Such operations might be initiated as a result of a tip-off and can be understood as defensive rather than deterrent measures. They also add another layer of security and augment physical protection at nuclear facilities. Operations of this kind provide a supplementary defensive layer in those cases where the supplier does not yet have a genuine and ready buyer; if the seller already has a buyer lined up, or is moving material to order, then the opportunity for interception through posing as buyers is limited.
- Undercover operations that are largely oriented towards snaring potential buyers rather than sellers. This kind of operation can determine which — if any — nations or organizations (terrorist or criminal) are actively seeking to acquire nuclear materials through the illicit market. Once again, it can be initiated as a result of tips from informants, but is likely to be effective only when buyers are operating on the open market. Buyers who have established their own supplier chains will be far less vulnerable. It is possible, however, that as potential proliferant states attempt to set up supplier chains, undercover operatives can insert themselves in the process at an early stage. This would not only give them the potential to acquire considerable knowledge about supplier networks but also offer some prospect for disrupting the acquisition of strategic nuclear materials.

The distinctions here, of course, are not hard and fast. There is potential overlap among the objectives of undercover operations, although there are also tradeoffs and potential tensions among the objectives outlined above. In the case of a significant amount of weapons-grade material, for example, disruption, seizure and arrest would be paramount and interdiction would probably have to take place as early as possible. In these circumstances, the acquisition of knowledge about routes, methods, and the end-game would take second place if indeed it merited any consideration. Conversely, the greater the desire to acquire information about the operations of trafficking networks, the dynamics of the market, and the nature of the customers, the more likely it is that a trafficking operation would move nearer to fruition — with perhaps a greater possibility of a loss of control, and the material actually ending up in the hands of a customer who avoids being apprehended. If the material was of little strategic significance, then this might be a risk worth incurring. Where there is a single clear-cut objective, then those involved are far less likely to face dilemmas about the timing of arrest and seizure operations.

In all cases, however, irrespective of the objective, undercover operations related to nuclear material trafficking incur risks. Several kinds of risk can be identified, ranging from operations going wrong and causing political embarrassment to the government or governments responsible to the possibility that undercover buyers will create a greater sense of demand than really exists and thereby actually stimulate the market that they are trying to disrupt or diminish. There are also specific risks. These are largely dependent on the type of operation taking place, however, and are discussed, therefore, in relation to each kind of undercover operation.

b. Types of Undercover Operations

1. CONTROLLED DELIVERIES

Controlled deliveries usually involve knowledge by law enforcement or intelligence agents of an illegal transaction or set of transactions, but without any inhibiting or interfering action apart from surveillance until the transactions are completed. In other words, the trafficking process is allowed to move from initial diversion to final delivery and payment for the product. A controlled delivery, of course, can be aborted at any stage if it appears that things are moving out of control. The main objective of a controlled delivery is to obtain knowledge about: the market dynamics, the market players involved in this particular transaction, trafficking routes and methods of concealment, the network connections, possible corruption that facilitates movement, the amounts of money involved at various stages if there are interim sales, and perhaps most important, the link with the buyers, and the payment mechanisms. Techniques include observation, wiretapping and electronic surveillance, possible infiltration of the network, or the use of an informant within it to ensure supervision of the illegal goods that are being trafficked. One of the key issues concerns the point at which the criminal operation is brought to an end: too soon and the information obtained will be limited; too late and the opportunities to disrupt the delivery and seize the material might be lost. Perhaps the major risk with a controlled delivery, especially in the area of nuclear material trafficking, is that at some stage it could becomes uncontrolled and the transaction with a buyer actually go through. The tradeoff, of course, is between heavier surveillance designed to prevent this, and the possibility that such surveillance will be detected. If an informant or infiltrator is being used as part of the operation, then the danger of discovery would also exist. If the informant is discovered, then there would almost certainly be subsequent action by the traffickers to elude continued surveillance. The risks resulting from a loss of control over the end-game would be minimal in the event that the shipment involves either very little weapons-grade material or large amounts of non-weapons-grade. The difficulty here, however, is that in either case it might not be possible to identify the real buyers, thereby reducing the value of the operation.

2. POSING AS BUYERS

Buyer operations are relatively straightforward in that undercover agents act as potential customers for nuclear materials and can either solicit a specific theft and delivery, or are simply known to be in the market for certain kinds of material already available. The objectives to be reached by posing as a buyer in the nuclear material black market can be: to discover who might be trying to sell nuclear materials; to obtain a better understanding of what material might actually be available for sale; to ensure that a particular diversion of nuclear materials does not end up in the hands of genuine customers and real end-users; and to sow mistrust about buyers and to introduce a greater sense of risk on the part of potential traffickers of nuclear material.

In the final analysis, there is a great deal to be said for posing as buyers or potential buyers of nuclear materials — especially where this results in contacts with those who actually have materials. It is possible that traffickers with materials in their possession might be open to "better offers" than made by their original, or intended customers. As a result, it might be possible to use the buyer cover to ensure arrest and seizure of material irrespective of when it was actually stolen and who it was stolen for. At the very least, buyer operations make it possible to determine the availability of materials that can be used for the development of nuclear weapons, and the kinds of prices that traffickers expect the material to bring.

The key requirement, of course, is to establish credibility as a serious buyer. This requires knowledge about the material, access to adequate funds, a cover story that is credible — either because it is readily verified, or at the very least because it is unverifiable, but highly plausible — and the capacity to generate sufficient trust that those with nuclear material are willing to deal. The danger is that of being an *agent provocateur*, both in relation to an individual deal, and with the market as a whole. There is also the possibility that even if material is stolen to meet a specific request from a definite customer, once the traffickers have the material in their possession, they might decide that they can do better on the open market. The possibility that the traffickers will renege on their commitment to provide the material to the original customer in the hope that they can get a better offer from someone else is a double-edged sword. It is something that undercover operations can exploit under some circumstances, but are vulnerable to under other circumstances. More generally, although black markets depend in large part on trust, they also operate on information and rumor. The other danger with the buyer scenario is that the buyers spark even more interest — and activity — than they really want. One way around this might be to make very clear that the material is urgently needed, and that it already has to have been diverted from a facility. This might actually be a useful strategy given concerns that materials were removed from facilities in the months and years immediately following the collapse of the Soviet Union.

3. POSING AS SELLERS

Undercover operations in which law enforcement or intelligence agents pose as sellers are a means of targeting potential end-users, or in some cases, middlemen acting on behalf of end-users. Seller operations offer an opportunity to derail potential buys, while the possibility of such operations could help to deter some potential buyers. An additional advantage of posing as a seller of illegal nuclear material is that it offers an opportunity to discover whether or not there really are buyers. The standard view has been that genuine buyers have not been evident in the market — perhaps because they would organize their own supply chain rather than leave the acquisition to the operation of the black market, in effect creating a directed network rather than relying on a more random and less controllable transactional network. Undercover operations based on the ostensible possession of a significant cache of weapons-grade material, and including a small sample for testing, might nevertheless succeed in drawing out potential buyers willing to work the nuclear material spot market, especially if dedicated supply chains were not proving as effective as expected.

As with buyer operations, so with sellers, establishing credibility is critical. In the case of sellers, this might require a small sample of material that can be tested for authenticity. If the material is good it is possible that the appetite of the potential buyers will be so whetted that they will become less cautious about their cover and therefore more vulnerable to arrest. A good model for this was the undercover operation arranged by US customs in the mid-1990s in which Dan Supnik, a Customs agent, posed as a weapons dealer and ensnared Iraqi agents seeking to buy bomb-making components. The risks in seller operations are lower than those incurred with controlled deliveries or buyer operations. They include the possibility that the undercover agent will be identified as such and consequently be harmed or killed. Another possibility is that the seller is so plausible that he attracts the attention of those concerned with preventing the buyer from acquiring nuclear materials, and will be killed as part of their prevention strategy. Less serious, but still a distinct possibility is that the seller operation will fail because the real customers will hide behind agents or middlemen of their own, thereby protecting both their own identity and nationality, and knowledge of the final destination of the material.

4. POSING AS MIDDLEMEN

It is also possible to establish a presence in the nuclear material market as a broker, someone who buys and sells materials as they become available, and acts as an important link between those involved in stealing or trafficking and those who might be interested in buying the material. Indeed, this would be an ideal means of obtaining information about the operation of the nuclear material market. To the extent that the broker is well plugged in to trafficking networks, then he is likely to obtain advance notice (i.e. early warning) about the availability of material. It is also possible that a broker might be approached by a potential customer and commissioned to act on the customer's behalf, thereby enabling the customer to minimize the risks of exposure.

Becoming established as middleman in illegal arms trafficking or nuclear material trafficking would almost certainly take time as customers and sellers determine whether the broker is effective and trustworthy. Nevertheless, the more one becomes an established figure in transactional networks, the greater the opportunities for obtaining insights into the trade. To the extent that nuclear material trafficking is accomplished through transactional networks, rather than directed networks, then the broker is in the ideal position. In effect, this approach involves infiltration of the market rather than the infiltration of a criminal organization or trafficking group. An undercover operation centering on a broker would have great possibilities but also incur a complex set of risks that combine those attendant on buying and selling in illegal markets. As a buyer the broker could be out-bid by other players and the material lost. As a seller, an apparently effective broker with material in his possession could easily become a potential target for other countries intent on stopping any deal.

5. USE OF INFORMANTS

Another form of undercover operation is the use of informants. This can involve simply identifying people in nuclear facilities who are willing to provide to law enforcement or intelligence agencies any information they obtain about suspicious activities within the facilities. Alternatively, it can revolve around the tacit defection of a member of a criminal organization or network who, while pretending to remain loyal, informs the authorities of the activities of the organization. For law enforcement and intelligence agencies, informants can provide both strategic and tactical information. This can range from prior warning of a criminal activity such as theft or diversion of nuclear materials, to information about smuggling routes, methods of concealment, crime-corruption networks, and the like.

Informants can greatly facilitate the interdiction process in a specific trafficking incident. Where they provide advance warning of a diversion, there might even be an opportunity to forestall or prevent the theft of the material.

In using informants within criminal organizations, it is important to identify “soft targets” who, for whatever reason, are somewhat disaffected with the organization. It is also important to ensure reliability, and to provide adequate cover for the informant. In some cases, money can be the critical incentive. Nevertheless, there is always a danger of discovery and the loss of the informant at a critical stage. Another danger is that the informant will be discovered and then used by the trafficking group to supply disinformation that sends those trying to monitor or intercept the operation in the wrong direction.

6. INFILTRATION OF CRIMINAL ORGANIZATIONS AND TRAFFICKING NETWORKS

Another important type of undercover operation occurs when a law enforcement agent or intelligence operator manages to infiltrate a group that is either involved in the initial diversion of the material, or that is trafficking the material after the initial theft. Rather than trying to persuade members of a criminal organization to defect, it is also possible to insert undercover operators within a criminal organization. This is a long process, however, especially if the infiltrator is to become a confidant of one or more of the core members of the organization. Nevertheless, when succeeds the payoffs can be huge. An infiltrator with good access to the upper-level decision makers in a criminal organization can provide both tactical and strategic intelligence. The ideal of course is advance warning of forthcoming diversions or trafficking operations. Yet this is not always possible as prior to such an operation security is likely to be tightened up.

Becoming an accepted member of a criminal organization is not easy. One of the scarcest commodities in the criminal world is trust. Consequently, anyone seeking to infiltrate a criminal organization faces inherent suspicion. In addition, it is necessary to prove one’s credentials often by displaying a willingness to engage in criminal, and especially violent, actions. The most obvious risk is that the infiltrator will be discovered and killed. There are also other limitations and potential risks in this kind of operation. While an infiltrator or an informant could provide valuable information about the theft or trafficking process, it is not clear how much access they would have to sensitive information, or to the overall strategy adopted by the group. Moreover, if the thieves or traffickers suspect that information is leaking about their operations, this is something that they could exploit for deception purposes, to lay false trails, or to divert attention from more serious theft or trafficking activities. The possibility that a criminal organization could exploit infiltrators (and informants) is given little attention but is a very real danger.

c. The Historical Record

In considering the undercover operations in the nuclear material black market that have taken place since the end of the Cold War and the demise of the Soviet Union, there are several key questions that need to be asked: (1) Who undertook the undercover operation? (2) Why was the undercover operation initiated? (3) How was the undercover operation undertaken? (4) Who were the smugglers? (5) At what stage in the trafficking process was the undercover operation undertaken? In addition, there are several supplementary questions concerning the purpose of the operations, the agencies or institutions responsible for the undercover operation, the role of the undercover agents and the transactions they were involved in, the countries involved, and the kind of materials seized as a result of the operation. The difficulty, of course, is that because undercover operations are such a sensitive issue, (in terms of protecting those engaged in the operation, maintaining appropriate levels of security about the operations themselves and the desire to avoid political controversy) the details about them are very sparse. Nevertheless, a detailed examination of cases involving undercover operations found in Paul Woessner's Chronology[15] leads to the following observations:

- In all cases the undercover agent or agents posed as buyers. We have identified no cases in which agents posed as sellers and entrapped possible buyers, whether representatives of potential end-user states or terrorist organizations.
- The major countries involved were the Russian Federation, which topped the list with nine cases, Turkey, with eight undercover operations, and Germany, which had six cases. Together these three countries account for over half the undercover operations we identified. There is a second tier of states with more than one undercover operation. This tier consists of Lithuania, which had four such operations, Ukraine with three, Romania with three, and the United States with two undercover operations. Other states with at least one undercover operation in the open literature include Finland, the Czech Republic, Estonia, Kazakhstan, South Africa, Cyprus, Italy, Belgium and Greece. Significantly, there is also an interesting temporal distribution: the German cases all occurred between 1992 and 1994, while the Romanian cases have taken place since 1999. The others were less concentrated into a short period.
- The materials involved (with the number of cases in parentheses) were as follows: uranium (25), plutonium (4), cesium (3), strontium (3), zirconium (2), mercury (2), californium, mustard gas/sarin, osmium, missiles, nuclear waste, cobalt and cadmium/bismuth. All the strontium cases took place in 2000 and 2001, while the others were more evenly distributed. Significantly, six of the last eight cases involved radioactive but not nuclear material (e.g. uranium).
- In the FSU those involved in the undercover operations were either intelligence agencies or the MVD, while in other countries it was almost exclusively law enforcement agencies (e.g. police, Customs, etc.) rather than intelligence agencies that were responsible for the operations. In Lithuania the law enforcement agencies seemed to work in conjunction with the local prosecutor general's office.
- In several cases, the smugglers had been under surveillance for some time, either as a result of tips from informants or because of highly suspicious and visible behavior that attracted the attention of the authorities. In 16 cases, the undercover operations were initiated as part of broader investigations, some of which were investigations into other types of smuggling (e.g. arms, drugs, etc.). These investigations seemed to involve mainly police or MVD rather than intelligence agencies. It is possible, of course, that intelligence agencies are under-represented in the open literature because their activities are less likely to be public knowledge, even when they result in seizures.
- It appears that most of the undercover operations were essentially designed to interdict material. There is little evidence of a controlled delivery designed for knowledge acquisition. Nor does it appear that undercover operators have posed as sellers in order to determine if there are real end-user buyers in the market. There is some evidence of the use of informants, although whether these were directly involved in the operation is unclear.

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[15] Paul N. Woessner, *Chronology of Radioactive and Nuclear Materials Smuggling Incidents: June 1989–April 2001*. This is the most recent version of the Chronology and can be obtained by e-mailing the author at: paul.n.woessner@verizon.net.

- Most of the undercover operations seem to have involved the brokering stage, with the sellers trying to find a buyer and negotiate the sale of the material they had acquired. It is rarely possible to tell whether the "buyers" actually encouraged the initial acquisition of the material, or were simply responding to information that there was material available for sale.

The record is particularly interesting because of the similarities of the undercover operations: there is little diversity and the purpose was almost invariably interdiction. Almost all the undercover operations were case-driven rather than initiated for any broader purpose, such as creating a greater sense of risk in the market, or acquiring fuller knowledge of market dynamics. It is useful, therefore, to identify a fuller range of opportunities for undercover operations in relation to nuclear material trafficking theft and trafficking. This can perhaps best be done by considering the options discussed in relation to the Nuclear Smuggling Pathway Model mentioned above.

d. The Nuclear Smuggling Pathway Model and Undercover Operations

The Nuclear Smuggling Pathway Model (NSPM) developed by James Ford and Richard Schuller disaggregates the process of stealing and trafficking nuclear materials. By breaking each activity down into its constituent components, it helps to highlight points of vulnerability in the security of nuclear facilities and installations that need to be remedied, as well as components of the trafficking process that might be particularly vulnerable to interdiction and arrests. In all cases, the Nuclear Smuggling Pathway Model (NSPM) begins with an identification of those involved — either insiders or outsiders. The insiders could include management (of a facility), technicians, guards, etc. The outsiders could include (former or current) intelligence or law enforcement officers, organized crime, criminal businessmen, etc. Each of these categories of people or groups, either individually, or in combination, might approach the process differently, and this could help to determine the most appropriate form of undercover operation. Even acknowledging such variations, however, the pathway model offers an extremely helpful way to obtain for a more differentiated analysis of the advantages and disadvantages of undercover operations at various stages of the trafficking process.

1. THEFT BY INSIDERS

There are several distinct stages in the pathway model. The first involves the theft within the plant by insiders on their own initiative. To deal with this contingency there are three major options for law enforcement and intelligence agencies: obtain informants, infiltrate the group interested in theft and trafficking of nuclear materials, or pose as potential buyers outside the plant. Law enforcement (or intelligence) agencies would almost certainly need to have a strong suspicion that some kind of criminal operation was underway in a particular facility, however, before they would be willing to commit the resources to undertake such activities. In the event they do, however, they do have several alternatives:

- *Obtain informants inside the facility.* This would have several advantages: it would enable law enforcement or intelligence to observe any potential diversion that is initiated from the inside — and either stop it prior to the removal of the material, or allow it to go ahead to identify potential points of vulnerability in the security of the facility — and then seize the material and arrest the thieves. In effect, this could be regarded not as a controlled delivery — it is too truncated for such a designation — but as a controlled diversion of material that would permit identification of appropriate remedial action to block similar diversions in future.

- *Infiltrate the group.* Another closely related possibility is somehow to infiltrate a group considering theft and diversion of nuclear materials. This would have the same advantages as the use of an informant, would probably make a controlled diversion somewhat safer, and would also make it easier to identify any outsider looking for a supplier. It is more feasible where there is a larger group rather than simply one or two individuals acting alone, although even in this case would depend on the prior establishment of trust.
- *Pose as brokers or buyers.* Having undercover operatives close to nuclear facilities posing as brokers or buyers of stolen nuclear material is a useful insurance policy in the event that there are no informants or successful penetration of a "criminal" group within the facility. It is also useful insurance in the event that the informant, or "mole," fails to identify an impending diversion and it occurs without any foreknowledge or advance warning.

The possibility of an undercover operation (informant or infiltration) within nuclear facilities would add an extra "layer" of risk for those who might be contemplating a diversion of material. If such an undercover operation is to be effective, however, those involved must be completely trustworthy, as otherwise they could be enticed into participating in the diversion themselves. There is also a dilemma here: knowledge of the possibility of informants could act as a deterrent to those contemplating a diversion; but it might simply make them more prudent in how they undertake the theft, and ensure that the group involved is as small as possible. This raises the classic dilemma of law enforcement — when it is effective it can either deter criminals, or encourage them to become more sophisticated and find ways to neutralize the enforcement effort. Criminals can compensate for increased risks with increased efforts to counter risks and develop circumvention strategies. Nevertheless, this might be a price that law enforcement and intelligence agencies would be willing to pay, not least because the other great advantage of undercover operations initiated within facilities is that they test the security of the facility, thereby providing a red team exercise. Such an approach undertaken in a number of installations would facilitate a much better appreciation of weaknesses, highlighting points of vulnerability in each installation that would need to be plugged.

The greatest risk would be that posing as brokers or buyers would provide incentives to people to steal material — thereby encouraging the very activities that law enforcement agencies are trying to prevent or disrupt. Situations in which this risk is warranted could include the following: knowledge of a recent insider theft; or, a need to "flush out" the smugglers when no other leads are available. Probably the lowest risk involves recruitment of informants. This provides a primitive but possibly effective early warning system.

2. OUTSIDER-INITIATED DIVERSIONS

Outsider-initiated diversions are of two kinds. The first is where the outsiders themselves enter a nuclear facility and acquire material that they then bring out. This could be done either through some form of deception, or by "breaking and entering." Because of the dangers involved in both these options, however, it is far more likely that the outsiders will seek to recruit insiders. Consequently, the idea of informants or infiltrators within the facility remains relevant. There are several other areas where informants or infiltrators might also prove important in relation to outsider-initiated diversions: as members of criminal organizations, as employees or officers of criminal-controlled businesses, especially import-export companies, and as members of ex-law enforcement and intelligence networks involved in various kinds of illegal activity. Indeed, having people either inside or outside (or even both) would offer a reasonable probability of obtaining early warning of any trafficking activity. The difficulty is that unless the informant (planted or turned) was directly involved, it might not always be possible to obtain much detailed information.

The local buyer option is also an important one at this early stage and can be considered as an extension of security at the facilities themselves. It will only work, however, where the trafficking group is seeking to divest itself of the material and find a buyer very quickly. For the more sophisticated criminal organization or a criminal-controlled company, there is almost certainly a ready capacity to transfer the material away from the facility. Consequently, the local buyer undercover operation will prove less effective than expected. After the initial theft and diversion, the next stage of the NSPM model in which undercover operations are relevant is the brokering/sale stage.

3. THE BROKERING STAGE

The first requirement in this stage is to identify a broker so that those who initially acquired the material (unless they have a sophisticated trafficking network of their own in place) can move it out of their possession and obtain some financial benefit. The search can be easy if there is some prior contact with a known and trusted broker, or if there is a link through friends or close associates. In the absence of such connections, however, the group with the material has to initiate an open search for a broker or buyer. This provides an opportunity for undercover operatives posing as buyers to set up a deal and subsequently to arrest those involved and to seize the material. Whether they are able to do so, of course, will depend on their credibility. The criminals are likely to be inherently suspicious, and will want to check the broker's record, reputation, and validity before closing the sale. This will be less likely if the initial theft and diversion has been discovered, and there is a law enforcement search for both the material and the perpetrators. In these circumstances, possession of the material could very quickly come to be seen as a liability and those with it are likely to want to get rid of it as rapidly as possible, without worrying too much about the credentials of the buyer.

If the diversion remains undiscovered, then the criminals are likely to be much more careful and take longer in both checking the broker, and negotiating a sale. Indeed, the sale might involve the provision of a sample of material (if desired) to establish its authenticity, as well as a small advance payment. Assuming all this goes well, the material will be removed from its interim storage and transported to the rendezvous site. If the undercover operation has been successful up to this point, then this is where the seizure and arrests are likely to occur. Yet there is also another possibility here — that the undercover operatives now in possession of the material consummate the sale, then act as sellers, and try to locate a buyer.

4. THE SALE TO CUSTOMER AND DELIVERY STAGE

This is the kind of operation that, in the domain of nuclear material trafficking does not appear to have been tried — at least if the public record is anything to go by. Yet it offers enormous opportunities for the acquisition of information about the market and for creating risk for potential end-users who might be tempted to acquire the materials. There are several things that an undercover operation in this stage of the process would help to discover:

- Whether or not there are real buyers seeking access to stolen nuclear material.
- The kind of price that a potential buyer would be willing to pay.
- The favored location for delivery of the material.
- The ease or difficulty of trafficking the material across borders and through or around customs checks.
- The effectiveness of customs posts in detecting material.
- The kind of documentation that is (a) necessary and (b) effective to move stolen nuclear material successfully across national borders.
- The kind of payment arrangements that the customers are able and willing to make, and whether or not they are willing to provide some funding in advance of final delivery.

In effect, posing as broker makes it possible to continue the trafficking process through to the sale — at which point buyers are arrested and the material retained. It provides an excellent way of identifying vulnerabilities in anti-trafficking efforts as well as the vulnerabilities of the traffickers themselves. It also makes it possible to accomplish the equivalent of controlled deliveries without the risks normally attendant on such an approach. Controlled delivery is much safer when control is maintained directly rather than through monitoring or observation with the attendant risk of detection and/or losing the traffickers under surveillance.

In sum, the historical record suggests that undercover operations have been limited in both purpose and scope: they have been almost exclusively buyer operations done in an effort to interdict stolen nuclear materials and arrest traffickers. As a result, they might — as a secondary effect — have created a sense that the market for stolen nuclear materials is a risky one and that the potential risks outweigh the potential profits. Any inhibiting or deterrent effect, however, has been simply a collateral benefit rather than something that law enforcement and intelligence agencies deliberately sought to achieve. Even more obviously, there has been a dearth of both controlled deliveries and seller operations. The irony is that successful undercover operations at the buyer stage really prepare the way for continued operations at the seller stage and the use of what might be described as a particularly controlled form of controlled deliveries. Such an approach would have to be handled with considerable caution given the nature of the materials, but could result in significant payoffs in terms of both the knowledge that would be obtained and the potential deterrent effect on possible end-users. In other words, it is necessary to develop a coherent and comprehensive strategy for undercover operations rather than simply doing more of the same. Undercover operations are an invaluable tool in combating the illegal trade in nuclear materials, but need to be used more extensively, more imaginatively, and more comprehensively than they have in the past. Buyer operations alone are not enough. What makes a new approach all the more critical is the adaptability that nuclear material traffickers have displayed in moving from western to southern routes and the central but under-estimated role played by organized crime. Both considerations make more extensive undercover operations an imperative that governments and international agencies ignore at their peril.

QUESTIONS AND ANSWERS

I. Ray (EC): What is the intended market for smuggled nuclear materials trafficked via organized crime? The cases we have investigated involved material that was of no use for scientific or weapons purposes. Moreover, I consider that only 5–10% of cases come to light.

P. Williams (USA): Those cases that haven't come to light probably involve end-user organized supply chains. We would need "seller" undercover operations to identify a potential market.

N. Kravchenko (Russian Federation): Did your group analyse the threat of smuggling during legal movement, i.e. import-export, of NM? What is the level of the threat?

P. Williams: There have been some cases, particularly in the early 1990s, of import-export companies being involved in nuclear material trafficking. Their visibility, however, seems to have declined. This might reflect greater sophistication and thus greater difficulty of detection.

F. Steinhäusler (Austria): In the former Soviet Union, production managers allegedly established secret "honeypots" of surplus nuclear material, unreported to the authorities, which could be used later if production fell short of the target. If this is true, what would be the significance regarding uncertainty about the amount of NM involved in illicit trafficking?

P. Williams: These reports are persuasive. The existence of NM unaccounted for in inventories implies: a) additional opportunities for trafficking; b) greater complexity in efforts to combat trafficking as there are no immediate signs of diversion; c) the possibility of weapons grade material being trafficked.

K. Hirano (Japan): Referring to the keyword "network", I would like to know if a breakdown into categories exists of the 150–200 cases of trafficking in NM involving organized crime. You defined them as ranging from amateur to highly sophisticated.

P. Williams: Such an analysis does not exist at this stage. Having cross-referenced to some extent with Monterey, I would find it useful to look at the IAEA database to identify the types of organized crime involved in the relevant incidents.

THE WORLD CUSTOMS ORGANIZATION'S PARTNERSHIP CONCEPT

E. SAKA
World Customs Organization, Brussels

Presented by D. Smith

Abstract. The World Customs Organization (WCO)[1] is an independent intergovernmental body with world-wide membership (153 Members, as of 1 April 2001) whose mission is to enhance the effectiveness and efficiency of Customs services in the areas of compliance with trade regulations, protection of society, the environment and revenue collection, thereby contributing to the economic and social well-being of nations. The internationally accepted best strategy for effectively combating illicit trafficking in nuclear and other radioactive materials is to stop their illegal movement at the national border before entering or leaving the country**.** From this point, Customs services are identified one of the unique governmental cross-border control agencies due to their basic advantages. There is no doubt that illicit trafficking in nuclear and other radioactive materials is recognized as a new enforcement phenomenon.In fact, significant investments in terms of money and human resources have been made at all levels since the1990s. In general terms, law enforcement actions to prevent and detect illicit trafficking of these materials always start with information or intelligence received and ends by bringing these illicitly trafficked materials under the necessary control. However, this effort clearly requires a comprehensive and co-ordinated national action plan and the inclusion of inputs from the relevant national agencies such as Customs, police, the competent nuclear authority as well as the relevant industry. These efforts also require each relevant national institution to develop its own action plan in compliance with the national action plan and to review it on a permanent basis. For the Customs community, the challenge is not limited to the prevention and detection of these materials. It has been noted that international movements of contaminated scrap and other materials also have to be stopped at national borders. In addition, the need for safety measures for Customs inspectors and the lack of internationally accepted investigation standards, even between neighbouring countries, is increasing the scale of the problem. Within the law enforcement community, we bear witnesses to close co-operation between Customs, police and regulatory bodies and common understanding which is greatly supported by the relevant international organizations, namely the IAEA, WCO and ICPO/INTERPOL. In line with its mission, the WCO secretariat has already developed an enforcement programme to respond to this important enforcement topic and has developed a partnership concept at international level, not only to harmonize but also maximize limited resources by signing a Memorandum of Understanding (MOU) with the relevant international organizations such as IAEA and ICPO/Interpol. This partnership concept also implies solidarity and standing shoulder to shoulder with the relevant institutions and assisting the Customs community to cope with this problem through the inclusion of the partners' technical input in our current programme. The Customs community is, without any doubt, aware of its potential role in preventing and detecting this non-financial crime and has always been ready to take part in any partnership initiatives at all levels.

1. INTRODUCTION

The objective of this paper is to brief the international community on the reasons why Customs services must participate in the fight against radioactive materials smuggling and devise the WCO's partnership concept at international level.

2. NEED FOR INTERNATIONAL PARTNERSHIP

There is no doubt that the desire and discussion over the need for close co-operation among international organizations have always been an integral part of many international meetings,

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[1] In June 1994, the Council adopted the working name "World Customs Organization (WCO)" for the Customs Co-operation Council, to reflect more clearly the nature of the Organization and its international functions. The Convention establishing the Organization was not amended, so the official name is still "Customs Co-operation Council".

in addition to regional and national meetings. Although there have been significant developments and success in this field, it has been recognized that there is still room for improvement.

The need for close co-operation among the relevant international organizations becomes almost an obligation when the aim is to effectively combat transnational organized crime. This discussion leads us to an examination of the basic reasons for this vital requirement.

2.1. LEGAL FRAMEWORK

Each international organization is usually set up by a special convention which underlines the scope of its competence. It is almost impossible to act beyond legal borders and it becomes a necessity for the international organization to approach the relevant international institution to ensure the optimal implementation of its convention or to respond to its Members' requests comprehensively.

2.2. EXPERTISE AND HUMAN RESOURCES

The accumulated experience, availability and quality of human resources are other significant elements for international organizations to consider when seeking partners in order to properly deal with the subject being tackled. This need will be greater if we consider insufficient financial sources as another element in this respect.

2.3. EFFORTS TO AVOID DUPLICATION OF WORK

There is considerable concern about the activities conducted by each international organization and a fear of duplication of work in the same field. This has always been emphasized by Member States and has required international organizations to take the necessary action to minimize any potential risk of duplication of work or projects in the same domain.

2.4. TECHNICAL POSSIBILITIES AND RESOURCES

International organizations are also invited to look for potential partners to launch joint projects or to enquire as to the possibility of use each other's technical resources for their own purposes. This effort will undoubtedly assist the international community as well as Member states to make considerable savings in terms of time, money and human resources. Regional training centres, training courses, communication channels and databases are seen as best examples in this respect.

2.5. SPECIFICATION OF THE SUBJECT ADDRESSED

We are also aware that the scope or characteristics of the subject addressed require international organizations to work together and develop a partnership concept. This becomes a requirement if we wish to obtain the best outcome. While combating organized crime at all levels. Combating drugs and radioactive materials smuggling could be given as best examples.

We naturally note that the partnership between international organizations will be subject to legal, administrative and operational limitations and conditions, as well as the principles established by their decision-making bodies.

However, it is reassuring to highlight that the desire for further or close co-operation among the existing international organizations is well recognized by the international community and concrete steps have already been taken in many fields.

3. POTENTIAL ELEMENTS OF INTERNATIONAL PARTNERSHIP

The following elements are listed as a potential fields or elements of any partnership between international organizations.

3.1. IDENTIFICATION AND HARMONIZATION OF POLICIES

In relation to (i) awareness- raising (ii) prevention (iii) detection and (iv) response.

3.2. DERIVING MAXIMUM BENEFITS FROM LIMITED SOURCES

In terms of (i) funding (ii) human resources and (iii) technical equipment.

3.3. POSSIBILITIES FOR SHARING PRACTICAL EXPERIENCE

In the field of (i) data collection exchanges and analyses (ii) instruments for sharing practical experience and (iii) identifying and removing barriers to co-operation.

3.4. PROMOTING AND EFFECTIVELY IMPLEMENTING CURRENT INTERNATIONAL LEGAL INSTRUMENTS

Through (i) modular legislation (ii) modular action plan and (iii) joint help desk.

3.5. IDENTIFYING COMMON FUTURE STRATEGIES

Including (i) periodically reviewing process (ii) training programmes (ii) training materials and (iv) information collection.

4. REASONS FOR CUSTOMS SERVICES' INVOLVEMENT IN COMBATING RADIOACTIVE MATERIAL SMUGGLING

The task of Customs services throughout the world is categorized as (i) revenue raising (ii) facilitation of international trade and (iii) protection of society and the environment. The two last tasks are non-fiscal functions and require Customs services to strike a balance between facilitation and an effective control mechanism, achieved through the application of risk assessment, profiling, targeting techniques.

The scope of Customs' role in protection of society may vary from country to country and over time, but this important role has been recognized as an integral of traditional Customs business. In its capacity as a governmental cross-border control agency, Customs is still expected to play a key role in preventing and detecting illicit cross-border movements of goods before they leave or enter the country. This role falls in the category of "protection of society" and it ranges from combating drug smuggling to prevention of illicit trafficking in nuclear and other radioactive materials.

In addition to this legal and practical reality, Customs officials, particularly Customs inspectors, must have basic knowledge on how to safely handle expected and suspect consignments and hazardous or dangerous materials.

We will now examine the ***legal, administrative and technical advantages of Customs services:***

4.1. LOCATION OF CUSTOMS OFFICES

Customs services are mostly located at national border check points, such as airports, seaports, etc. This physical position enables Customs to stop illicit cross-border movements of radioactive materials before they leave or enter the national territory.

4.2. CAPABILITY OF MONITORING INTERNATIONAL TRADE

Customs administrations have all the relevant documents and data on national and foreign trade in terms of value, quantity, passengers, exporters, importers, means of transportation, goods and trends in foreign trade. This helps Customs administrations work proactively to increase their detection capacity when combating criminal activities.

4.3. AUTHORITY TO CONDUCT PHYSICAL INSPECTIONS

Customs services are furnished with the legal power to conduct physical inspections and searches of goods, vehicle and passengers entering or leaving the country. This is the minimum power of Customs services. Only physical inspections and monitoring can lead to the discovery of smuggled goods, including illicit trafficking in nuclear and other radioactive materials.

4.4. SEIZURE AND PRELIMINARY INVESTIGATION POWERS

Customs services are usually authorized to detect and seize illicit trafficking in goods and conduct at least preliminary investigations into smuggling or attempts to smuggle goods. Through this function, Customs has gained enormous experience and knowledge on investigation techniques, as well as establishing an internal and external contact points network for collecting information and intelligence.

4.5. EXPERIENCE IN DEALING WITH CRIME AND CRIMINALS

As a natural result of being a government border control agencies, Customs is accordingly obliged to stop all kind of cross-border offences. This provides them with a great experience on crime and criminals, such as frequently smuggled goods, key nationalities involved, routes taken, concealment methods used, etc.

4.6. WORLD-WIDE EXCHANGE OF INFORMATION AND INTELLIGENCE NETWORK

With the WCO's guidance, most Customs administrations throughout the world are now able to exchange information and intelligence globally on Customs offences, including radioactive material smuggling. This is usually done via the electronic network created by the WCO Secretariat called the Regional Intelligence and Liaison Offices (RILO) project, the Customs Enforcement Network (CEN) and the WCO Members Web site.

In addition to this technical support, the WCO Secretariat has also developed administrative and legal instruments as a legal or administrative basis for better information and intelligence exchange among Customs services. These instruments are model bilateral agreements, model memoranda of understanding (MOUs), recommendations, resolutions and the International Convention on Mutual Administrative Assistance for the Prevention, Investigation and Repression of Customs Offences (known as the Nairobi Convention).

4.7. AWARENESS-RAISING AND TRAINING

In line with the availability of human resources and funding, Customs services are continuously being supported by the WCO through training courses or the production of training materials. As part of this concept, most Customs administrations are either holding their own awareness-raising/training programmes or participating in relevant seminars or courses. This has also resulted in the deployment of the necessary detection equipment by certain Customs services.

4.8. USE OF RISK ASSESSMENT TECHNIQUES

Customs services are advised and encouraged to use targeting and the selectivity approach through risk assessment techniques enabling them to asses the probability of goods passing through Customs controls not being legally entered or declared. This technique is enabling Customs services to maximize the optimal use of limited resources to detect any kind of fraud including nuclear and other radioactive material smuggling.

5. THE WCO ENFORCEMENT PROGRAMME ON COMBATING RADIOACTIVE MATERIALS SMUGGLING

As a response to the international concern and in Member administrations' interest, the WCO Secretariat launched a special enforcement programme in 1993 in the field of radioactive material smuggling.

The objective of this programme is to assist Member administrations enhance their enforcement capabilities for preventing, detecting and responding to illicit trafficking in nuclear and other radioactive materials. This programme is basically intended to provide the necessary awareness background to ensure that nuclear and other radioactive materials are securely monitored and controlled so that their illicit trafficking is repressed and that processes and procedures are in place to detect and respond to any attempted illicit trafficking.

In order to attain this overall objective, the WCO enforcement programme consists of the following elements and developments in each area.

- increasing awareness.
- developing training materials.
- designing training programmes.
- exchanging information and developing a database.
- international co-operation.

5.1. AWARENESS-RAISING ACTIVITIES

The WCO's awareness-raising activities could be summarized as follows.

- The First Seminar on Dangerous and Toxic Products was held in Brussels on 14 and 15 March 1994.
- The Second Seminar on Nuclear Materials, organized by the US Customs service in collaboration with the United States DOE, held in Brussels on 31 May 1995.
- The First Working Group on the Identification of Nuclear Materials and Dangerous Goods, held in Brussels on 1 and 2 June 1995.
- Adoption of a WCO Recommendation concerning Action Against Illicit Cross-Border Movement of Nuclear and Hazardous Material (including their waste), adopted by France (March 1998), Sweden (January 1998) and Finland (May 1998).
- Issuing of a progress report on WCO Awareness and Training Programme on Nuclear and Hazardous Material (June 1996).
- The First IAEA/WCO Technical Committee Meeting, held in Vienna (Austria) from 8 to 12 July 1996.
- The Second IAEA/WCO Technical Committee Meeting held in Vienna (Austria) from 14 to 18 July 1997.
- The Third IAEA/WCO Technical Committee Meeting held in Vienna (Austria) from 6 to 10 July 1998.
- The fourth IAEA/WCO Technical Committee Meeting held in Brussels (Belgium) from 7 to9 July 1999.
- The fifth IAEA/WCO Technical Committee Meeting held in Vienna (Austria) from 30 October to 3 November 2000.

5.2. TRAINING MATERIALS

At the request of its Members, the WCO recently developed a very comprehensive Customs Enforcement Training Module on smuggling nuclear and other radioactive materials. This training module provides guidelines for Customs trainers to develop their own national training programmes.

This module was prepared in close co-operation with the IAEA and special contributions were made by certain Member countries. In particular, it was possible to combine the IAEA/WCO Joint training course experience and the knowledge of the Customs enforcement experts who met at the first and second expert group meetings held in Brussels in 1995 and 1996.

5.3. TRAINING PROGRAMMES

In keeping with our Members' requests, the WCO Secretariat has given priority to designing training programmes for Customs at regional level in order to improve their enforcement structures and national measures. However, this activity is seen an integral part of the WCO/IAEA technical co-operation and partnership concept.

Top priority is given to the Eastern and Central Europe region in the framework of partnership concept. The joint training courses have covered Customs, police and the relevant nuclear authorities and have been conducted through the co-sponsorship of the IAEA, WCO, ICPO/INTERPOL and the EC.

The following joint regional training courses have been conducted up to 2001:

- "Train-the-trainer" course held in Vienna (Austria) from 2 to 6 June 1997.
- Awareness Training course for field officers held in Vienna from 28 September to 2 October 1998.
- Awareness-raising training course for field officers held in Vienna from 13to 17 September 1999.
- Awareness-raising training course for field officers from Mediterranean Countries held in Malta from 8 to12 November 1999.
- Awareness-raising training course for field officers held in Vienna from 26 to 30 June 2000.
- Awareness-raising training course for field officers held in Vienna from 4 to 8 September 2000.

5.4. INFORMATION EXCHANGE AND DATABASE DEVELOPMENT

One of the principal elements of effective global preventive efforts concerning the illicit cross-border movement of nuclear materials is timely, comprehensive and rapid exchange of information and intelligence.

With a view to assisting its Members, the WCO Secretariat has developed a separate database for nuclear and radioactive material smuggling at WCO Headquarters with the support of Members and the relevant international organizations.

The basic aim of this database is to enable Customs services to carry out their own information analyses and produce strategic, operational and tactical intelligence for their own needs, such as regional and international trends, modus operandi employed by smugglers, commonly used routes, etc.

Regular seizure data exchange between the IAEA and the WCO deserves special mention as part of this concept. The specifications of this database can be summarized as follows:

- Accessible to Customs services through the WCO's electronic information exchange network (RILO and CEN).
- Information gathered from Members, international organizations and open sources (unconfirmed cases).
- Protected with double password.

5.5. INTERNATIONAL CO-OPERATION — "PARTNERSHIP CONCEPT"

One of the pillars of the WCO's programme is to co-operate with international organizations and relevant non-governmental organizations as well as business associations to effectively implement its programmes and to ensure the broadest communication channels for timely and accurate information exchange in the best interests of Member administrations.

The following list clearly shows the WCO's partners in different areas. This partnership is established through signing Memoranda of Understanding.

The international Air Cargo Association	*TIACA*	*10 July 2000*
The International Centre For Migration Policy Development	*ICMPD*	*21 May 1999*
The International Criminal Police Organization	*INTERPOL*	*9 November 1998*
The Caribbean Customs Law Enforcement Council	*(CCLEC)*	*18 November 1997*
The United Nations Drug Control Programme	*(UNDCP*	*6 November 1996*
International Drug Control Board	*INCB*	*6 November 1996*
International Chamber of Commerce	*ICC*	*19 June 1996*
The International Federation of International Movers	*(FIDI)*	*10 October 1995*
The International Banking Security Association	*(IBSA)*	*25 April 1995*
The Federation of European Movers Associations	*(FEDEMAC)*	*9 January 1995*
The International Chamber of Commerce Commercial Crime Services	*(ICC CCS)*	*9 January 1995*
The Universal Postal Union	*(UPU)*	*15 September 1994*
The International Council of Chemical Industry Associations	*(ICCA)*	*11 March 1994*
The Federation of National Associations of Ship Brokers and Agents	*(FONASBA)*	*22 November 1993*
The International Federation of Customs Brokers Associations	*(IFCBA)*	*7 July 1993*
The Baltic and International Maritime Council	*(BIMCO)*	*22 June 1992*
The Airport Association Council International	*(AACI)*	*13 August 1990*
The International Road Transport Union	*(IRU)*	*17 August 1989*
The International Express Carrier Conference	*(IECC)*	*21 October 1987* *13 December 2000*
The International Federation of Freight Forwarders Associations	*(FIATA)*	*September 1987* *22 September 1998*
The International Association of Ports and Harbours	*(IAPH)*	*21 August 1987*
The International Air Transport Association	*(IATA)*	*23 June 1986*
The International Chamber of Shipping	*(ICS)*	*5 December 1985*
World Health Organization	*WHO*	*Under discussion*

6. THE WCO–IAEA PARTNERSHIP

Co-operation between the WCO and the International Atomic Energy Agency (IAEA) deserves specific mention due to the progress made in the implementation of the MOU signed in 1998.

- **Joint Technical Committee Meetings:** The IAEA and WCO have conducted annual Joint Technical Committee meetings since 1996. The basic aim is to bring together nuclear and Customs experts from the countries where most nuclear and other radioactive materials are seized, in order to review the action taken, share practical experience and discuss future steps to be taken to effectively combat radioactive material smuggling.
- **Attending Technical Meetings**: Both organizations are making every effort to attend each other’s technical meetings, ranging from expert to interagency meetings.

COMBATING CUSTOMS OFFENCES IN PIRATED & COUNTERFEIT GOODS

Bureau international des sociétés gérant les droits d'enregistrement et de reproduction mécanique	*(BIEM)*	*12 February 1997*
The Motion Picture Association of America and Motion Picture Association	*(MPA)*	*27 August 1997*
The International Federation of the Phonographic Industry	*(IFPI)*	*8 June 1988*
The Business Software Alliance	*BSA*	*4 July 2000*

COMBATING CUSTOMS OFFENCES IN THE ENVIRONMENTAL PROTECTION FIELD

Secretariat for the Convention on international trade in endangered species of wild fauna and flora CITES)	*(CITES)*	*4 July 1996*
Secretariat of the Basel Convention	(SBC)	17 November 1997
The International Atomic Energy Agency	**IAEA**	**13 May 1998**
The International Council of Museums	*ICOM*	25 January 2000
United Nations Educational, Scientific and Cultural Organization	*UNESCO*	26 October 2000
The Organization for Prohibition of Chemical Weapons	OPCW	Under discussion

- **Co-sponsorship for international conferences**: the WCO has decided to be one of the co-sponsors of the IAEA International Conference in France and Sweden.
- **Support for training publications and technical documents:** The IAEA and the WCO have also agreed to provide the necessary technical support to the work concerning the production of training awareness materials.
- **Exchange of information on radioactive materials seizures:** The IAEA has agreed to send the seizure information data to the WCO secretariat case by case and on an quarterly basis.
- **Joint Regional Training Courses:** the IAEA and the WCO has agreed to conduct jointregional training courses and, where necessary, to hold national training courses (see se

7. RESULT

Preventing and detecting illegal movements of nuclear and other radioactive materials being illicitly trafficked at national borders before they enter or leave the country is always interpreted not only as protecting a country's own citizens, but also protection our global society.

It is therefore widely accepted that Customs Services around the world have a role to play in preventing and detecting these illicitly trafficked materials through their clearly identified legal, administrative and operational advantages.

This role can be maximised through a national, regional and international partnership concept in which the WCO express its readiness to share its practical experience in the "partnership " field. At the same time, the WCO Secretariat stresses that the Customs community is always encouraged to implement this concept at national level by using the instruments developed by the WCO secretariat that are currently available.

QUESTIONS AND ANSWERS

A. Nilsson (IAEA): According to earlier presentations, the involvement of organized crime in illicit trafficking seemed to be decreasing. Could you comment on that?

D. Smith (USA): It is hard to say whether a perceived decline in organized crime-sponsored smuggling of NM is real or due to data anomalies.

OPEN SOURCE INFORMATION

J. SJÖBERG
Swedish Armed Forces HQ, Stockholm, Sweden

Abstract. The purpose of my presentation is to provide some thoughts on Open Sources and how Open Sources can be used as tools for detecting illicit trafficking and proliferation. To fulfill this purpose I would like to deal with the following points during my presentation:
-What is Open Source?
-How can it be defined?

- Different sources
- Methods

Open Source information can be defined as publicly available information as well as other unclassified information that has limited public distribution or access to it. It comes in print, electronic or oral form. It can be found distributed either to the mass public by print- or electronic media or to a much more limited customer base like companies, experts or specialists of some kind including the so called gray literature. Open Source information is not a single source but a multi-source. Thus, you can say that Open Sources does not say anything about the information itself, it only refers to if the information is classified or not.

Open Source information is the use of coordinated methods:

- The discovery of sources.
- The monitoring of sources.
- Collection of open data and information.
- The structuring of retrieved information.
- The communication process with and dissemination of information to the end users.

During the existence of the "Iron-Curtain" and the "Berlin-Wall" the access to and use of Open Sources was rare. Of decisive importance was the question of military and political early warning between the east and the west and different channels to obtain information about the adversary was more or less institutionalized. In a way, the world was more predictable compared with the world today and hence the need to use Open Source information must be regarded as very limited and restricted. Thus, the end of the so-called "Cold World Era" did to a certain extent contribute to the progress of Open Source information as an intelligence source.

The revolution, or more correctly the evolution, in information technology, has made it possible to get quick and global access no matter where you are and no matter where the threat emerges. The Internet with its World Wide Web has made Open Source Information accessible to the public. The World Wide Web made it possible to easily retrieve and to share information without having any special computer skills. Complex databases that were difficult to access were suddenly easy to use for almost everyone. Thus, during the last ten years an increasing bulk of information has been possible to obtain through overt channels.
Open Sources also enables you to get information quickly to a low cost. Even though you actually need to buy the information, which you will need in most cases, it is still a cost-effective opportunity to obtain necessary information at the right time, especially if you compare it with covert sources.

Another reason for using Open Source information is the fact that it provides unclassified intelligence or lower classifications. In many areas classified intelligence capabilities are either not available, or the information cannot be shared. Information sharing both within your organization but also outside your organization, increases your efficiency and enables cooperation with parties that you cannot share classified information with for different reasons.

New threats have emerged, and some threats that had existed for a long time have been upgraded and have received a higher priority. Asymmetrical warfare, terrorism, organized crime, migration, drug dealing, environmental damage, and the reason for why this conference is taking place proliferation and illicit trafficking, demands new and improved methods to get the necessary information. Those threats demand new ways of thinking. Traditional intelligence does not always incorporate civil and political information. Open Sources do.

As mentioned earlier, Open Sources are cost-efficient. Don't send a spy when you can send a schoolboy.

Open Sources are not a substitute for classified capabilities. Confidential information in all its shapes is still in many cases of a profound importance. However, Open Sources can, and should, be used to corroborate/confirm, refute and deny, i.e. to be used as a sanity-check. It could also be the other way around. Information that comes to your intention through Open Source information could be an early warning sign that bring about a full investigation. It can also enhance and be a supplement to information already known before. A narrow range of classified sources may mislead the analyst into accepting a narrow interpretation of events. Using different sources decreases the risk for misunderstandings.

Last but not least, decision-makers that are dependent on people's opinions react primary on Open Source information. The debate is mostly held in media and most decision makers use media as a way to communicate with the public but also with other parties, national and international.

Open Sources are all non-classified sources and hence it would be impossible and pointless to try to give an extensive overview of all sources included. However, there are some categories that are worth mentioning. The first group are think tanks and other kind of research establishments. In most cases the information that they provide is of an analytical nature and mostly cost free. Most of them also have links to other sites with related information. Federation of American Scientists, SIPRI, Center for Non-proliferation Studies at the Monterey Institute and Nuclear Control Institute in Washington are some examples.

The second group consists of images, maps and web cameras. Open Source images can be divided into two sub categories. The first group is real time images from commercial satellites. These are associated with very high costs, but on the other hand you can get high-resolution images quick. Worth mentioning is that it is more difficult to get images over the so-called 'third world'. One of the providers is Space Imaging. The second sub category is images that are free. These have in most cases poorer resolution and are not real time images.

There are several thousand of maps available for free and they cover all kinds of areas: historical; country; regional; weather; topographic etc.

Web cameras can also be useful. However, the can be tricky to find and there is always a risk of disinformation.

The third group consists of media and it covers everything from a particular newspaper to huge databases such as Reuters Business Briefing and Lexis Nexis. Most newspapers are possible to read without a fee but accesses to databases are in most cases associated with a high cost.

The next group of Open Sources are Governments and International governmental organisation and Nongovernmental organisation. Valuable information could be press releases and reports. This information is generally free.

The fifth group comprises of the so-called grey literature, i.e. conference papers, research reports, internal reports, preprints and working papers are non-commercial sources. Although hard to find, they are in most times very valuable sources of information.

And finally, there are a lot of sites on the Internet that covers a special interest group such as different 'liberation Movement'. Today almost every obscure group has their own website.

However, the cheapest way to get relevant information is to ask the person who knows. Internal knowledge networks can save your organisation a lot of money.

The first question you must ask yourself before you start searching for information on the Internet is if you should surf or trawl. The difference between trawling and surfing is if you know what you are looking for and your search is meant to catch the fish or if you with your search just want to see what kind of fish the sea contains.

The Internet contains billions of WebPages and there are mostly no substantive editorial quality control, meta-tags, independent reviews, or other forms of value-added discrimination. Furthermore, most of these WebPages are not properly indexed in some sort of universal directory. There are approximately 2.1 billion online WebPages and 7 more million pages are added every day. There are at least 330 million Internet users today and the risk for information overload is high. Besides Internet, there are also thousands of online, i.e. Internet based, databases for example Reuters, that produces approx 70 000 articles each day (60 mil in archive) and Dialog that has 9 TB of information in 600 databases.

The reason why I'm mentioning all this statistics is for you to understand how enormous the Internet is and especially how important it is to use the right tools to search for information.

The questions that follow is what kind of tools can you use?

The first and maybe the most common tool are *Search engines*. They create their listings automatically, crawl the web, and then people search through what they have found. So you are not actually searching the Internet. Size of the database, frequency of update, search capability and design and speed may lead to amazingly different results. Search engines are in most cases very simple tools with less precision. No one has indexed more than 50–60 per cent of all WebPages.

Meta-search engines, contains a central place with a uniform interface, where a query can be entered and the search can be conducted simultaneously in as many search engines and directories as necessary, and search results can be brought back and displayed in a consistent format.

There are also four other groups of tools:
Subject directories are often called subject "trees" because they start with a few main categories and then branch out into subcategories, topics, and subtopics. Because humans organize the websites in subject directories, you can often find a good starting point if your topic is included.

Subject guides is similar to a Subject directory but with links only. Specialized Databases are portals from where you can access different sub categories, which are made up of specialized databases, and finally, the last tool is Virtual Reference Libraries, consisting of a compilation of links.

The best way is to try different tools and then chose two, three that suits your needs best.

Even though Internet is said to be global, there are certain geographical limitations. Of all the millions of Internet users in the world almost 45 per cent makes up of US based users, followed by Europe's 27 per cent and Asia/Pacific on 22 per cent. This means that Africa, Middle East and South America only account for altogether 7 per cent of all Internet users. In the Russian Federation there is approximately 3–6 million Internet users, i.e. between 1 and 2 per cent of all users. These figures indicate that, most likely, Internet today is for the western countries and contains the information the western user request.

Furthermore, of all billions of WebPages on the Internet, 75 per cent are in English. The fastest growing Internet language is Chinese. Spanish is expected to grow with 550 per cent in three years.

Information in relation to intelligence is in most cases not validated. The information needs to be corroborated and confirmed before used as facts. To facilitate the sanity check process primary sources should, if possible, be used, with the ambition to be as closed to the event as possible. Information presented in a local Swedish newspaper about an event in Moldova might be third or fourth hand information. The risk is hence apparent that the information has been distorted on its way to the end source.

There are several different analytical tools for visualizing search patterns and different kinds of information mapping. Diagrams made in the Analyst Handbook can for example show associations between people and transactions. What seem to be hidden relationships suddenly appear clear. When working with a lot of information the problem facing the analyst is not the shortage of information but understanding what that information means.

QUESTIONS AND ANSWERS

J. Fechner (Germany): Who specifies the criteria determining what should be searched for in the various open sources and who evaluates the findings of the search — are they specialists or generalists?

J. Sjöberg (Sweden): Short and long term intelligence requirements determine the search targets. The open source collection function is separate from the assessment department but it is important that also those collecting information have good knowedge of the fields to be investigated and that there is efficient communication between collectors and evaluators.

S. Fernandez Moreno (Argentina): Reliability of open sources is a key issue. Do you use stringent validation criteria to filter open sources that could trigger further investigation?

J. Sjöberg: By definition, open source information is not validated. We do have search criteria and regard the collectors' knowledge in the field, and good co-operation between collectors and assessors, to be of fundamental importance.

V. Lapshyn (Ukraine): Who uses this information besides facility operators? Is there a database used for other purposes?

J. Sjöberg: One of the main ways of disseminating the information is through internal databases within the Swedish armed forces.

RUSSIAN SPENT MARINE FUEL AS A GLOBAL SECURITY RISK

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Abstract. In this paper, we have examined the proliferation component of the overall security risk. The results indicate that several types of spent marine fuel represent an important risk of proliferation of nuclear material. Most concern is associated with spent fuel with very high initial enrichment (80–90%) with low or moderate burn up. A reactor core with initial 90% enriched fuel burned to 40000 MW(d) and initial 150 kg. U-235 still contain 100 kg U-235 80% enriched. This amount of highly fissionable material is probably sufficient for several nuclear devices. Secondly, one have to consider closely the amount and quality of plutonium in low-burn-up marine spent fuel with low initial enrichment of U-235, below 30%, and long cooling times. Calculations show that the amount of Cs-137 decides the level of self-protectiveness of the spent fuel. As a starting point, none of these types of spent fuel might be considered self-protected, however, this has to be calculated in each case. Poor engineered and institutional safeguards in the present Russian Federation make these fuel types an international security threat demanding international attention and cooperation to curb and control.

1. INTRODUCTION

This paper discusses the security risks associated with Russian spent marine fuel. Intrinsic properties such as quantities, potential quality for weapons purposes and self-protectiveness of the fissile material are calculated on the basis of a suggested, generic model of a Russian marine reactor. In the final conclusions we suggest a ranking of the proliferation risk associated with the different types of spent fuel.

2. BACKGROUND

Considerable efforts have been made to consolidate of fresh marine fuel and implement sustainable material protection, control and accountancy (MPC & A) solutions for Russian facilities containing fresh marine fuel. However, the security risk of Russian marine spent fuel has not been considered important, neither of the Russian government nor its international partners. Early efforts to point out the security dimensions of the fissile material in spent fuel were presented in 1997, [6] later the issue has been considered in more detail, and as part of a larger security context. [7, 8] The US MPC&A Program for the Russian Federation excluded irradiated nuclear fuel initially, and has since then concentrated its efforts "*to HEU (20% and greater) and Plutonium (excluding Plutonium in irradiated fuel)",* as stated in their Strategic Plan. [9]

A reasonable estimate of the present amounts of spent fuel in different kinds of storages, adds up to about 34 000 fuel assemblies. Additional 12000 are currently said to be located in the Far East, and approximately 25 000 spent marine fuel assemblies might arise during the next

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decade. Based on figures as of December 2000, there are also large quantities of fuel ready to be taken on-shore:

> " (…) 184 nuclear submarines have been decommissioned in the Russian Federation. Of these vessels, 48 have been dismantled, 28 are in the process of being cut up, and 112 are still waiting the initiation of work. Most of these vessels still have loaded reactors. "[15]

In total, about 120 000 spent fuel assemblies will in some form another have to be stored properly until a decision has been made on what to do where, how and when.

The scenarios for an accident or diversion of this material are multitudes, ranging from large releases to air, sea and/or terrestrial environment, to sabotage and other radiological incidents initiated on purpose or in despair, and, last but not least, thefts or other illegal, organized diversion of radiological or fissile material by sub-national groups or states. In this paper, we will discuss one of the most important specific components of the diverse security dimension of this material, *the risk of proliferation of Russian spent marine fuel for the purpose of producing nuclear weapons*.

3. ANALYTICAL FRAMEWORK

A framework for considering the non-proliferation risk might divide the risk into three components: a) material attractiveness, b) the levels of safeguards and physical protection applied to the material, and c) the impact of the different societal factors. This will serve as a methodical basis for the risk analysis in section 6 of this paper.

The tool for modelling Russian marine reactor and fuel burn has been the computer tool HELIOS developed and supported by Studsvik Scandpower. HELIOS has been extensively qualified by comparisons with experimental data and international benchmark problems for reactor physics codes as well as through feedback from applications. Some of these benchmarks and studies include fuel enrichments up to 90% and Russian naval reactors. [13]

4. SELECTION OF REACTOR AND FUEL CASES

Most of the Russian submarine reactor data is classified due to military restrictions. Based on earlier efforts to model the fuel behaviour in Russian naval reactors, a model of a light water moderated Russian marine reactor as used in the Russian cargo ship *Sevmorput* was chosen as the basis for this work. [14] Russian icebreakers have been used to test reactor and fuel configurations in the overall development of marine reactors in the Russian Federation due to the use of similar design criteria in the development of the reactors (e.g. size, fuel configuration and the need for effective transmission of power to the propulsion system). The most important core and fuel data are summarized in Table I.

Regarding the model data for the reactor and fuel, we have based our selection on the discussions and data presented in the mid 90-ties [10, 11, 12], and our own studies of other generations of Russian marine reactors. [3] In the recent years, very little additional information on the fuel and reactor properties has been presented, probably due to a different political climate in Kremlin.

While the calculations in earlier works were based on initial data corresponding to the early stages in the development of Russian marine reactors, a set of data assumed to be of more relevance for later generations have been chosen. The changes affect primarily the fuel material, the number of assemblies, enrichment and the initial content of U-235. While the number of fuel assemblies for the first generation was believed to be limited to 181 241 fuel assemblies are used in the calculations in this article due to more sophisticated designs and subsequently operating regimes. The most immediate consequences are seen on the mass and dimension of the specific item that a proliferator will have remove. Regarding the parameters of prime interest such as enrichment and initial content of U-235, their range is closely connected to which stage in the development of the Russian marine reactor the actual reactor represents as shown in Table II.

Table I: Selection of stable core and fuel assembly dimension data for the model of the Russian marine reactor used in the calculations

Active core height:	100 cm
Core diameter:	121.2 cm
Assembly outer diameter:	6 cm
Thickness of outer clad:	0.06 cm
Thickness of inner clad:	0.06–0.006 cm
Number of pin positions/assembly	55
Number of assemblies/core	241
Burnable absorber:	Gadolinium

Table II. Reactor and fuel assembly data used as in this paper as model parameters compared with data for earlier constructions [3, 10, 11, 12, 14]

	Early Russian marine reactor properties (≈first/second generation of Russian submarine reactor)	Later Russian marine reactor (≈third and subsequent generations of Russian submarine reactor) used in this paper
Fuel material:	U0-2 (sint. ceramic pellets)/ U-Al/U-Zr	U-Al/U-Zr (alloy, metallic or dispersion fuel)
Enrichment:	5–21%	15%–99%
Initial content of U-235:	50–70 kg.	100–200 kg.
Max. thermal power:	90 MW	200 MW

Important to note is the use of enrichments as high as 90% in Russian marine reactors, such as in *Sevmorput*. Weather the same core configuration has been used in the military vessels is not presently known, but might not be excluded. The higher initial amounts of U-235 corresponds not only to icebreaker data as orally presented of representatives for Murmansk Shipping Company, but also for US submarines as this has been estimated.

5. PRESENTATION OF CALCULATIONS

This calculations has been performed to estimate the following properties: A) the amount and enrichment of U-235, B) the amounts and quality of the Pu, and C) the level of self-protectiveness of the spent fuel. The results will be the main in-put in the risk analysis in section 6.

The thermal power has been chosen to be 100 MW, variation in this property has shown no significant effect on neither the amounts and quality of fissile material nor the amounts of fission products. The fuel material has also been switched from U-Al alloy to U-Zr alloy with no significant effect. For a more complete analysis, including threat considerations and proliferation mechanisms, these properties and other properties should be considered more carefully [2].

The main part of the results is presented in this section. However, more specific results, such as specific values, are included in section 6 as part of the proliferation risk analysis.

5.1. THE AMOUNT AND ENRICHMENT OF U-235

The amount of U-235 for different enrichment levels, displayed in figure 1, follows a similar development as it decreases from the initial quantity during operation. There are small differences between fuel loads with various initial enrichments due to fission of Pu in fuel with lower enrichment. The effects of higher initial content of U-235 is, of course, important for how long it is possible to burn the reactor. The main concern is the overall amount of U-235, amount of U-235 pr. fuel assembly and final enrichment of the HEU in reactors with very high initial enrichment (80% and above). Even in fully burned cores, the enrichment stays above 50% in these cases as described in figure 2.

In figure 3, we see how different initial content of U-235 affects the enrichment as the fuel is burned. An important aspect is that a lot of HEU is left in the fuel when the fuel is fully burned for marine fuel with high initial enrichment. The question is then how much fuel there exist with enrichments above 60%, how much of this fuel that is partly and fully burned, to which extent this fuel might be considered self-protected, and the level of safeguards presently at the ground to protect the material.

5.2. THE AMOUNTS AND QUALITY OF PU

Regarding the amount of Pu, as seen in figure 4, we have to consider the lower spectrum of initial enrichments to obtain significant quantities. We observe that amounts of Pu are produced with extraordinary qualities regarding the explosive properties in a partly burned (30 000 MW(d)) model core with low initial enrichment, 15%. Similar results have been obtained earlier for the first and second generation of Russian marine reactors. In a fully burned submarine reactor the quality of the Pu will similar to the quality of Pu in commercial reactor fuel as seen in figure 5: with about 60% Pu-239 and, in addition, a substantial proportion of Pu-240 and Pu-241, which make the fuel not very attractive to handle.

5.3. FISSION PRODUCTS AND ACTINIDES IN THE SPENT FUEL

The most important obstacle in the handling of the spent fuel is extensive gamma radiation from the fission products and the actinides. For the relevant period of time for this study, 10–100 years after end of operation, the most important gamma emitters is Cs-137. Other less important gamma emitters are Eu-154, Cs-134, Sb-125 and different actinides, the contribution of these, however, is limited to maximum a couple of per cent. Even if the relative importance of the actinides increases with time, for this study, we can therefore limit the evaluation to consider the decay of Cs-137 as described in figure 6.

6. PROLIFERATION RISK CONSIDERATIONS

This considerations focus on the same intrinsic properties as the first parts of this paper; amounts and quality of fissile material and the associated self-attractiveness. In order to put the number and figures into a familiar and useful perspective, we have introduced the Spent Fuel Standard in these considerations. The Spent Fuel Standard does not imply a specific combination of radiation levels, isotopic mixture etc., but is more of a condition-like nature and a base-line measurement. It was originally developed to assess different solutions proposed for disposition of weapons-grade Pu to make this plutonium roughly as inaccessible for weapons use as the much larger and growing stock of plutonium in civilian spent fuel. [4] The Spent Fuel Standard refers only to the intrinsic properties of the actual material; the results might not change due to the implementation of additional safeguards measures.

6.1. GENERAL REACTOR AND FUEL PROPERTIES

The basis for the Spent Fuel Standard is a Light Water Reactor fuel assembly — as the array of fuel rods and spacers that is the smallest item that could be removed from intact from a spent-fuel storage pool or shipping cask. An overview over these and other properties are seen in Table III together with the properties of the fuel and reactor model.

The data in Table III point at the basic differences between power reactor fuel and marine fuel. With this in mind, one might question the relevance of using the Spent Fuel Standard at all in the evaluation of security risk associated with the spent marine fuel. For example, the fuel dimensions make a marine fuel assembly transportable by one person on foot, the method used to steal one fresh fuel assembly at a Russian naval base in 1993.

If we consider some of the most important barriers against a threat, weather this is a proliferant state or a sub-national group, dimensions and mass are important factors decisive for much of infrastructure needed to protect the acquires, hide, transport and store the material. However, due to normal safety considerations, we have to expect that the spent fuel cores are not stored as a whole. Most probably, they use different types of casks made to fit a limited number of fuel assemblies. Still, properties such as size and weight and fuel material might be decisive for thefts and illegal diversion.

Table III. Selected reactor and core properties for the Russian model marine reactor, a typical PWR and BWR related to two different types of threats

	Model of Russian marine reactor	**PWR**	**BWR**
Core diameter:	121.2 cm		
Active core height:	100 cm	400 cm	400 cm
Assembly outer diameter:	6 cm	25 cm × 25 cm	15 cm × 15 cm
Number of assemblies/ core	241	193	457
Fuel material:	U-Al/U-Zr (alloy, metallic or dispersion fuel)	UO2	UO2
Weight (kg.) pr. fuel assembly (heavy metal)	0.42–4.15 kg.	600 kg.	200 kg.
Initial enrichment:	15%–99%	≈ 3.5%	≈ 3.5%

Considering fuel material, the alloy or metallic fuel that is probably used in marine fuel implies less effort to make it useable for weapons purposes than needed to convert power reactor fuel. The result is that even with comparable material properties, the need for protection of the marine fuel has to be considerable higher than for civilian PWR- or BWR-fuel. Another conclusion is that the Spent Fuel Standard has limited validity when it comes evaluating proliferation risk, and that adequate tools needs to be developed in order to facilitate a common understanding the priority of the proliferation risk associated with spent fuel.

6.2. RUSSIAN MARINE HEU-TO-GO?

The calculations indicate that large amounts of highly enriched uranium are left in the spent fuel, provided the initial enrichment and initial amount of U-235 are as described in the calculations. An example on resulting enrichments and quantities are presented in Table IV. However, considering the amounts and isotopic composition of the uranium in each assembly, if present, compared to the amounts of Pu, the HEU option points out to be most attractive for a proliferator, especially a terrorist state or a sub-national group with limited technical possibilities for refining the material and actually making a nuclear bomb. Properties like less probability for spontaneous fission and a limited number of rods to get the necessary material have earlier been emphasized together with more general considerations on how to make a nuclear device from naval fuel [16].

Table IV. Amounts of uranium and enrichment (of U-235) in spent fuel in partly burned submarine model reactor cores (15% and 90% enrichment –30 000 and 70 000 MW(d))

	U-235 content in one reactor core	**U-235 content in one fuel assembly**	**Enrichment (U-235)**	**Total content of uranium in one reactor**	**Total content of uranium in one fuel assembly**
15%, 30 000 MW(d), initial amount of U-235 150 kg.	114.22 kg.	0.47 kg.	11.85%	955.86 kg.	4.00 kg
15%, 70 000 MW(d), initial amount of U-235 150 kg.	71.64 kg.	0.30 kg.	7.80%	926.82 kg.	3.81 kg.
90%, 30 000 MW(d), initial amount of U-235 150 kg.	111.91 kg.	0.46 kg.	82.95%	133.65 kg.	0.66 kg
90%, 70 000 MW(d), initial amount of U-235 150 kg.	62.25 kg.	0.26 kg.	67.33%	93.06 kg.	0.38 kg

Even if the final amounts give reason for concern, the number of submarines having used 90% enriched uranium fuel, however, is limited. However, little information is available and virtually nothing is verified of the Russian authorities. Dispersion fuel enriched to 90% has reportedly been used in the Russian liquid metal cooled reactors. However, the dispersion matrix, which probably includes beryllium oxide, imposes additional difficulties for a possible proliferator compared to a more straightforward U-Al or U-Zr alloy. On this basis we have to consider the possible presence of significant quantities of highly enriched uranium as the most urgent proliferation issue associated with spent marine fuel. For initial enrichments lower than

80%, the final enrichment levels in the spent fuel are moving towards an area where considerable efforts, including removal of fission products and re-enrichment techniques, are needed. Then the proliferation risk has to be considered considerable lower. This is especially relevant for initial enrichments in the area of 21–45%.

The icebreaker fleet has also reportedly used 90% enriched fuel for several of its vessels, among others, for the *Sevmorput*. However, the spent fuel at the fuel storage ship *Imandra* has been included in a modern, electronic custom-made electronic accountancy system for fresh and spent fuel installed at MSCO in February 1998. A general upgrading of the systems for physical protection and control has also been provided during the last years. Also the security of the material in the icebreakers themselves is being enhanced. The Norwegian and Swedish government has provided a stand-alone physical protection system on the nuclear-powered icebreaker Sovjetsky Soyuz. The system consists of both organizational measures (rules, schedules, programs, personnel training procedure, maintenance measures) and mechanical and teletechnical protection equipment such as reinforced doors, locks, sensors, alarm system and closed circuit television systems. Hardware and support were also parts of the delivery. The Swedish Nuclear Inspectorate (SKI) is now exploring the possibility to continue this work on other icebreakers, among others in cooperation with British authorities.

The last concern evolves around the persistent rumors on the Russian development of small, marine reactors as flexible power sources in coastal areas in the high north and Far East of the Russian Federation. However, this is more a concern for the future compared to the existing problems with the accumulated spent fuel at the different Russian naval bases.

6.3. PU IN SPENT MARINE FUEL — A LOT OR MORE?

When comparing the amount and quality of the Pu produced in the reactor as produced of the calculations and displayed in Table IV, one specific set of properties draw one's attention; low-burned low- and medium-enriched fuel. HEU fuel, initially enriched to 60–90%, with low — burned fuel also produces Pu with relatively low levels of the higher Pu-isotopes, however, the amount is more than a decade less than in the first case. A complete marine core in this case is equivalent to about 0,43 kg. of Pu assuming initial enrichment on 90% as seen in Table 5.

Similar, however, more generic concerns regarding low-burned fuel and the content and quality of Pu, have been expressed earlier [5]. While the international non-proliferation regime doesn't separate Pu into different groups, three categories have been suggested in order to target MPC & A measures better in the future: reactor-grade, fuel-grade and weapons-grade Pu. While the first group is defined as having more than 19% Pu-240, the second to be in the area of having less than 19%, but more than 7% Pu-240, and the third plutonium containing less than 7% of Pu-240. Another way of separating the groups has been to divide between degraded Pu (e.g. in high-burn-up fuel), low-grade Pu (e.g. separated from spent fuel of normal burn-up) and high-grade Pu (e.g. from weapons or low burn-up fuel).

The cases we have presented in this paper are relevant for all groups of Pu. While most of the Pu is in the area of fuel-grade and reactor-grade, we cannot rule out a possible presence of low-burned, low-enriched fuel with long cooling times, e.g. as a result of accidents and malfunctions. As seen in Table 5, given the right core and fuel data, a proliferator would have come a lot closer to acquire the necessary amount of material for one nuclear device by getting hold of one core load of spent fuel of a certain configurations. More specific analysis has to be carried out to conclude on the attractiveness according to the Spent Fuel Standard, but one has to keep in mind that the content of Pu at least decreases proportionally with the weight of the reactor (as the enrichment increases).

What is the advantage having fuel-grade instead of reactor-grade Pu? The main part is less occurrence of spontaneous fission in the bomb material. For a terrorist or sub-national group, this is very important due to the lack of resources and technical capabilities. For a nation aiming to have a sustainable weapons-program, this is less important. An independent nation, even a member of the non-proliferation community including safeguards agreement with the IAEA, lack neither possibilities nor opportunities over time to produce the needed quality of Pu. As in the case of North Korea, even the mere *potential* for producing fissile material is considered a threat to the neighboring states.

Regarding Pu, one single marine core might contain approximately the same amount of Pu as one fuel assembly in a civilian power reactor. The differences between large and small initial contents of U-235 are not very large. Due to smaller cores in older vessels, including a lower number of fuel assemblies, the quantities of Pu assuming the same initial enrichment is the same, ≈kg. fuel- and reactor-grade Pu.

Table V. Comparison of isotopic concentration of Pu in submarine reactors (15% and 90% enrichment –30000 and 70000 MW(d)) and in some specific power reactors

	Pu-238	Pu-239	Pu-240	**Pu-241**	**Pu-242**	**Overall Pu- content in one reactor core**	**Pu-content in one fuel assembly**
15%, 30000 MW(d)	0.3%	84.6%	10.9%	4.0%	0.2%	4.8 kg.	0.0200 kg.
15%, 70000 MW(d)	1.5%	66.1%	18.8%	11.4%	2.3%	8.7 kg.	0.0360 kg.
90%, 30000 MW(d)	2.5%	81.1%	11.3%	4.6%	0.3%	0.43 kg.	0.0017 kg.
90%, 70000 MW(d)	16.8%	51.2%	16.0%	12.6%	3.3%	0.80 kg.	0.0033 kg.
PWR (33000 MW(d)/t)	2.6%	59.8%	23.7%	10.6%	3.3%	1160 kg.	≈ 6 kg.
BWR (27500 MW(d)/t)	1.7%	56.0%	24.1%	12.8%	5.4%	1140 kg.	≈ 2.5 kg.

6.4. RADIATION HAZARDS TO ACQUIRES AND SEPARATORS: THE ISSUE OF SELF-PROTECTIVENESS

The importance of the radiation hazards is displayed in The Convention on Physical Protection of Nuclear Materials. Included in material category 1, the presence of one of these types of material requires for example restricted access, determination of people's trustworthiness, constant surveillance and response forces, is *"Irradiated Pu and HEU in a reactor but with radiation level equal to or less than 100 rads/hour at one meter unshielded."* Other groups of material in category 1 are fresh Pu and U-233 in quantities higher than 2 kg and fresh HEU in quantities higher than 5 kg. The typical spent fuel in the Spent Fuel Standard is considered to be 30 years old measured from its time of its discharge from the reactor, irradiated to 33000 MW(d)/t, displaying radiation levels in the range of ≈800 rem/hour.

Based on the main result in section 5, the important isotope is Cs-137 due to its gamma radiation. Based on this assumption, we find that fully burned fuel are self-protected in the formal sense since the level of radiation would reach about 300 R/h. Medium burned–fuel cooled for 40 years has radiation levels close to the limit given above, while low-burned fuel represents lower radiation levels. However, in all cases one has to remember that the implementations of sufficient radiation protection measures are much easier for the marine fuel due to its limited size. On this basis, it is conceivable that spent marine fuel might not be considered self-protected more than a decade, or possibly less. Considering the massive decommissioning of submarines the last 10–15 years, the need for protection of spent marine fuel has to be evaluated closely as fast as possible.

7. CONCLUSIONS

A selection of the main intrinsic properties of the spent marine fuel have been closely examined in this paper in order to rank the different types of fuel based on their proliferation potential. Based on the results from the calculations, the highly enriched uranium is a major concern. The most serious proliferation concerns in this context are related to spent fuel with particular high initial enrichment and low-burn-up. More general security concerns are related to the removal of spent fuel removed from the vessels with little or no indication of operation history and isotopic concentrations. The results show also that, after more than 30 years storage after decommissioning, the fuel assemblies cannot be regarded as being self-protected, and this limit might be closer to a handful of years rather than decades. On this basis, we have suggested a top 5 list in Table VI over the security threats due to proliferation that might be associated with Russian spent fuel.

The most important issue, though, is the rather vague nature of these results due to the lack of precise information. Despite numerous attempts from among others the US authorities, very little information has been released. In order to have a more precise description of the situation on the ground, and to initiate an international cooperation to solve the current problems, the Russian authorities have to take an initiative to address the problem without compromising their need for secrecy. The current ambiguity is only giving away valuable time to a possible proliferator, and making it more difficult to achieve international funding and assistance. There are no legal obligations for the Russian Federation as a nuclear weapon state (NWS) for making declarations or allowing international control of any type of nuclear materials beyond what's given in its national legislation regarding the production, use and storage of nuclear materials, in itself a concern keeping in mind the labile political and societal in the Russian government, its concerned regions and cities in North-West and far East of the Russian Federation.

Further work is needed to clarify the complete risk picture associated with Russian spent marine fuel. This includes a closer look at the properties evaluated in paper and other properties important for the handling of the spent fuel, detection of diversion and relevant properties for converting the fuel material to a nuclear weapon. A complete risk analysis would also have had to include a clear-cut design basis in order to serve as a sufficient analytical tool for future upgrading. Regarding the engineered and institutional safeguardspresent in the back end of the marine fuel cycle in the Russian Federation, we have no information on substantial upgrading of the MPC & A systems at sites storing spent naval fuel except for the Nordic efforts at MSCO. Considering how important the role of the insider has been in earlier thefts of fresh fuel and other crisis, the physical protection might be virtually missing, together with necessary accountancy systems. Today there is also confusion on how the Russian Federation plans to regulate the area of decommissioning nuclear submarines, an area including most of the spent fuel. There are no regulations valid at the moment covering material taken from the military to the civilian sphere As a brief conclusion, one might say that the national ability to account for and control spent fuel of any enrichment and radiation level is questionable and probably close to zero. Considering the international assistance programs, they are neither numerous nor comprehensive, among other things due to the consistent lack of information in this field.

Table VI. Ranking of the proliferation risk associated with Russian spent marine fuel

Priority No.	Type(s) of material	Reactor and fuel characteristics	Type of vessel (as indicated in available sources):	Cooling time:
1	HEU	Initial enrichment >80%, Low-, medium and fully burned fuel High initial amount of U-235	Icebreakers Submarines of third/subseq. generations	Any cooling time
2	Pu	Initial enrichment below 20% Low- and medium burned fuel	Submarines of first and second generation	Any cooling time
3	Pu	21%> Initial enrichment >30% Low- and medium burned fuel	Submarines of third/subseq. generations	Any cooling time
4	HEU	20%> Initial enrichment >80% High initial amount of U-235 Low- and medium burned	Submarines of third/subseq. generations	Any cooling time
5	Pu	30%> Initial enrichment > 80% Low- medium and fully burned fuel	Icebreakers Submarines of third/subseq. generations	Any cooling time

REFERENCES

[1] GUSSGARD, Knut (1997), ”Spent fuel at the Kola Peninsula”, in KIRK, Elisabeth, “Decommissioned Submarines in the Russian Northwest — Assessing and Eliminating Risks”, Kluwer Publishers, Dordrecht.

[2] BOERRESEN, Sigurd, SOBIESKA, Mathylda and GUSSGARD, Knut (1998), ”Criticality Considerations of Russian Ship Reactors and Spent Nuclear Fuel”. Studsvik Scandpower Report no. TR1/41.20.03, Kjeller, Norway.

[3] REISTAD, Ole and GUSSGARD, Knut (2000), “An estimate of the amount of ^{235}U, ^{239}Pu and the material attractiveness in naval irradiated nuclear fuel from the from the first and second generation of Russian submarines” — presented at the INMM 41st meeting, July 2000 (proceedings in press), Institute of Nuclear Materials Management, New Orleans.

[4] US Department of Energy (1999), Panel to review the Spent-Fuel Standard for Disposition of Excess Weapons Plutonium, Committee on International Security and Arms Control, National Academy of Sciences.
[5] CARLSON, John, BARDSLEY, John, BRAGIN, Victor and HILL, John (1997), "Plutonium Isotopics — Non-proliferation and Safeguards Issues, IAEA-SM-351/64, 1997 (www.fas.org/nuke/intro/nuke/O_9705.htm).
[6] SHIELDS, John and POTTER, William (1997), "Dismantling the Cold War", MIT Press, London.
[7] MOLTZ, Clay and ROBINSON, Tamara (1999), "Dismantling Russia's nuclear Subs: New Challenge to Non-Proliferation", Arms Control Today, June 1999, pp. 10–15.
[8] SAWHILL, Stephen G. (1999), *Cleaning-up the Arctic's Cold war Legacy — Nuclear Waste and Arctic Military Environmental Cooperation,* paper presented at the conference Nuclear Risks, Environmental and Development Cooperation in the North of Europe, Apatity, Russia, June 19–23, 1999.
[9] US Department of Energy (1999), "Office of Non-proliferation and National Security — Strategic Plan", (http://www.dp.doe.gov/nn/default.htm).
[10] NILSEN, Thomas, KUDRIK, Igor, NIKITIN, Alexandr (1996), "The Russian Northern Fleet — Sources of radioactive contamination", Oslo.
[11] BUKHARIN, Oleg et al. (1995), "Russian Nuclear-Powered Submarine Decommissiong", Science & Global Security, no. 5, pp. 245–271.
[12] BUKHARIN, Oleg (1996), "Analysis of the Size and Quality of Uranium Inventories in Russia", Science & Global Security, no. 6, pp. 59–77.
[13] STAMM'LER, R. J. J., BOERRESEN, S., CASAL, J. J. and FORSLUND, P., (1996), *« «Helios» — Verification against Kritz and other critical experiments»*, International Conference on Physics of Reactors PHYSOR 96, Mito, Ibaraki, Japan, 16–20 September 1996, Vol. 3, pp. F58-65.
[14] Safety report of Sevmorput — *Information of Safety of Icebreaker — Transport lighter-container-ship with nuclear propulsion plant Sevmorput.* Approved by the Register of Shipping of the USSR.
[15] MOLTZ, Clay (2000), "Coordinating International Assistance for Russian Submarine Dismantlement", Meeting Summary (not published, submitted by author), Monterey.
[16] MAERLI, Morten Bremer (2001), "Proliferation potential of naval nuclear fuel" (not published, submitted by author).

QUESTIONS AND ANSWERS

I. Badawy (Egypt): a) Is this study being undertaken of behalf of the Russian Federation? b) How could the spent fuel be used and c) under what conditions?

O. Reistad (Norway): a) No, it is being done for the Norwegian radiation protection authority. b) Separate out the uranium, which in some cases might be enriched to over 50%, reprocess it and make use of the plutonium. c) An example would be a State with the available time and resources (e.g. North Korea is situated close to the Russian bases in the Far East).

S. Fernandez Moreno (Argentina): The Working Group on the CPPNM has recommended excluding the military use of NM from the convention. So under what circumstances would your recommendation of strengthening security measures be applicable?
O. Reistad: Spent fuel from military vessels will probably be included in the civilian sphere and be placed under civilian control.

TECHNICAL CONSIDERATIONS FOR DETECTION OF AND RESPONSE TO ILLICIT TRAFFICKING IN RADIOACTIVE MATERIALS

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Abstract. Numerous incidents in the past years involved illegal movement of nuclear materials and other radioactive sources across State borders. Even more frequently radioactive sources out of regulatory control have entered the public domain and sometimes caused significant radiation exposure. This created potential serious hazards to public health as well as a thread of nuclear proliferation and terrorist activities. The IAEA, in close co-operation the World Customs Organization (WCO) and INTERPOL, conducted joint studies, meetings and training programs to support Member States in combating illicit trafficking. Within this programme technical information has been derived on requirements and methods to detect and respond to events involving inadvertent movement of and illicit trafficking in radioactive materials. The paper summarises the most important results and the experience obtained in this field.

1. INTRODUCTION

Illicit trafficking in nuclear and radioactive materials is not a new phenomenon. However, concern about a "nuclear black market" has increased remarkably in the last decade. Although the number of illicit trafficking incidents has risen since the collapse of the former Soviet Union, the overall extent of the problem is restricted neither to Europe nor to nuclear proliferation. A small percentage of these incidents involve so-called "nuclear materials", which may be used for nuclear weapons and therefore causes a threat of nuclear proliferation. The vast majority of these incidents, however, involve radioactive sources, or involve low-enriched, natural and depleted uranium, which are not usable for weapons. These incidents do not represent true "illicit trafficking," but are indicative of "inadvertent movement," where radioactive materials and sources have escaped regulatory control. There have been instances in which the loss of security over radioactive materials has led to serious, even fatal, consequences to persons. Examples include unintentional incorporation of radioactive materials into recycled metals, recovery of lost radioactive sources by unsuspecting individuals, and deliberate theft or diversion of radioactive material.

Another problem of increasing importance is the cross-border movement of metallurgical scrap. Today metal scrap is acquired for recycling from and transported all over the world, often without a clear reference to its origin. Occasionally, such metal scrap shipments have included radioactive materials and sealed radioactive sources. One study of this problem in the United States has shown over 2300 instances where abnormal radiation levels were found in shipments of metals for recycling [1]. And of that total, about 11% of those instances involved sealed radiation sources or devices. While most of the discoveries of abnormal radioactivity were due to surface contamination by naturally-occurring radioactive materials (NORM), other radioactive material sources and devices "orphan sources" are creating a risk of radiation exposure for workers and the public and have also led to inadvertent melting of radioactive materials by those recycling facilities.

The need for guidance and recommendations explicitly directed to the problem of illicit trafficking in nuclear materials and other radioactive sources was raised by the IAEA Director General at the IAEA General Conference in December, 1994 and measures were agreed by the IAEA Board of Governors in March, 1995 [2]. Measures to prevent, detect, and respond to illicit trafficking are common for all radioactive materials, including nuclear materials. However, nuclear materials are, or should be, subject also to safeguards for nuclear non-proliferation purposes and to physical protection to prevent diversion. The IAEA has established close co-operation with intergovernmental and non-governmental organizations, in particular the World Customs Organization (WCO) and INTERPOL, to conduct joint studies, meetings and training programs and to support Member States in their border control activities. Technical information and experience gained on requirements and methods to detect and respond to events involving inadvertent movement of and illicit trafficking in radioactive materials is summarised here.

Figure 1 shows the annual frequency of illicit trafficking incidents contained in the IAEA database for the period 1993–2000, which have been verified by the relevant Member States.

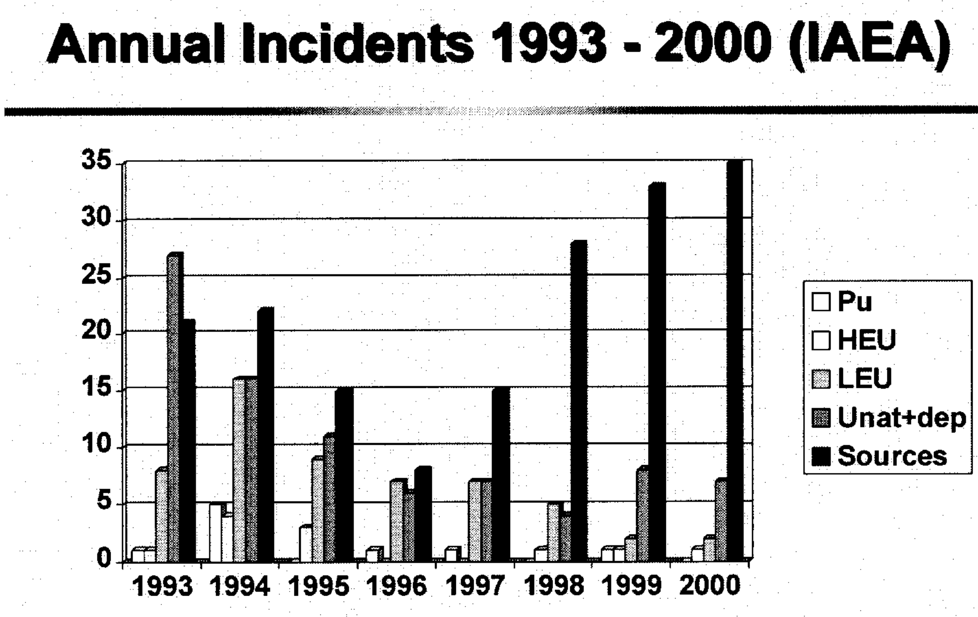

FIG. 1. Annual frequency of illicit trafficking incidents recorded in the IAEA database.

2. DETECTION OF RADIOACTIVE MATERIALS

2.1. STRATEGY FOR DETECTION

The extent and scope in developing a radiation detection strategy needs to be based on the potential or actual threat of illicit trafficking in a particular country. The detection strategy should be developed according to the synthesis of the information resulting from analysis of the situation of the country, but also according to the objectives the State would wish to achieve, balanced against the means it can deploy and according to non-proliferation treaties in effect. These objectives can be defined by the volume of traffic to be monitored, and the nature of the radioactive or nuclear materials and their quantities.

Detection of inadvertent and illicit movements of radioactive materials including radioactive sources out of administrative control requires a combination of multiple efforts, in particular

- a well established intelligence network to cope with criminal incidents,
- radiation monitoring of the scrap cycle at steel plants, scrap yards and waste deposits such as land fills, incinerators etc.
- radiation monitoring at land and sea borders, as well as airports

Close co-operation between and adequate involvement of all relevant national agencies, in particular regulatory agencies, Customs, border police and other law enforcement agencies is essential. The detection strategy needs to be based on a detailed assessment of the traffic coming from foreign countries, the domestic traffic and the frequency of illicit trafficking incidents discovered in the region so far. The analysis of all these parameters allows the authorities of the country to get a general idea of the situation of the existing radioactive and nuclear materials and of their movements, and allows them to assess the volume of the traffic with which they must cope. The detection strategy should also consider the budget which will be available. Ideal situations, in which the needed budget is readily available, are very rare. So compromises will be necessary, and they need to take into account the cost of equipment, its sensitivity, its maintenance, the number of operators to be trained, locations to be monitored, etc.

In order to discover illicit trafficking or inadvertent movement in radioactive materials, the following steps are required:

- detection of any abnormal radiation level, i.e. a significant increase in natural background,
- verification of such detection,
- localization of the origin of the radiation and radiation safety measurement,
- identification of the radioactive material to determine if it is illicit or "innocent", e.g. naturally occurring radioactive material (NORM), a legal transport or medical isotope administered to a patient etc.

In addition to intelligence measures, radiation monitoring for detection of illicit trafficking or inadvertent movement of radioactive materials is the only efficient method to provide non-invasive monitoring of people, transport vehicles and cargo at national borders and other locations. Specialised equipment is available for performing one or more of the steps indicated above, with or without an individual being present. If an individual is involved, radiation safety is an important consideration.

2.2. RADIATION MONITORING AT BORDERS

To implement this strategy, different equipment must be employed and rapid monitoring procedures are essential. The monitoring process should be conducted at locations, which have the greatest potential for identifying and intercepting illicit trafficking.

In general, gamma radiation monitoring is sufficient for the detection of radioactive materials or the presence of gamma radiation sources. However, for detection of nuclear materials additional neutron monitoring is essential. Detecting a neutron radiation source is a serious indication of the presence of nuclear materials, because significant neutron sources do not exist as naturally occurring radioactive materials or as radioactive materials used in medicine. Therefore separate alarms for gamma and neutron radiation are important. In the case of detection of illicit trafficking, the possible presence of alpha and beta must be considered. However, experts should be called in to assess the hazard from these sources.

Two types of radiation monitoring are to be distinguished:

- gamma and neutron monitoring, to detect the presence of radioactive or nuclear materials,
- dosimetric radiation safety measurements, to inform the investigator about the radiation levels, to protect human health, and to protect the environment from contamination.

It should be recognized that there is a basic difference between monitoring instrumentation and radiation dosimeters. Dosimeters are not useful for monitoring purposes due to their limited sensitivity.

Instruments to detect illicit trafficking in radioactive materials can be divided into three categories:

- Pocket type instruments, used to detect the presence of radioactive materials and to inform the investigator about the radiation level;
- Handheld and mobile instruments, required to detect, locate or identify radioactive materials. Such instruments may also be useful for more accurate dose rate measurement, to determine radiation safety requirements;
- Fixed installed, automatic instruments, designed to be located stationary at road and rail border crossings, airports, seaports, etc. Such rather complex and expensive systems should require no highly specialized training of staff. Such instruments allow high sensitivity monitoring of a continuous flow of persons, vehicles, luggage, packages, and cargo, without significantly interfering with the flow of traffic.

In order to evaluate available instrumentation under practical “border conditions” and to derive minimum performance requirements, design criteria and procedures for operation, calibration and testing, a large scale pilot study (“ITRAP”) [3] has been conducted in co-operation between IAEA, the Austrian Research Centre Seibersdorf (ARCS) and the Austrian Government. It included laboratory testing ARCS and field testing at the Austrian Hungarian border and the Vienna airport, each for a duration of more than one year. Based on the results of ITRAP technical specifications and minimum requirements for the above mentioned instrument categories are described.

2.3. POCKET TYPE INSTRUMENTS

2.3.1. General

The technology for detecting nuclear materials has developed rapidly in the last years. Breakthrough advances in the miniaturization of low power electronics have made possible the development of a new class of small gamma-ray radiation detectors. These detectors, which are roughly the size of a message pager, can be worn on a belt or carried in a pocket for hands-free operation and still quietly alert the operator to the presence of radioactive materials. Because of their small size, these instruments are ideally suited for use by individual officers and first responders to a radiation alarm, without requiring extensive training. One result of this new technology is the practicality of each individual officer possessing a sensitive for its size personal radiation detection instrument, much as each officer possesses other personal duty equipment. These instruments are relatively inexpensive, are small enough to be worn on the uniform, and have low power consumption, so that they need not be turned off. Another advantage of these radiation detectors is their inherent mobility, which allows closer approach to a suspected radiation source. Many small radiation detectors, worn by personnel in the course of their regular duties, can represent a "moving curtain" that can be very effective compared to fixed-installed instruments and thus cover a wide variety of possible traffic routes. In a dynamic environment this device can readily locate the source of the radiation signal.

2.3.2. Description

A pocket type instrument is a small, lightweight, robust device that will alert the wearer to radiation levels above background from gamma and X ray radiation. A scintillation detector with a volume of at least $3cm^3$ should be used in the instrument to ensure the required sensitivity. It must be maintenance free, of rugged construction, weather resistant and battery operated with adequate operation time. The alarm threshold should be pre-adjusted before issuance to the officer, to account for the natural background radiation at the particular location. A pocket type instrument should be able to produce three types of alarms, a visual (light), audible (tone), and vibrating (silent) alarm, when the radiation intensity exceeds the alarm threshold. For covert operation, disabling of the audible alarm should be possible. The audible tone should change as a function of dose rate. A display should provide a simple, luminescent indication, which is proportional to dose rate. This indication serves two purposes, radiation safety, i.e. to warn the officer of greater radiation levels, and as a search tool for locating radiation sources.

2.3.3. Operation, Calibration, and Testing

A pocket type instrument should be worn on the body, pocket, belt or similar location. A self-testing feature should verify proper operation of the instrument before usage. also alarms, i.e. alarms without radioactive materials present, will occur occasionally due to the fluctuations in background. When the alarm threshold is set properly, i.e. about three times natural background level, false alarms should occur not more than once per day. Radiation triggering innocent alarms may be detected by a PTI on an occasional basis. This is due to the fact that many objects contain small quantities of radioactive material such as natural thorium or uranium (see Appendix 1). A pocket type instrument should be tested, on a daily basis if possible, for its continued ability to detect radiation. This may be done by placement of the instrument near a radiation check source and observing a repeatable radiation level. Like most radiation detectors, it is recommended that it be calibrated once a year by a qualified individual or maintenance facility.

2.3.4. Minimum Requirements

2.3.4.1. Sensitivity for gamma radiation

At a background level of 0.2 μSv/h, the alarm should be triggered when the dose rate is increased by 1 μSv/h for a duration of 1 second. The probability of detecting this alarm condition should be 99%, i.e. no more than 100 failures in 10000 exposures. This requirement has to be fulfilled in a continuous, incident gamma energy range from 60keV to 1.5 MeV (tested with ^{241}Am, ^{137}Cs and ^{60}Co).

2.3.4.2. Alarm threshold

The system should provide adjustable threshold levels.

2.3.4.3. Dose rate Indication

If the system provides a dose rate indication the uncertainty has to be within? 50%, when calibrated with ^{137}Cs. If a dose rate range is indicated this uncertainty should be met in the middle of each range.

2.3.4.4. False alarm rate

No greater than 1 false alarm in 12 hours of operation.

2.3.4.5. Environmental Conditions

The instrument should meet the minimum requirements listed above in a temperature range of –15°C to +45°C and a relative humidity of at least 95%, non-condensing conditions.

2.3.4.6. Battery life

Larger than 800 hours under no alarm conditions for instruments with non-rechargeable batteries and larger than 12 hours for units with rechargeable batteries. Under alarm condition: the battery lifetime should be larger than 3 hours.

2.3.4.7. Drop Test

The instrument should meet the specification after 0.7 m drop on concrete, three times.

2.4. HAND-HELD SEARCH INSTRUMENTS

2.4.1. General

Hand-held radiation monitors are small, battery-powered, instruments that measure the ambient background intensity and then calculate an alarm threshold. They may contain microprocessors. Thus, this instrument can compensate for variations in the background level when turned on, or on command. These monitors continuously make short measurements of the radiation level and compare the results to the alarm threshold. The hand-held monitors can effectively search pedestrians, packages, cargo, and motor vehicles. The most significant difference between the hand-held and fixed installed monitors is the human factor that strongly influences the ability of a hand held instrument to detect radioactive materials in the field. Training is therefore of vital importance. If the officer does not move the monitor to within close proximity of any radioactive material that is present, it may not be detected. The small distances that can be obtained between radioactive material and the radiation detector give the hand-held monitor the greatest potential sensitivity of any of the radiation monitors. To achieve that sensitivity, officers must be trained in the proper technique to conduct effective searches, and the training must be repeated periodically. These instruments should also have the capability to measure dose rate for radiation safety purposes. In addition, the capability of measuring alpha and beta contamination levels is recommended. Preferably, such instruments should also be capable of identifying radioactive materials.

2.4.2. Operation, Calibration, and Testing

Hand-held monitors can be used as either the primary search device or as second stage search device for fixed stationary monitors. The monitor should be equipped with an audible alarm to enable the officer to perform the search without watching the device. For search applications, the instrument should have a handle that makes it easy to hold and it should weigh less than approximately 2 kg. The instrument should use scintillating material for gamma ray detection and should also have neutron sensitivity. The capability to distinguish between gamma and neutron alarms is essential. For effective use, the battery lifetime of the instrument should be at least 12 hours under non-alarm conditions or greater than 3 hours under alarm conditions. These instruments should make measurements on short time scales of approximately 0.5 s, so that they can be used to scan quickly the surfaces of packages, pedestrians, vehicles, and cargo. To allow for location of the radiation source, the alarm indication should either automatically reset itself every 0.2–0.5 s, or the frequency of the alarm tone should increase with dose rate. A hand held instrument should be tested, on a daily basis if possible, for its continued ability to detect radiation. This may be done by placement of the instrument near a radiation check source and observing a repeatable radiation level. Like most radiation detectors, it is recommended that it be calibrated once a year by a qualified individual or maintenance facility.

2.4.3. Minimum Requirements

2.4.3.1. Sensitivity for gamma radiation

At a background level of 0.2 μSv/h alarms should be triggered when the dose rate is increased by 0.2 μSv/h for a duration of 3 seconds. The probability of detecting this alarm condition should be 99%, i.e. no more than 100 failures in 10 000 exposures. This requirement has to be fulfilled in a continuous, incident gamma energy range from 60keV to 1.5 MeV (tested with ^{241}Am, ^{137}Cs and ^{60}Co).

2.4.3.2. Sensitivity for neutron radiation

If the instrument provides neutron detection capability, the detector should alarm when exposed to a neutron flux emitted from a ^{252}Cf source of 0.01 μg (approximately 20 000 n/s) for a duration of 10 seconds, at 0.25 m distance, when the gamma radiation is shielded to less than 1%. The probability of detecting this alarm condition should be 99%, i.e. no more than 100 failures in 10000 exposures.

2.4.3.3. False alarm rate

Rate of alarms which are not caused by a radioactive source at the specified background conditions: 1 false alarm per minute within 12 hours of operation, i.e. not more than 100 false alarms in at least 100 minutes.

2.4.3.4. Dose Rate Indication

If the instrument indicates dose rate, it should be capable of measuring at least 10 mSv/h within an uncertainty of less than $\pm$30%, when calibrated for ^{137}Cs.

2.4.3.5. Over- range indication

The instrument should provide an over-range indication or continuous alarm at high dose rates, at least up to 10 mSv/h

2.4.3.6. Environmental conditions
The instrument should meet the minimum requirements listed above in a temperature range of –15°C to +45°C and a relative humidity of at least 95%, non-condensing conditions.

2.4.3.7. Battery life

The instrument should meet the minimum requirements listed above for more than 12 hours under no alarm conditions and more than 3 hours under alarm conditions.

2.5. FIXED INSTALLED INSTRUMENTS

2.5.1. General

Fixed installed radiation pedestrian and vehicle monitors are designed to detect the presence of radioactive material automatically by comparing the gamma-ray and neutron intensity, while the monitor is occupied, to the continuously-updated background radiation level which is measured (and updated) while the monitor is unoccupied. The use of suitable occupancy sensors is essential for achieving the required low false alarm rate. Gamma and neutron radiation levels should be measured and indicated separately. These monitors automatically search pedestrians or vehicles as they pass through the monitor, continuously measure the background radiation level and adjust the alarm threshold to maintain a constant statistical false alarm rate. The monitoring distance is an important parameter. For pedestrian monitors passage should be restricted to 1.5 m or less. For passenger vehicles, one-pillar monitors are acceptable if the maximum passage width is limited to 3 m or less. For large trucks and buses, two pillars are required and the maximum distance between pillars should be less than 6 meters (this is, of course, dependent on the maximum width of the vehicle to be scanned).

2.5.2. Installation and Operation, Calibration and Testing

A fixed installed radiation portal monitor is only as effective as the "choke point" where it is installed. The monitors must be installed such that all the pedestrians, vehicles, and cargo traffic are forced to pass through the monitors. The effectiveness of fixed installed instruments is strongly dependent on its ability to measure the radiation intensity over the entire search area and therefore, when installing the monitor, the detector should be positioned so that it has the best view of the entire search area as described in section 6.5.3. Although the monitor should be physically protected from mechanical damage, it requires an unobstructed view of the whole search region and large obstacles such as gates or walls, which could shadow the monitor, should be avoided. It further requires that inspection officers promptly respond to alarms. These alarms may be remotely observed. Alarm indications should be in clear view of the officers manning the inspection point. The automatic portal monitor must be calibrated and tested periodically to be sure that it is giving its best performance. Automatic portal monitors should be checked daily with small radioactive sources to verify that they can detect radiation intensity increases. This simple test verifies that the system is operating and that no immediate repair is required.

2.5.3. Pedestrian Monitors

Pedestrian monitors may be installed as single or dual pillar monitors. Barriers must be installed to restrict the pedestrian traffic so that passage is within 1.0 to 1.5 meters of the monitor. Where pedestrian traffic corridors are larger than 1.5 meters, dual pillars should be installed, but even dual pillars lose effectiveness when the passage is larger than 4 meters. The monitor should be placed away from heavy doors, which can cause excess false alarms, since effective shielding by the doors may lead to increased fluctuations in the radiation background. The occupancy sensor must be positioned so that it is only triggered when the instrument is occupied and not by individuals walking in the vicinity of the monitor. Because of the possibility of gamma shielding in luggage and packages, the monitors are most effective when they are used in combination with X ray machines which can be used to easily identify the presence of shielding material.

2.5.4. Vehicle Monitors

Using fixed installed radiation monitors to search vehicles for radiation sources is complicated by the inherent shielding *due to* the vehicle structure, drive train, and engine. While standard truck-bed monitors are effective in detecting abnormal radiation levels in shipments of metals for recycling, they are much less effective in detecting the illicit trafficking of radioactive or nuclear materials when that material is purposely concealed, due to the different detector geometry, i.e. horizontal versus vertical detector pillars. Monitors designed to detect illicit trafficking, which have detectors to view all areas above and below vehicles are more effective than truck-bed monitors. Barriers, which do not obstruct the view of the monitor, should be installed to protect the monitor from being damaged by the vehicles. Since the sensitivity of the monitor is strongly dependent on monitoring time, the instrument should be placed where the speed of the vehicle is controlled and reduced. The speed of the vehicle should not exceed 8 km h^{-1} and the vehicle should not be allowed to stop while passing through the monitor. The occupancy sensor must be positioned so that it is only triggered when the monitoring system is occupied and not by other traffic in the vicinity.

2.5.5. Minimum Requirements

2.5.5.1. Sensitivity for gamma radiation

At a background level of 0.2 μSv/h, alarm should be triggered when the dose rate is increased by 0.1 μSv/h for a duration of 1 second. The probability of detecting this alarm condition should be 99.9%, i.e. no more than 10 failures in 10 000 exposures. This requirement has to be fulfilled in a continuous, incident gamma energy range from 60keV to 1.5 MeV (tested with ^{241}Am, ^{137}Cs and ^{60}Co).

2.5.5.2. Sensitivity for neutron radiation

The detector should trigger alarm when exposed to a fission neutron flux of approximately 20000 n/s for a duration of 5 seconds, at 2 m distance. This sensitivity corresponds to the detection of a 0.01 µg ^{252}Cf source when the gamma radiation is shielded to less than 1%. The probability of detecting this alarm condition should be 99.9%, i.e. no more than 10 failures in 10000 exposures.

2.5.5.3. Search region

Geometrical region in which the minimum requirements for alarm level are fulfilled:

- Pedestrian monitor: vertical: 0 to 1.8 m, horizontal: 0 to 1.5 m at a normal walking speed of 1.2 m s^{-1}.
- Car monitor (one pillar): vertical: 0 to 2 m; horizontal: up to 4m, speed up to 8 km/h.
- Truck and bus monitor (two pillars): vertical 0 to 4 m, horizontal: up to 3 m, i.e. 6 m between the two pillars, speed up to 8 km/h.

2.5.5.4. False alarm rate

1 false alarm in 10 000 passages. The recommended testing requirement is not more than 4 false alarms in 40 000 occupancies.

2.5.5.5. Operational availability

99%, i.e. less than 4 days out of operation per year.

2.5.5.6. Environmental Conditions

Out door operation in a temperature range of –15°C to +45°C. Dependent on conditions at checkpoint lower temperatures down to –35°C may be necessary. Weather resistant.

2.6. SELECTION OF AN INVESTIGATION LEVEL

An "investigation level" is defined here as the radiation level at which an alarm is triggered and consequent investigation of individuals, vehicles or goods should be established. In order to select a particular investigation level, the alarm threshold of a monitoring instrument has to be adjusted accordingly. The alarm threshold can be expressed in terms of multiples of background, or as a multiple of the standard deviation of the background count rate. Since the relationship between background dose rate and its standard deviation depends on the detection sensitivity of the instrument and the actual value of the background, it cannot be generally stated. Under the condition that fixed installed instruments meet the above mentioned minimum requirements, typical values for detection sensitivity and related count rates can be assumed. A compromise must be reached in establishing a practical alarm threshold so that significant amounts of radioactive or nuclear materials may be detected with an acceptably low false alarm rate. "Innocent" radioactive materials will also trigger alarms, but the subsequent investigation should disclose this and allow continued movement of the individual or goods.

Recommendations for an optimized investigation level can be derived from results obtained from the ITRAP study [4]. Innocent alarms due to NORM and low level contamination are most frequently observed when trucks and lorries are monitored, due to the large amounts of material involved.

Figure 2 shows the frequency of gamma and neutron alarms observed within a duration of one month for the truck lane at Nickelsdorf, the border test site of ITRAP. The intensity of the radiation signal triggering alarm is shown in terms of multiples of background.

It can be seen from this diagram that the vast majority of the alarms comes from radiation signals of less than double background, i.e. in this location less than some 150 nSv/h. The alarms which have been analysed by hand-held isotope identifiers were caused essentially by four different categories of goods (Table I).

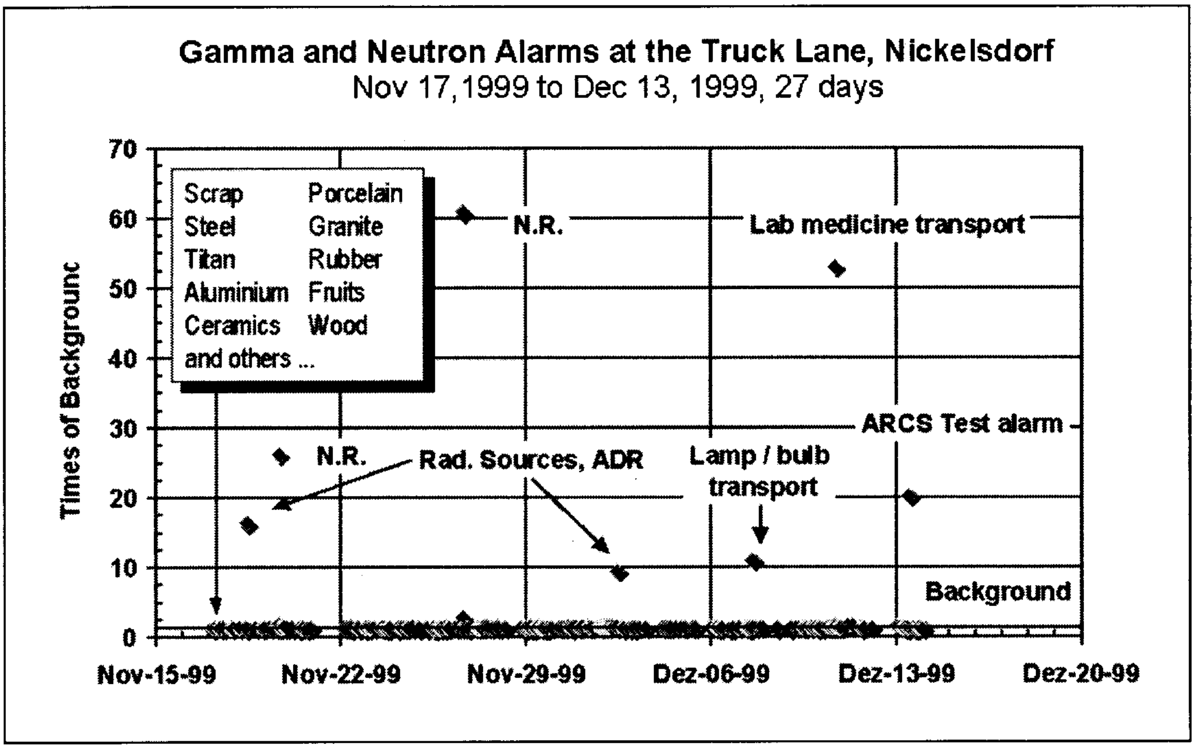

FIG. 2. Frequency and intensity of alarms observed in one month at the ITRAP truck lane.

Table I. Categories of goods which triggered alarms at the truck lane during an observation period of 6 months

Alarms*	Reason	Max. observed multiple of background
10 per day	**Industrial Products and Raw Material e.g. ceramics, fertiliser, lamps, TV, etc**	**10/some events with e.g. ceramics**
1 per week	**Agricultural Products e.g. fruits, vegetable, wood, etc.**	**5/e.g. one event with a chicken transport**
1 per week	**Iron and Metal Transports e.g. Scrap, etc.**	**50/e.g. contaminated metal plates**
1 per week	**ADR (legal) Transport of Radionuclides e.g. radio pharmaceuticals and industrial sources, etc.**	**60/almost all legal transports**

* Traffic approximately 1000 trucks per day.

Results from the ITRAP field tests for truck monitoring indicate that an investigation level of at least 1.2 times natural background (at a normal background level of approximately 0.70 μSv/h), is needed to meet the minimum requirements for the false alarm rate as given in section 6. If the investigation level is raised to 1.4 times background, in addition to fulfilling the false alarm rate requirements, the frequency of innocent alarms can be decreased by approximately by a factor of ten. For example, a truck lane handling some 1000 trucks per day would see innocent alarms reduced from 10 per day to 1 per day, corresponding to an innocent alarm rate of 1% per truck to 0.1% per truck. With this increase of the investigation level the required sensitivity of detection for real illicit trafficking incidents will still be obtained. For instance an unshielded radiation source of 3.7 MBq (0.1 mCi) ^{137}Cs will trigger alarm under the worst case conditions for all fixed installed monitors. For monitoring of pedestrians or cars, where innocent alarms should be caused by medical isotopes only and are generally not so frequent, a lower investigation level of 1.2 times natural background is recommended.

2.7. IDENTIFICATION OF RADIONUCLIDES

2.7.1. General

Whenever an alarm has been triggered and subsequently verified to be a real alarm, caused by an actual increase in radiation intensity, identification of the radionuclide is of vital importance for determining the illicit or innocent nature of the event. Preferably this identification should be performed by the frontline officer responding to the alarm or at least his supervisor in duty at the border checkpoint or the location of the alarm. Although it may be necessary to request outside expert assistance in more serious or complicated events, this is unacceptable in routine situations in view of the hold up time for the individuals involved in the alarm situation.

Radionuclide identification devices are hand-held, battery powered instruments used for field radionuclide identification by non-experts. The instrument should provide consistent energy self calibration. The present generation of available instruments fails to meet all the requirements which are important for field application of such instruments and improvements are needed [4].

The identification of a gamma emitter follows after the detection of an alarm (e.g. by a border monitor or a radiation pager) and the localization of the source, using a portable gamma search tool. Therefore, it is assumed that the identification can, in most cases, be done from close distance (if the dose rate allows) and that sufficient time is available for this investigation.

2.7.2. Radiation detectors

Presently these hand held gamma spectrometers mostly use NaI(Tl) or CsI(Tl) detectors. These detectors have, however, properties which limit their use for in-field isotope identification:

- the limited resolution prevents resolving closely spaced gamma peaks,
- the energy calibration strongly depends on the temperature, count rate, presence of magnetic fields, and detector high voltage;
- the non-linear energy response of these detectors.

These factors make it difficult for such detectors to operate with the desired accuracy under field conditions. Future developments using semiconductor detectors such as CdZnTe, should yield significant improvements in energy resolution and linearity. However, such detectors have limited detection efficiency due to small volume and presently less proven field durability.

2.7.3. Energy range, calibration, and software

Most of the isotopes encountered at borders can be identified by instruments capable of identifying spectra consisting of gamma ray energy peaks between 30 keV and at least 1.5 MeV.

2.7.4. Minimum Requirements for Isotope Identification

The isotopes of greatest interest and those most likely to be encountered are:

- Nuclear Materials: ^{235}U, ^{233}U, ^{239}Pu.
- Industrial Isotopes: ^{137}Cs, ^{60}Co, ^{192}Ir, ^{241}Am, ^{226}Ra, ^{57}Co, ^{133}Ba, ^{232}Th.
- Medical Isotopes: ^{99m}Tc, ^{201}Tl, ^{67}Ga, ^{123}I, ^{125}I, ^{131}I, ^{111}In, ^{133}Xe, ^{192}Ir.
- Naturally occurring radioactive materials (NORM): ^{40}K, ^{226}Ra, ^{232}Th, ^{238}U.

Radionuclide identification devices should be capable of identifying all radionuclides listed above and classify them into the four groups. Since the probability of observing particular isotopes at different types of border crossings, e.g. land borders, airports, seaports etc. varies, it is recommended to define application specific sub-groups. For pedestrian border crossings and airports medical isotopes are most likely to be encountered. Naturally occurring radioisotopes such as ^{40}K, ^{238}U, ^{226}Ra and ^{232}Th are most likely to be detected when large quantities of materials are transported, i.e. at seaports, trains, and truck traffic at land borders.

2.7.5. Test procedures

After calibration the following isotopes, producing a gamma radiation dose rate at detector, of about 0.5 μSv/h above background, should be identified:

- unshielded, less than 1 min: ^{111}In, ^{99m}Tc, ^{201}Tl, ^{67}Ga, ^{133}Xe, ^{125}I, ^{123}I, ^{131}I, ^{192}I.
- behind 3 mm steel shielding, less than 10 min.: ^{235}U, ^{238}U, ^{57}Co, ^{241}Am.
- behind 5 mm steel shielding, less than 10 min.: ^{239}Pu, ^{233}U, ^{133}Ba, ^{40}K, ^{226}Ra, ^{232}Th, ^{137}Cs, ^{60}Co, ^{192}Ir.
- it is desirable that combinations of isotopes, such as ^{137}Cs + ^{239}Pu, ^{131}I + ^{235}U, ^{57}Co + ^{235}U, ^{133}Ba + ^{239}Pu can be identified.

2.7.6. User interface

Great care has to be given to the design of the user interface of the isotope identifier. In particular the device should use an LCD screen, as large as possible and easily readable under various lighting conditions, and a limited number of buttons and keystrokes for navigation. The menu structure should be simple and easy to be followed intuitively. A gamma spectrum is not required to be shown, although should be available at a deeper level of the menu for diagnostics by an expert user. The resulting messages should have a high certainty, if an isotope cannot be identified unambiguously, "not identified" or extended measurement required, should be shown, rather than a wrong identification. Indication of more than one choice for a single radioisotope is not acceptable. The processing speed of the software should be high and analysis results shall be available on the spot with an analysis time of <1 min. The possibility must exist to store spectra in a non-volatile memory and to transfer them to a computer or over a remote link for expert review, if problems cannot be resolved on the spot.

2.7.7. Combined instruments

Often it is the desire of the user to have a combined hand-held instrument with the following functions: dose rate meter with alarm functions, neutron and gamma search instrument and isotope identification. While it has been demonstrated that all these functions can in principle be combined in a single device, significant compromises must be made, either to size, weight and battery life, search capability, neutron detection sensitivity or performance of the isotope identification

3. RESPONSE TO ILLICIT TRAFFICKING IN RADIOACTIVE MATERIALS

Discovery or disclosure of illicit trafficking in or inadvertent movement of nuclear and other radioactive materials requires well established response mechanisms to manage such events. Incidents vary considerably, and while the majority of these relate to the illicit trafficking in or inadvertent movement of small quantities by individuals, there have been some instances of large-scale shipments or attempted shipments of radioactive or nuclear materials across international boundaries. Within all response measures health and safety aspects are of primary importance. Despite the varied nature of these incidents, two clear response paths have emerged. The first is the need for immediate reactive measures when an incident is discovered and it is suspected that there are radioactive or nuclear materials at the scene. The second is a proactive response based upon intelligence reports. Whatever the scope of the incident, the fact that radioactive or nuclear materials are involved only heightens international concern, and it is imperative that all such incidents are correctly handled.

3.1. REQUIREMENTS FOR RESPONSE

A reactive response will be required in the following circumstances:

- detection of the unauthorized or uncontrolled presence or movement of radioactive or nuclear materials through radiation monitoring;
- notification of radioactive or nuclear materials having been found in an unauthorized location;
- notification about an object suspected of containing radioactive or nuclear materials;
- notification about an incident involving, or suspected of involving, radioactive or nuclear materials, and where illicit activity is indicated; and
- discovery of a discrepancy between a customs declaration form and the corresponding shipment of radioactive or nuclear materials.

A proactive response will be required in the following circumstances:

- notification about the detection of instances of non-compliance with transport regulations;

- discrepancies found in the inventory of radioactive or nuclear materials; and
- receipt of information suggesting the illicit trafficking in or inadvertent movement of radioactive or nuclear materials.

3.2. SCALE OF RESPONSE

An assessment of previous incidents has shown diverse situations ranging from inadvertent or illicit possession of small quantities of radioactive materials, which were relatively harmless, to the possession and trafficking in weapons grade nuclear materials, which may pose a serious security threat. Irrespective of the severity of the incident, the over-riding considerations will be:

- to minimize any potential health hazards;
- to bring the radioactive or nuclear materials under appropriate control; and
- to investigate, gather evidence and prosecute offenders.

The scale of the response should be geared to the severity of the individual situation. In cases where there is no significant health hazard, security implication or proliferation threat, front-line officers and the routine response mechanisms of their respective agencies can deal with an incident simply yet effectively. In a serious incident, there will be a need for a more elaborate response mechanism and the scale of the response will increase. It is therefore appropriate to consider a flexible approach, which can move from the immediate operational requirements into a tactical response mechanism and, on very rare occasions, to a strategic level if the need arises.

3.3. OPERATIONAL RESPONSE

Operational Response includes the immediate response mechanisms to be adopted upon an alarm, which could be from a fixed installed, hand-held or pocket type radiation monitor. There are other ways in which a First Information Report may be received by a responding agency, such as Intelligence Reports. In many situations, the use of radiation detection equipment will provide either the first information or confirmation that radioactive or nuclear materials are present. An alarm activation should trigger an alert whereby personnel at the scene are made aware of a potentially hazardous situation. The alert process should also result in the Duty Supervisor of the responding agency being informed of the incident and assuming initial command and control functions. A flowchart which outlines the process to be adopted upon an alarm activation is illustrated in figure 3.

3.3.1. Safety Considerations

Irrespective of the scale of the incident, response personnel must always be aware that there may be hazards associated with an incident involving radioactive or nuclear materials. In such cases the safety of response personnel and the general public is of paramount importance. Response personnel must be familiar with safety procedures and the measures which can be adopted to mitigate health hazards. In the unlikely event that a situation arises whereby there are injured individuals at the scene, who may have been contaminated by radioactive materials or exposed to radiation, casualty handling at the scene may be necessary.

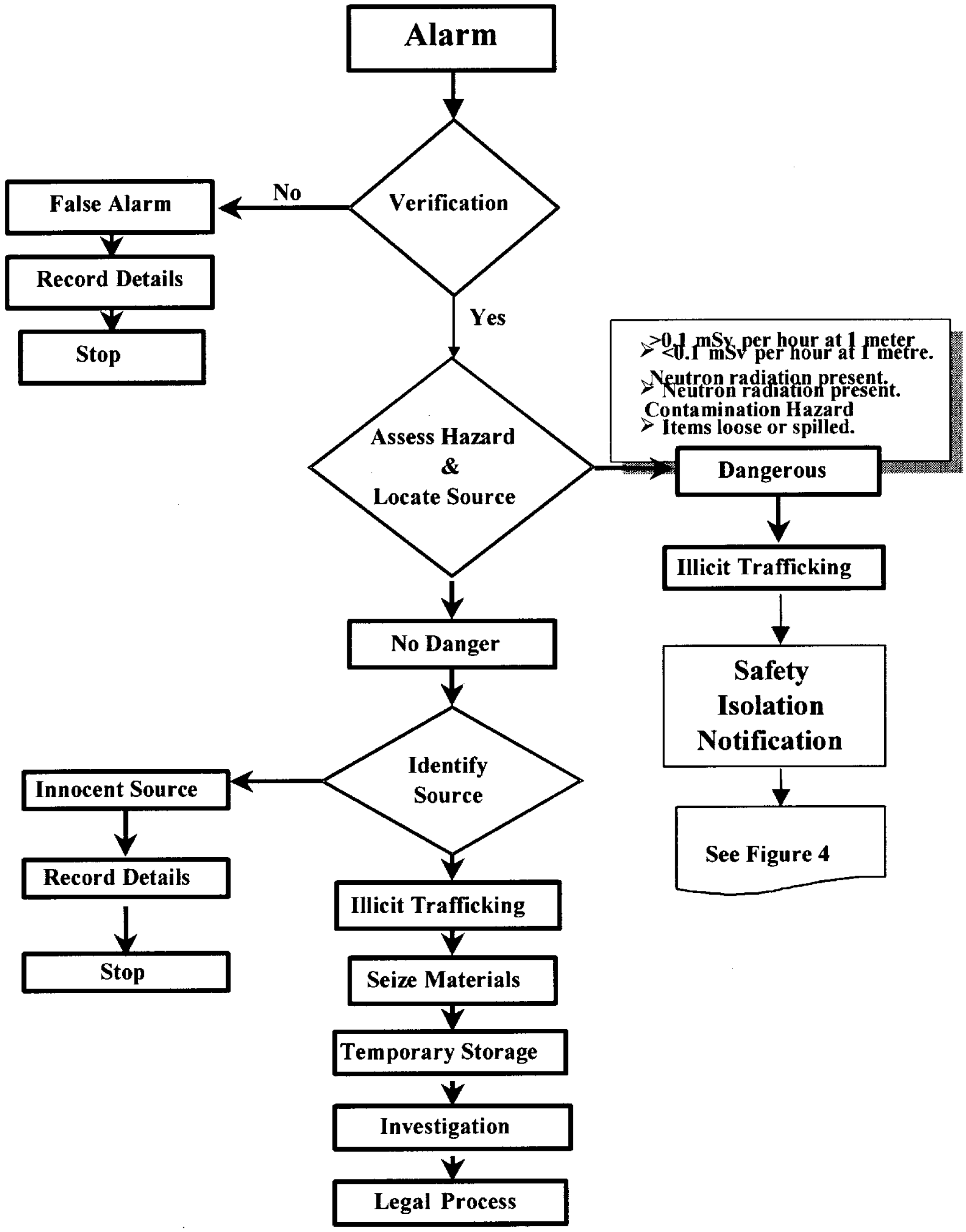

FIG. 3. First response after alarm activation.

3.3.2. Actions by the First Responder

It is assumed that response personnel at the scene will be equipped with radiation detection equipment. This equipment should enable the First Responder to assess the radiological hazard by measurement of the dose rate, and to locate and identify the radioactive source. When an alarm is activated as a result of a radiation monitoring programme, the First Responder should report the circumstances of the alarm activation to the Duty Supervisor, giving as much information as is immediately available. The Duty Supervisor should then take action to verify the alarm.

3.3.3. Verification Procedures

To verify that the alarm is genuine and to confirm the presence of radiation, the First Responder should use a second set of radiation detection equipment. For instance, if a static portal alarm is activated, the First Responder could utilise a radiation pager, hand-held survey meter or some other radiation detection equipment to verify the presence of radiation. If the initial alarm cannot be verified by a second instrument, it may be assumed that the first indication was a false alarm. If the presence of radiation is confirmed by the verification process, action should then be taken to assess the radiological hazard.

3.3.4. Methods to assess the Radiological Hazard

To assess the radiological hazard at the scene of an incident, hand-held dose rate meters (survey meters) have to be used. While locating a radioactive source, radiological safety is one aspect to be considered, as determined by the dose rate measurement.

3.3.5. Location of the Radioactive Material

The First Responder should act to establish the location of the radioactive material. At this stage, it is sufficient to determine the general location of the radioactive source without knowing its exact location. For example, it would be acceptable to determine that the radioactive source was confined to a piece of luggage or a vehicle or to something like a large commercial container, where the materials could be isolated if the situation proved to be hazardous. The location of the radioactive material could be determined without opening the item which contains the material. Until such time as a full radiological assessment is made, response personnel must take precautions to avoid contact with radioactive materials. Although it may not be possible to avoid exposure from external radiation, it should be noted that skin contamination, inhalation and ingestion of radioactive substances may also pose health hazards. Response personnel should therefore avoid eating, drinking and smoking in the immediate area until it is ascertained that they have not been contaminated with radioactive materials. Having identified the general location of the radioactive source, the First Responder may approach the radioactive source using a dose rate meter to determine the extent of the radiological hazard and to observe the situation close to the radioactive source.

If the First Responder encounters any of the following conditions, the scene should be considered dangerous:

- a reading in excess of 0.1 mSv per hour[1] at a distance of one metre or further from the item containing the radioactive source;
- any indication that there is neutron radiation present[2]; or
- any indication that the packaging or container containing the radioactive source have been ruptured or damaged, or that radioactive materials are loose or have been spilled.

In such a situation the First Responder should primarily ensure the safety of individuals in the vicinity, the isolation of the radioactive source and the notification of the situation to the duty supervisor. He should then withdraw to a safe distance from the radioactive source.

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[1] This reading is equivalent to the upper dose limit at 1 m distance from a package used for the legal transport of radioactive materials, as detailed in IAEA Safety Standard Series No. ST-1 [6].

[2] The presence of neutrons suggests that fissionable nuclear materials may be present.

The level of 0.1 mSv per hour at a distance of one meter has been chosen assuming that the First Responder will be this close to the radioactive source for only a brief time. Lower levels may be set according to national regulations. An assessment of previous incidents has shown that the majority are of a minor nature with little or no radiological hazard. These can be dealt with at an operational level without the necessity to activate a Tactical Response or an Emergency Response Plan.

3.3.6. Identification of the Radionuclide

If it has been established that there are no significant radiological health hazards associated with an incident, the next action of front-line officers should be to identify the radioactive source. At this stage it is possible that the suspect radioactive source may be identified as an innocent source. If that occurs, front-line officers should record the details and terminate their response.

If it is determined that it is a case of illicit trafficking, the First Responder should consider the gathering of evidence at the scene to support a future criminal prosecution. If it is ascertained that the radioactive materials are nuclear materials, those materials have to be seized, contained securely under constant surveillance by guards, and the relevant competent authorities notified immediately. To ascertain if there are any circumstances which indicate inadvertent or illicit activity, it should be noted that, in nearly all cases of legal transportation of radioactive materials, the persons responsible for the shipments should be in possession of authentic documentation to support the transportation. The radioactive materials should be labelled and packaged in accordance with the regulations governing the transportation of radioactive materials [6] and most importantly the radiation levels should be within the acceptable levels for the transportation of such materials. It should also be noted that specific regulations exist for the physical protection of nuclear materials.

If it is ascertained that the radioactive materials arise from an innocent radioactive source such as medically administered isotopes, natural radiation not exceeding accepted levels or legal shipments of radioactive materials, then front-line officers should record details of the incident and terminate the response procedures.

3.4. TACTICAL RESPONSE

When a dangerous radiological situation develops, it will be necessary to adopt a tactical response mechanism. This entails the management of an incident by a response team which has a pre-designated command structure and which will operate to a Tactical Response Plan in accordance with the relevant procedures. Figure 4 shows a schematic flow diagram of a tactical response mechanism.

3.4.1. Command Structure

All military forces, law enforcement agencies and emergency services will have their own command structure and internal reporting procedures. Consequently it is not practical to specify a command structure, which could be adopted for tactical response to illicit trafficking in and inadvertent movement of radioactive or nuclear materials. The structure outlined in the following paragraph is offered as a generic model of the command functions, which may be required during a tactical response at the scene of an incident. Each command structure must cater for national and local conditions. It is a framework, which requires modification for

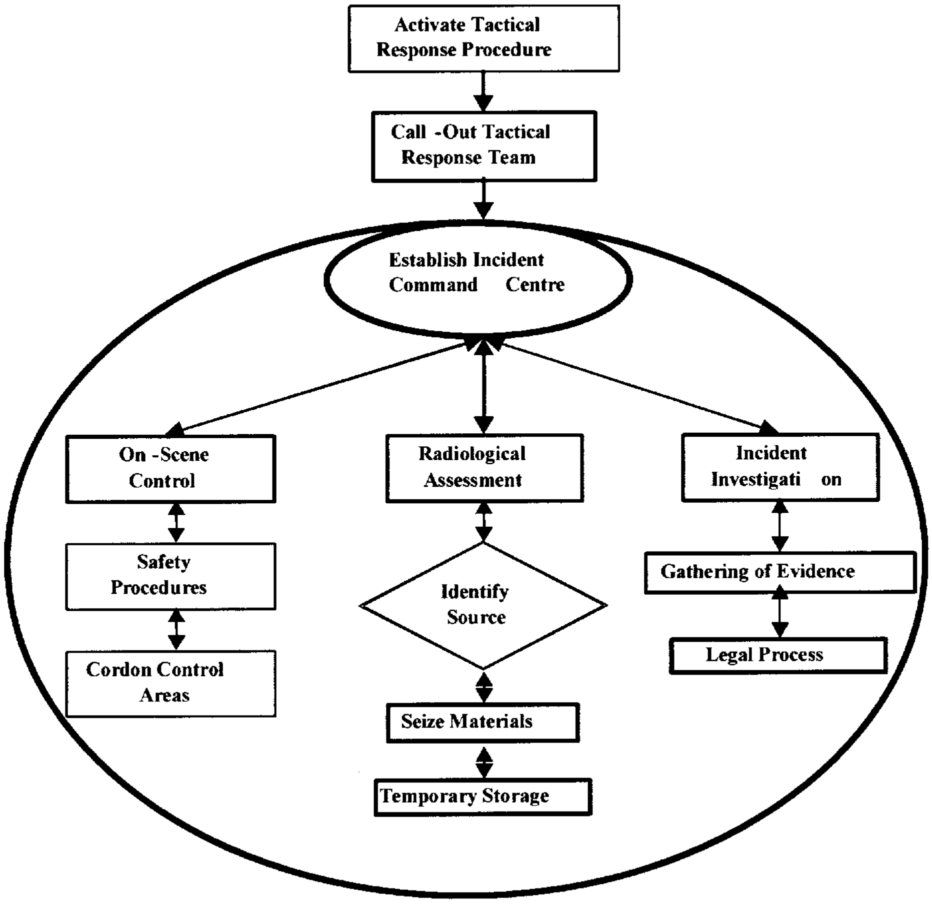

FIG. 4. Tactical response mechanism.

every incident, as each will present a different scenario and require differing levels of flexibility in the response procedures.

Activation of a tactical response should result in the mobilisation of three key command personnel, who will form the Response Team. These are the:

- Incident Commander in charge of deployment and direction of resources at the scene of the incident;
- Radiological Advisor responsible for radiation surveys, contamination control and radiation protection support to response personnel and the public; and to provide expert advice to the incident commander as appropriate; and
- Incident Investigation Officer responsible for all investigative processes associated with the incident, including evidence gathering and preparation for any future criminal prosecution, judicial inquiry, inquest or other statutory investigation.

From the time of the notification of the incident occurrence until the pre-designated officers are in position to exercise their command functions, the responsibilities of the Incident Commander should be assumed by the most senior officer of the responding agency at the scene of the incident.

3.4.2. Incident Command Centre

Tactical command of all field personnel should be co-ordinated from an Incident Command Centre, which should provide a facility for the Incident Commander to deploy resources at the scene. The Incident Command Centre should be the central point of contact for all agencies deployed. The siting of the Incident Command Centre will be dependent upon the prevailing circumstances at the scene. If there are no suitable buildings nearby, it may be necessary to operate the Incident Command Centre from a vehicle. There are several considerations regarding the siting of the Incident Command Centre. These are:

- Safety if outdoors, the Incident Command Centre should be sited up-wind of any radioactive sources, to avoid the spread of potential contamination and should be sufficiently remote to minimise exposure to radioactivity.
- Accessibility ideally, the Incident Command Centre should be sited adjacent to an approach route to the scene and the site should provide sufficient space for parking of emergency vehicles.
- Conspicuous the Incident Command Centre must be clearly marked and sign posted; and
- Security the Incident Command Centre must be secure from any criminal activity and accessible to authorized personnel only.

Communications are essential and all available systems must be considered. The use of radios and mobile phones, although extremely useful in field operations, are not secure unless encrypted. The configuration of the Incident Command Centre should provide facilities for representatives of all responding agencies deployed at the scene. This helps to ensure co-operation and encourages liaison.

The primary function of the Incident Command Centre is to provide facilities by which the Incident Commander can control and co-ordinate the response at the scene. In addition, inter alia, it makes provision for:

- liaison between responding agencies deployed at the scene;
- assessment of the radiological hazard (for all kinds of radiation);
- implementation of measures to protect health;
- handling and management of any casualties;
- handling and reception of any arrested individual(s);
- logging details of all personnel operating at the scene;
- supervision of cordon control areas; and
- traffic control and vehicle movement.

3.4.3. Cordons and Cordon Control Area

When a radiation hazard is suspected or known, it is essential that an inner cordon be established around the radioactive source and all personnel evacuated from within the inner cordon control area. The inner cordon should be set up at a dose rate level of not more than 0.1 mSv per hour. In certain incidents it may not be practicable to establish cordon procedures. For example, a passenger disembarking from an aircraft, train, bus or vessel and carrying illicit radioactive materials, may be detected when the individual passes through an inspection point. In such eventuality it would not be practicable to establish a cordon around the inspection point and the most appropriate response would be to immediately escort the individual to a secure room where he/she should be isolated.

For security reasons an outer cordon should also be established as a working area for field personnel and should be free of any individual who does not have authority from the Incident Commander to be within the cordon control areas. The distance of the outer cordon can be determined by the prevailing circumstances, but must allow sufficient area for field personnel to operate effectively. It must also be noted that the area of the outer cordon down-wind of the radioactive source should be kept free of personnel. A diagram of Cordon Control Areas is shown in figure 5.

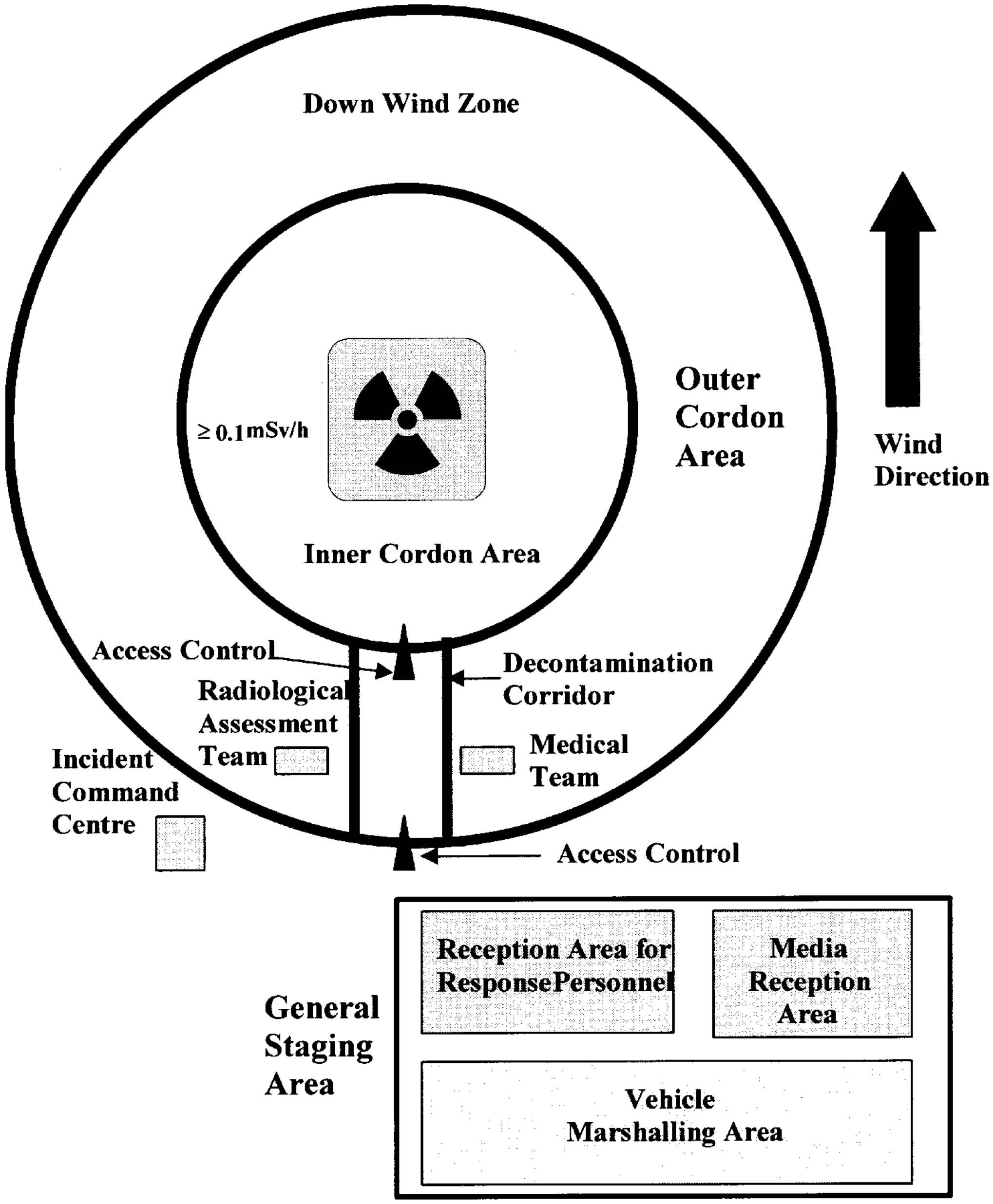

FIG. 5. Generic model for a cordon control area.

The Incident Commander should appoint cordon commanders to control access to the two cordon controlled areas, with specific instructions as to who is permitted into these areas. Any individual entering the inner cordon must do so on the personal directive of the Incident Commander and must at all times be accompanied and supervised by a radiological safety officer. It is the duty of the radiological safety officer to provide personal dosimeters and all other necessary protective equipment. All personnel on cordon duty must be fully briefed on their role, particularly those deployed on the outer cordon where sightseers and media personnel are likely to attempt entry. For reasons of radiological safety a log must be maintained on the movement of personnel into and out of the inner cordon, with specific timings.

3.5. MITIGATION OF HEALTH HAZARDS

3.5.1. General

The Radiological Advisor is responsible to the Incident Commander on all matters relating to mitigation of health hazards. Field personnel working at the scene should do so under the supervision of the Radiological Advisor and in accordance with prescribed dose limits. If there is external radiation at the scene of an incident, it may not be possible for field personnel to avoid irradiation. Exposure to external radiation should be controlled. This can be done by:

- maintaining a safe distance from the radioactive source;
- limiting the time in close proximity to the radioactive source; and
- using shielding materials to reduce the radiation.

Another health hazard is posed by surface contamination whereby field personnel have direct contact with radioactive materials. If this occurs, the contamination should be removed as early as feasible. If there are no standard facilities available, then arrangements should be made for field personnel to change their clothes and wash themselves as soon as practicable.

A further health hazard may be posed by incorporation of radioactive materials into the body, either through ingestion or inhalation. To avoid incorporation, field personnel should not:

- disturb any materials, which have leaked or spilled from a suspicious container.
- disturb the contents of any suspicious package; or
- eat, drink or smoke within the cordon controlled areas or prior to being checked for contamination.

3.5.2. Protective Measures

Protective clothing and gloves can help to avoid body surface contamination, but as a general rule field personnel should not touch suspicious substances. Arrangements should be made for the disposal of contaminated protective clothing. If there is any danger of air-borne radioactive particles, as advised by the Radiological Advisor, then field personnel should use respiratory protection as a precautionary measure. The use of specialized breathing apparatus, however, requires specific training and the equipment should only be used by trained professionals.

3.5.3. Personal Dosimeters

Personal dosimeters are used to assess radiation exposure. These are small instruments which are attached to an individual’s clothing. They record the dose of external radiation. Some may also provide a signal when radiation dose or dose rate above a predetermined alarm level is encountered. All field personnel working within the inner cordon area should be issued and use personal dosimeters. Standard dosimeters are generally not suitable to assess the dose arising from neutron emitting materials. In such cases, where there are neutron emitting materials present, the dose should be assessed by a hand-held neutron dose meter.

3.5.4. Hand-held Monitoring Equipment

Radiation survey meters are usually sensitive to beta-gamma radiation and can be used to measure the levels of radiation. They can also be used to monitor individuals for possible contamination. Unless there are fixed installations in place to monitor levels of radiation, a portable survey meter will normally provide the first information on radiation levels at a scene. It is standard practice to use a survey meter on the approach to any suspicious object, as the instrument should give an early indication of increased levels of radioactivity. This information will be important when trying to establish a safe working distance and to determine the size of the inner cordon. Records should be kept of all measurements and readings, together with the timing and exact location of the reading.

3.5.5. Monitoring and Decontamination

The establishment of cordon controlled areas should provide single access points to both the inner and outer cordon. The Radiological Advisor should implement contamination control at an appropriate place outside the inner cordon area. If necessary, and as space allows, the Radiological Advisor should also establish a decontamination corridor leading from the inner cordon area. Personnel and equipment should then be monitored when they exit the inner cordon area. As a general rule, if there are detectable contamination levels in excess of twice the normal background radiation levels, personnel should first proceed to the decontamination facilities and decontamination should be attempted. In life threatening situations, treat trauma first. Once this has been attended, decontamination may then be performed.

Decontamination serves several purposes. First, it reduces the potential for continued exposure. Second, it minimises dose to the individual and dose rates within the operational area. Third, it also limits the spread of contamination and hastens the return to normality. Final monitoring of personnel and equipment should be done at the exit of the outer cordon to ensure that no contaminated individuals or equipment leave the cordon controlled areas. Even if there are no detectable levels of external radiological contamination, response personnel should be advised to bathe or shower after leaving the scene and to launder clothing thoroughly. Basic decontamination processes involve removal of contaminated clothing and washing the entire body thoroughly. It is important to identify areas of skin that have been contaminated and to wash and rinse those areas repeatedly, but care must be taken not to abrade the skin surface. In the event that decontamination processes at the scene do not result in complete decontamination of an individual, that individual may, under the direction of the Radiological Advisor, be referred to an appropriate medical facility.

4. CONCLUSION

The information provided in this paper is intended as an overview of the detection and response measures required to deal with incidents of illicit trafficking in or inadvertent movement of radioactive and nuclear materials. It is written from the perspective of a customs or police officer, or other front-line response individual who may be confronted with such incidents. It is expected that more complete technical information on this subject will be published by IAEA in near future and available to the Member States of IAEA, the World Customs Organization (WCO) and INTERPOL.

REFERENCES

[1] LUBENAU, J.O., YUSKO, J.G., *Radioactive Materials in Recycled Metals an Update.* Health Physics, Vol. 74 (3), 293 (1998).

[2] DUFTSCHMID, K.E., *IAEA Activities for assisting Member States in combating the illicit trafficking of radioactive materials*, Proceedings International Conference on Physical Protection of Nuclear Materials, IAEA Vienna, November 1997, IAEA-CN–68/27 (1998).

[3] BECK, P., DUFTSCHMID, K.E., *ITRAP the illicit trafficking radiation assessment program,* Proceedings. IAEA Conference on the Safety of Radiation Sources and the Security of Radioactive Materials, Dijon France, Sept. 1998, IAEA TECDOC-1045, 265 (1998).

[4] BECK, P., DUFTSCHMID, K.E., SCHMITZER, CH., *ITRAP International Laboratory and Field Test Site Exercise for Radiation Detection Instruments and Monitoring Systems at Border Crossings,* Proceedings International Conference on Security of Material, Stockholm, May 2001, IAEA-CN-86 (2001).

[5] ARLT, R., BECK, P., DUFTSCHMID, K.E., KOVAR, A., SWOBODA, M., *Improvement of Equipment needed for the Detection and Characterization of Nuclear Material and Radioactive Sources at Borders.* IAEA International Conference on Security of Material, Stockholm, May 2001, IAEA-CN-86/28 (2001).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, *Regulations for the Safe Transport of Radioactive Material,* Safety Standards Series No. ST-1, IAEA, Vienna (1996).

QUESTIONS AND ANSWERS

I. Ray (EC): Border detection systems cannot detect contamination of scrap metal Pu, U or HEU in trace or powder form. Should swipe testing be introduced in scrap metal works?

K. Duftschmid (Austria): I fully agree. Border detection cannot even find strong gamma sources in shielded containers buried in scrap. However, I doubt whether the steel industry would agree to perform swipe tests routinely on scrap metal even though this would be the only efficient method in this case.

S. Erickson (USA): You mentioned that intelligence played a key role in detecting smuggling of nuclear material but you did not explain how. How would intelligence affect border procedures?

K. Duftschmid: Up to now, intelligence has detected NM smuggling more frequently than radiation measurements have, mainly due to the fact that very few border monitoring systems are in use worldwide. So far, intelligence has been much more important in triggering response measures to criminal groups who use sophisticated means of smuggling.

S. Fernandez Moreno (Argentina): Does the written text to be used by customs and other law enforcement officers clearly distinguish between "illegal", "malevolent" movements of NM and innocent movements caused by a breach in safety and security of a radiation source? Such a distinction should be made.

K. Duftschmid: Yes, there is a clear distinction in definition and in some response measures between "illicit", "inadvertent" and "innocent" movements. However, this distinction only becomes relevant after initial detection and response by a front-line officer. If the material can be identified on the spot, “innocent” can be ruled out. The distinction between “inadvertent” and “criminal” events is often made much later in court.

A. Nilsson (IAEA): Instructions to officers at borders must differ according to whether the material seized is nuclear material or other radioactive material.

K. Duftschmid: We need to distinguish between a first response on the border, when the officer has not clarified the situation, and a further response, when the type, amount and nature of the material is known, which will probably come much later.

ILLICIT TRAFFICKING — TECHNOLOGY AND METHODS
(Session 8)

Chairperson

D.S. IONESCU
Romania

IMPROVEMENT OF EQUIPMENT NEEDED FOR THE DETECTION AND CHARACTERIZATION OF NUCLEAR MATERIAL AND RADIOACTIVE SOURCES AT BORDERS

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Abstract. This paper addresses shortcomings of the present equipment generation used for the characterization of seized nuclear material and radioactive sources at borders, as identified by ITRAP (Illicit Trafficking Radiation Detection Assessment Program). It is shown, that the capability of hand-held isotope identifiers to detect shielded sources and mixtures of isotopes can be improved, if in conjunction with a scintillation detector, a large volume CdZnTe detector is used. Different detector models are compared, with the goal to find the most suitable one. A usability review of a hand-held device has been performed to investigate problems reported with the practical use of such devices. A number of specific problems have been identified and suggestions for improvements are made. It is intended to continue this effort with models of different manufacturers and to derive user interface design guidelines for such devices. In addition, a neutron monitor with a high sampling speed has been set up for test purposes to investigate the time distribution of neutron alarm events recorded with commercial monitors at the Airport Vienna-Schwechat. The monitor has been installed, data collection has started and first results are expected in the near future.

1. INTRODUCTION

Gamma rays and neutrons cannot be sensed by human beings. Therefore, technical measures play a decisive role in the detection of illicit trafficking of nuclear material and radioactive sources at borders. Such measures extend our senses and guide us to detect what others may have to hide. The instruments must be commercially available, affordable, reliable and they should have a high hit-rate. Significant effort from the side of instrument developers, fabricators — and also from the side of the organizations which have to accept, test, implement and operate the devices — is needed to achieve these goals.

This paper is a contribution to selected topics of improving the technical means to detect illicit trafficking of nuclear material and radioactive sources and to characterize seized items. It is based on the findings of a major equipment evaluation program (Illicit Trafficking Radiation Detection Assessment Program, ITRAP) which was conducted by the Austrian Research Center Seibersdorf (ARCS) in cooperation with the International Atomic Energy Agency [1].

Taking the ITRAP results as a starting point, one focus of this paper is on the improvement of the capability of hand-held isotope identifiers. In addition a contribution is made to investigate the origin of neutron alarms, which were observed at border monitors installed at the Airport Vienna-Schwechat. The work and results presented, make use of similarities and synergies of equipment needed to detect illicit trafficking, with technologies and instruments used in the Department of Safeguards for the verification of nuclear material.

2. HAND-HELD ISOTOPE IDENTIFIERS

2.1. SHORTCOMINGS FOUND BY ITRAP

Hand-held devices are multi-purpose instruments and used by customs, police officers and border guards to confirm an alarm of a border monitor, to locate the source and to do a first characterization of the suspicious item on the spot. Depending on the result of this first investigation, the course of further action is determined, e.g. the passage of a person who had an injection of a radioisotope for medical purposes, or calling in an expert team if there is the indication of illicit trafficking. Therefore, these devices must provide reliable readings to avoid misleading or wrong conclusions.

The ITRAP findings concerning hand-held devices can be summarized as following [1]:

“The ITRAP lab tests concerning isotope identification systems have shown that no instrument could fulfill all IAEA minimum requirements concerning isotope identification, particularly the requirements concerning identification of shielded isotopes. Further improvements of isotope identification systems (hard-and software) and advanced requirements for field tests are strongly recommended”, and

“In general it has been observed that several of the tested hand-held equipment was too complicated for practical usage by border guards”.

Similar problems were observed during training courses organized by the IAEA for customs and police officers and border guards. Because of obvious limitations of hand-held identifiers, national authorities are sometimes still hesitant to use them at borders. This may lead, e.g. to the consequence that at border crossings, persons treated with medical radioisotopes and causing an alarm of a border monitor, need to be delayed until a expert team has arrived to identify the radiation. It is also noted that there are considerations at the IAEA, to enhance the requirements compared to the minimum ITRAP requirements, in particular with reference to the detection of multiple isotopes and shielded samples [2]. Therefore, the knowledge of factors, which presently limit the performance of such devices, is important.

2.2. THE USE OF SCINTILLATION AND LARGE VOLUME CDZNTE DETECTORS FOR ISOTOPE IDENTIFICATION

2.2.1. Scintillation detectors

The present generation of hand-held isotope identifiers uses scintillation detectors, equipped with either NaI(Tl) or CsI(Tl) crystals. These detectors are commercially available, not expensive and well known.

But if used under field conditions in hand-held devices to identify isotopes, some of their properties limit the results that are achieved:

- Temperature dependency of the gain.
- Non linear energy scale.
- Limited resolution.
- Gain shift caused by magnetic fields.
- Gain shift due to high count-rate.

The introduction of various corrections can improve the performance to the extent that single isotopes and unshielded sources can be identified with good success. The software of the measurement devices, however, becomes sophisticated. The verification of shielded nuclear material and nuclear material masked by medical or industrial isotopes remains difficult.

2.2.2. Comparison of gamma spectra of shielded sources taken with NaI(Tl) and CdZnTe detectors

In figure 1, a comparison of gamma spectra of a Pu source (84% Pu-239) and a Ba-133 source measured with NaI(Tl) and CdZnTe detectors (model CZT/500s, volume 500 mm^3) is shown. Both sources were shielded with 5 mm of lead. The gamma spectra taken with the NaI(Tl) detector show a broad structure that is difficult, or even impossible to interpret using isotope identification software. The CdZnTe detector spectrum shows still distinct gamma peaks in the region around 400 keV, which can be used to distinguish Plutonium from Ba-133, although at the expense of extended measurement time.

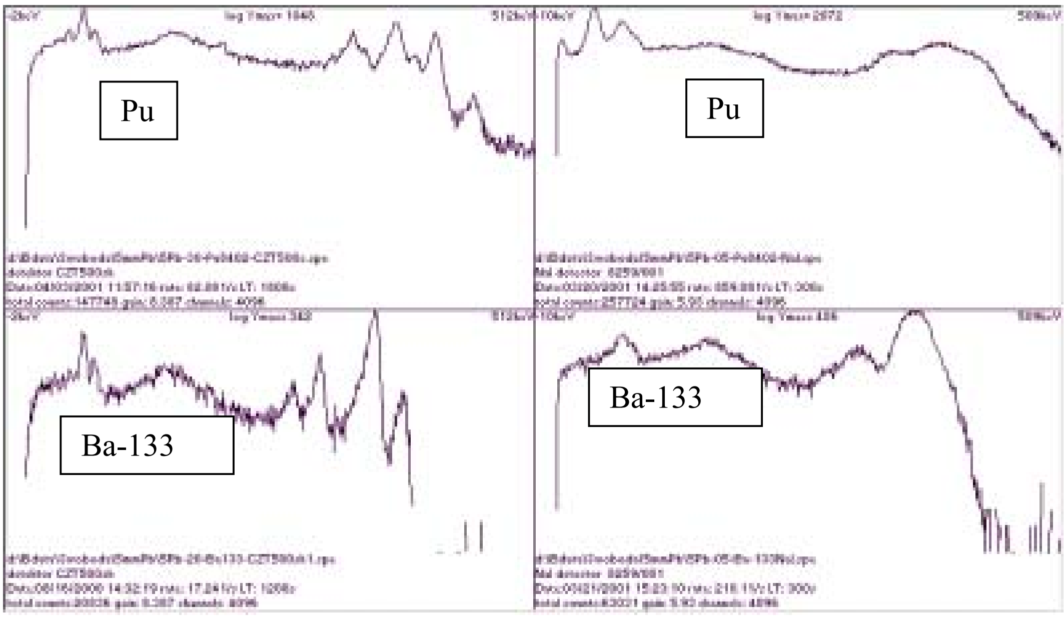

FIG. 1. Comparison of gamma spectra of Ba-133 and a Pu sample (84% Pu-239) measured with CdZnTe detector, model CZT/500s and NaI(Tl) detector 1 "X1"; left side — spectra measured with CZT/500s detector, on the right side — same sources measured with NaI(Tl) detector.

As it is evident from figure 1, the use of the CdZnTe detector considerably improves the detection capability of a hand-held isotope identifier — in particular if the source is shielded. What are the properties that make CdZnTe detectors suitable for use in isotope identifiers?

2.2.3. Properties of large volume CdZnTe detectors

CdZnTe detectors are room temperature semiconductor detectors, which have a resolution between that of liquid nitrogen cooled HPGe detectors and NaI(Tl) detectors. The development of this relatively new material and detector technology is mainly driven by medical applications and X ray astronomy. Detectors are commercially available and widely used by the IAEA and EURATOM safeguards inspectors to verify Pu, U and spent fuel [3].

Compared to NaI detectors, the following properties make CdZnTe detectors attractive for use in hand-held isotope identifiers:

- Good temperature and long-term stability.
- Linearity of the energy scale.
- 2–3 times better energy resolution.
- Not sensitive to magnetic fields.
- Large dynamic countrate range without peak shift.

Two drawbacks should be noted. Since CdZnTe detectors have a smaller volume, they are much less sensitive compared to NaI(Tl) detectors and they are also more expensive. Their lower efficiency leads to gamma spectra with lower counting statistics if the measurement time is not extended. In Ref. [4] we have investigated the extraction of gamma peak information from CdZnTe spectra with low counting statistics, but good energy calibration and resolution. Despite the low statistics of CdZnTe spectra, reliable peak information can be obtained — in particular for shielded and mixed sources. This suggests the use of CdZnTe detectors in hand-held isotope identifiers — but combined with a scintillation detector to compensate for their low sensitivity for gamma energies above 1 MeV. In Table I the properties of commercially available, large volume CdZnTe detectors are compared. Differences are obvious and some of them are discussed below.

Table I. Compilation of properties of various large area CdZnTe detectors

Model	Type	Volume cmm	FWHM at 662 keV	Peak/Compton ratio (662keV)	Relative photo peak efficiency at 662 keV
CZT500s	Hemisheric	500	15.2	4.5	27
CZT1500	Hemisheric	1687.5	17.4	5.2	93
CPG A2317	Co-planar	1687.5	22.8	4.8	100
CAP A2156	4XCAP	750	19.8	1.3	8
CAP A2157	9XCAP	1687.5	22.5	1.2	20

CAP detectors (eV Products), designed for low energy gamma spectrometry, are less expensive compared to hemispheric detectors (eV Products/RITEC) or detectors with co-planar electrodes (eV Products). Their photo peak efficiency and peak/compton ratio drops quickly at higher energies. This is shown in figure 2. If the detection efficiency for both detectors is normalized at 122 keV, the relative detection efficiency for CAP detectors in the region of 200–300 keV is about 2 times lower and in the region of 1 MeV about an order of magnitude lower compared to the hemispheric detector. The reduced efficiency of CAP detectors at gamma energies > about 200 keV and their poor peak/compton ratio for high gamma energies (see Table I), makes hemispheric detectors more suitable for isotope identification — but the customer must willing to pay the higher price.

The precision of the energy calibration under various field conditions is an important factor, which determines the reliability of the result of isotope identification. Good temperature stability of the gain of the gamma spectrometer is essential. Since NaI(Tl) detectors have a large temperature drift, complicated peak stabilization methods often involving the use of a radioactive source — need to be used. CdZnTe detector based gamma spectrometers exhibit a much better temperature stability compared to scintillation detectors. Practically, they can be operated without peak stabilization, which is an advantage.

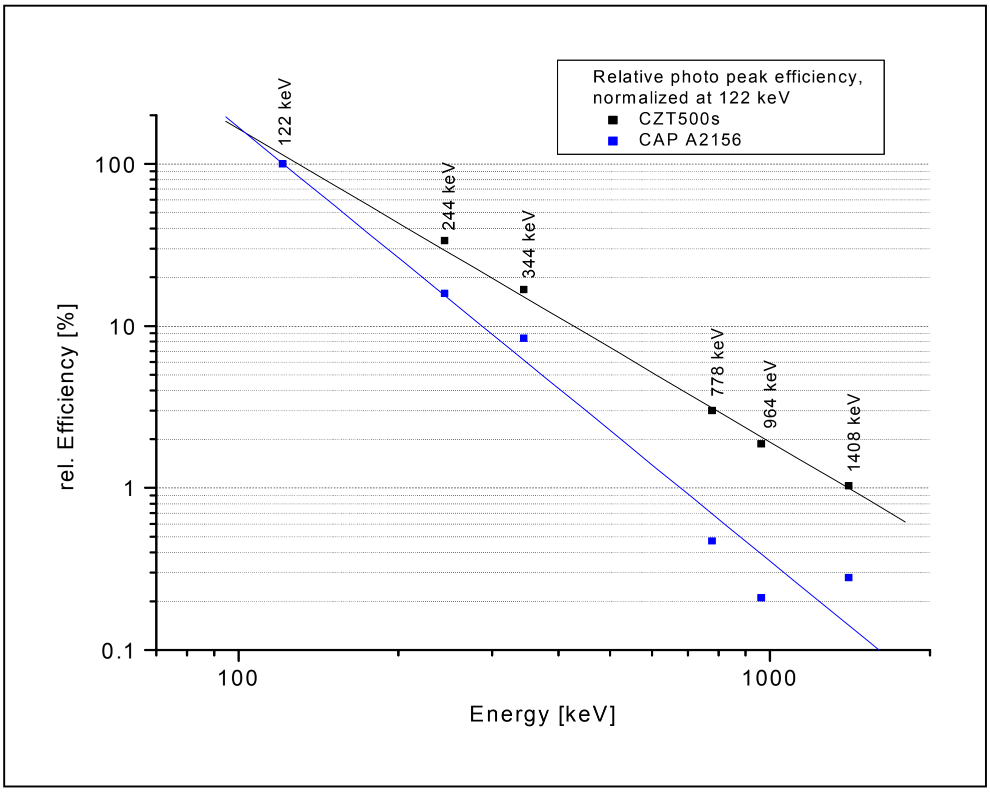

FIG. 2. Comparison of the slope of the efficiency curve for a CZT/500s detector (upper curve) and a CAP detector assembly consisting of an array of 4 detectors (lower curve). Both curves are normalized at 122 keV. The measurements were made with an Eu-152 source.

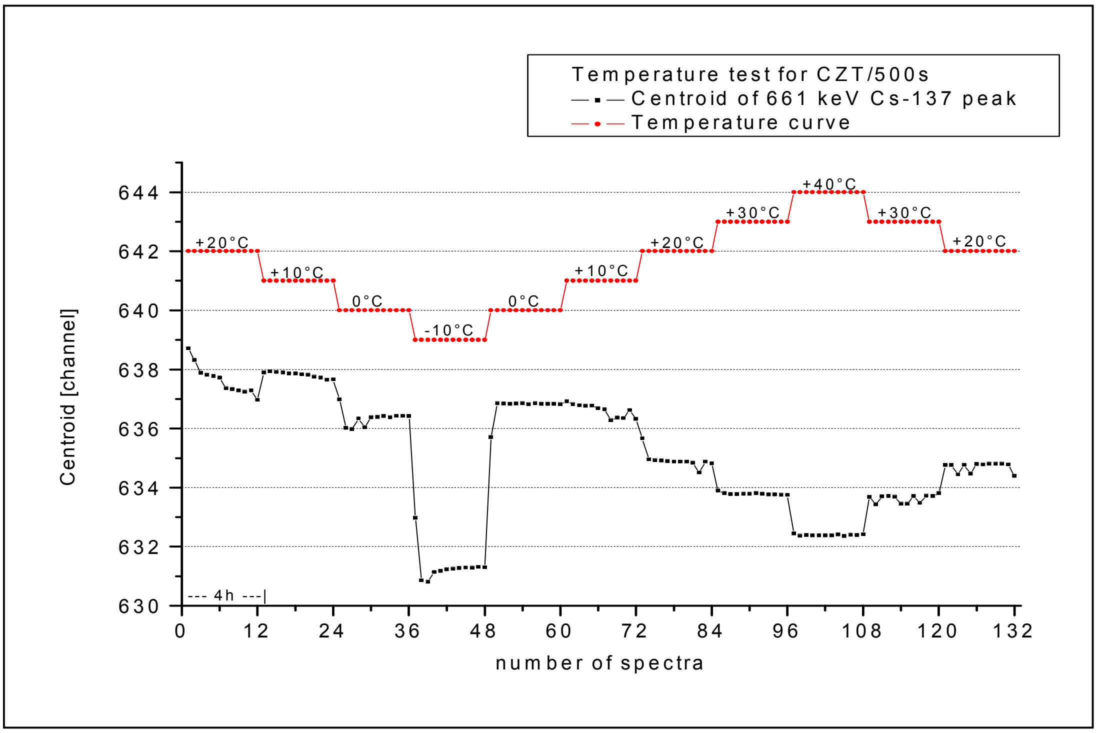

FIG. 3. Shift of the peak centroid of the Cs-137 gamma peak (at 20 degrees C located in channel 638.7) as a function of temperature for a hemispheric CdZnTe detector/preamplifier.

Not many data are published on the temperature stability of CdZnTe detectors in the temperature range of –10 to +40 degrees C. Therefore, a test of a CZT/500s and a 4XCAP detector in an environmental test chamber was performed.

The CZT/500s detector performed well over the whole temperature range from –10 to +40 degrees C and the maximum observed shift of the peak was about 1% (about 0.02%/degree C, about 20 times better compared to a NaI detector). The hysteresis in the temperature/peak location curve requires further investigation.

The 4XCAP detector failed, when the temperature was changing from +10 to 0 degrees C (significant deterioration of the resolution with no recovery when the detector was operated at room temperature again). The reason for this failure is under investigation.

2.3. USABILITY AND USER INTERFACE OF HAND-HELD DEVICES

Hand-held devices often use several radiation detectors and may execute different functions, such as:

- Gamma and neutron source search.
- Gamma dose and doserate measurements.
- Alpha/beta surface contamination check.
- Generation of doserate alarms and recording of integrated dose, e.g. since the beginning of a mission.
- Gamma spectrometry and isotope identification.

The devices have a small form factor and only a few numbers of buttons or dials. The size of the display is limited. The users are boarder guards and customs or police officers with no or little background in radiation detection technology. They have received training but there may be some time between training and use of the instruments. Therefore, it should be possible for the users to find/guess instrument functions intuitively. This requires engineering of usability into the device right from the beginning of the design phase.

Since ITRAP did identify usability problems, a usability review of a hand-held gamma spectrometer and isotope identifier, using the services of a usability expert, was performed [5]. A number of problems were found and some of them are described below. The most of them are of generic nature and are observed also with other devices.

2.3.1. Liquid crystal display (LCD) readability and status messages

Hand-held devices use backlit, monochrome liquid crystal displays (LCDs). Since they should operate over a wide temperature range, a regulation of the contrast is required (desirably automated — controlled by a temperature sensor). Otherwise, the display becomes difficult or even impossible to read at extreme temperatures. Care must be taken to avoid a situation when the displayed menu cannot be read anymore and the user is unable to figure out how to enhance the contrast with manual control. A similar situation of loss of control can occur when the device has multi-lingual support. The design of the user interface must allow to find the way back, if by mistake a wrong language was chosen that the user does not understand.
Essential status information should always be shown on the display, e.g.:

- Battery charge.
- Status of the audible alarm (ON/OFF).
- Alarm radiation level reached (either doserate or integrated dose).

Safety related alarm messages must be visible also if the device is operated in darkness, in particular alarms related to doserate or integrated dose alarms. If, e.g. the display lighting is off and a doserate alarm occurs, it must be turned on automatically to allow the user to read the alarm message.

2.3.2. Audio-visual support of source search

In the source finder mode, the most of the instruments provide audio/visual feedback. Two different indicators are used — often combined: A graphical indicator (e.g. a strip chart), and an audio indication — either the height of the tone or the number of "ticks" per unit time (Geiger Mueller tube sound). The graphical indicator must use automated re-scaling to cope with the large signal changes as the detector approaches the source. As for the audio signal, tests with users have shown that the variable "tick" signal is easier to interpret compared to changing the height of the tone. It seems that sources are often found faster with the audio indication compared to the use of the graphical indication. Therefore, the audio indication of the source search mode should be well developed.

2.3.3. Doserate indication and scaling

During use, the doserate reading may change by several orders of magnitudes. Often a graphical indication and a numeric reading are shown simultaneously to visualize the current value of the doserate. The problem is connected with visualizing a large signal range with an easy to read and unique message. If a logarithmic scale is chosen, doserate changes are compressed and small changes are difficult to see. If a linear scaling is chosen, re-scaling is needed. Quick re-scaling is difficult to catch by the user — often the change of the units of measurements by an order of magnitude is overlooked. A two-dimensional linear indication has been proposed to address this problem [5].

2.3.4. Indication of battery charging

As with a modern cellular phone, battery charging should be indicated when the device is turned on and also when it is turned off and the charger is connected. The latter requirement is more difficult to fulfill and often not implemented. If the instrument is in use, the battery charge status should be indicated, desirably in remaining hours of battery life, or in percent of remaining battery charge.

The presently available hand-held devices often do not meet these requirements and more effort from the side of the developers is needed to address the identified problems. The performance of usability reviews with devices of different manufacturers and the response of the users will allow in the future to establish guidelines on how to design the user interface of such instruments best.

3. BORDER MONITORING

One of the results of the ITRAP field test at the airport Vienna-Schwechat was the observation of neutron alarms. Commercial border monitors normally use front-end data filtering to reduce the number of data collected. Therefore, it is difficult to analyze the structure of the time distribution of an alarm.

To achieve an independent confirmation and explanation of the alarms, a second neutron monitor was set up, adjacent to one of the monitors which had indicted alarms. It allows a full analyzis of the time distribution of the neutron counts by recording the data without filtering. It was assembled from standard equipment components used in the Department of Safeguards, tested and installed at a location that allows comparing the readings of both monitors.

The device consists of a MiniMCA (MMCA) operated in multi channel scaler mode. An array of 12 He-3 counters with a tube length of about 1 m was used as neutron detector. The tubes were embedded in a 90 mm thick polyethylene moderator, 900 mm wide.

The data were transmitted via serial interface to a notebook computer and recorded continuously using WinMCS software operated in unattended data collection mode. With a sampling speed of 100 millisec per time channel, a data file was produced every 6.82 minutes — about 10 files/hour. The time stamped data files are stored on the hard disk of the computer. No front-end data filtering was done. This allows to distinguish short spikes in the data caused by cosmic events from the broader time distribution of a neutron source moved along the monitor, as shown in figure 4. They are processed for events using software that is able to handle large data arrays. The software uses a simple algorithm, which filters out those events in a data file that exceed a preset number of counts/channel.

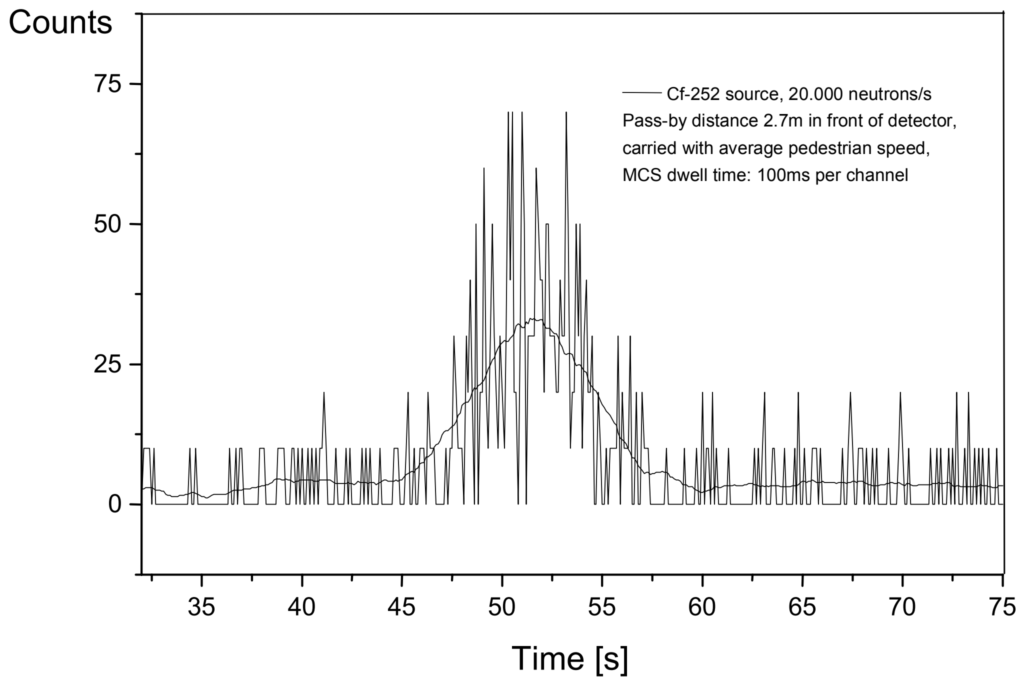

FIG. 4. Time distribution of the neutron countrate for a person carrying a Cf-252 neutron source (2 × 10^4 n/sec) walking at a distance of 2.7 m from the neutron detector. The solid line shows the signal average.

The monitoring system was tested in the ITRAP test facility of the Austrian Research Center Seibersdorf to fulfill minimum ITRAP requirements concerning detection sensitivity. To measure the walk-through characteristics, the time distribution of neutron counts produced by a person walking past the monitor carrying a neutron source was recorded. This curve (see figure 4) will be used to discriminate signal spikes (falling in one or only a few time channels) from events with a wide distribution as shown in figure 4. This system was installed at the end of March 2001. Data collection and evaluation is underway.

4. SUMMARY

The performance of hand-held isotope identifiers to detect shielded and mixtures of gamma sources can be significantly enhanced by combining a NaI(Tl) or CsI(Tl) detector with a large volume CdZnTe detector. The usability of such devices is an important issue. Based on a usability review, improvements have been suggested. A neutron monitor, which samples data points with a short dwell time, has been assembled and tested. Then it was installed at the Airport Vienna-Schwechat. The device will be used to clarify the nature of neutron alarms, which have been observed with commercial border monitors installed at the airport.

REFERENCES

[1] BECK, P. et al., "ITRAP International Laboratory and Field Test Site Exercise for Radiation Detection Instruments and Monitoring Systems at Border Crossing", Proceedings of the International Conference on Security of Material, Stockholm, May 2001, IAEA-CN-86-2P.

[2] DUFTSCHMID K.E., et al., "Technical Considerations for Detection and Response to Illicit Trafficking in Radioactive Materials", Proceedings of the International Conference on Security of Material, Stockholm, May 2001, IAEA-CN-86–29.

[3] ARLT, R., IVANOV, V., PARNHAM, K., "Advantages and Use of CdZnTe Detectors in Safeguards Measurements", Proceedings of the 2th International Conference on Material Protection, Control & Accountancy, Obninks, Russian Federation, 22–26 May 2000.

[4] ARLT, R., et al., "Use of CdZnTe Detectors in Hand-Held and Portable Isotope Identifiers to Detect Illicit Trafficking of Nuclear Material and Radioactive Sources", Paper presented at the IEEE Conference in Lyon, November 2000.

[5] ALEXANDER, M., "Report on the Usability Review of The fieldSPEC Gamma Spectrometer", Vienna, March 2001; unpublished.

QUESTIONS AND ANSWERS

M. Bahran (Yemen): Would you comment on a) the effect of detector size on performance efficiency and on b) the radiation hardness of the detectors.

R. Arlt (IAEA): We have done extensive tests comparing detectors of different volume, the results of which are available. We found that for some detector types, the measurement sensitivity does not correspond to the geometric volume.

C. Adesanmi (Nigeria): How much lower is the sensitivity of CdZnTe detectors than that of NaI detectors? Is the difference significant?

R. Arlt: The sensitivity of a large volume (about 1.5 cm^3) CdZnTe detector is about 10–20 times lower than that of a typical NaI detector. The effect of this difference on isotope detection is not, however, dramatic because of the good resolution and stability of CdZnTe.

DETECTION OF SMUGGLING OF NUCLEAR MATERIAL COVERED BY A LEGAL TRANSPORT OF RADIOACTIVE MATERIAL

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Abstract. Feasibility study was performed in order to investigate the possible on site measurement techniques and approaches applicable in cases when a legal transport of radioactive material is used to cover the radiation of the smuggled uranium. The study was concentrating on non-destructive, passive gamma-spectrometric methods. Possible application of NaI, CdZnTe, and high purity Germanium planar detectors was investigated. An important conclusion of the study was that the higher resolution of the measured spectra provides significant advantages.

1. INTRODUCTION

One of the worst scenarios for detection of illicit trafficking of nuclear material is when a legal transport of radioactive material in depleted uranium shielding is used to cover the radiation of the smuggled uranium. Feasibility study was performed by the Institute of Isotope and Surface Chemistry of the Chemical Research Centre of the Hungarian Academy of Sciences (hereinafter: Institute) in order to evaluate the possible on site measurement techniques and approaches applicable in such cases.

According to the recommendations of the International Atomic Energy Agency [1] concerning the safe transport of radioactive material, the type A and type B packages always incorporate a feature such as a seal. As a consequence, in a realistic scenario the confiscated nuclear material is expected to be placed outside the package. The passive neutron emission of the uranium is negligible for a reasonable isotopic abundance therefore the feasibility study was concentrating on non-destructive, passive gamma-spectrometric methods.

Part of the measurements was performed during a simulation exercise at a border crossing point of Hungary in November 2000, where — in addition to the in field test of the portable equipment and approaches for the non destructive assay, based on passive gamma-spectrometry — the response scenario was studied in a case of detected smuggling of nuclear material.

2. ON SITE RESPONSE SCENARIO, FOLLOWING THE DETECTION OF A LEGAL TRANSPORT OF RADIOACTIVE MATERIAL

Although it is expected when a legal transport of radioactive material is crossing a portal monitor, whenever an elevated level of the environmental radioactivity is indicated the responsible (e.g. customs) officer should investigate the vehicle by a hand-held survey meter in order to search for peaks in dose rates. If a peak was localized, which is different from the position of the legally transported package(s) and it cannot be excluded that it originates from another package the officer should requests for the expertise of the designated institutes. From this point attention should be paid for the preservation of criminal evidence, including the non-radioactive part of the package as well.

In order to bring the situation under appropriate radiation control, approaching the area should be prevented and the responsible authorities should be notified without delay. The radiohygiene expert of the "Frederic Joliot-Curie" National Research Institute for Radiobiology and Radiohygiene, dispatched to the spot identifies the source of the radioactivity, confirms (or excludes) that it is radioactive material, inspects the packaging (e.g. surface contamination) and takes a preliminary inventory of the material. If he or she suspects or cannot exclude that the seized material is or contains nuclear material, he or she notifies the duty office of the Institute. If it seems to be necessary, in the presence and under the surveillance of the radiohygiene expert the law enforcement authority present performs the first check for booby traps.

The expert of the Institute confirms that nuclear material was seized, performs the on site categorization by mobile non-destructive assay instrumentation. In addition, according to the preliminary measurements, a lower and an upper limit is provided for the quantity of the nuclear material.

The radiohygiene expert — based on the preliminary measurements — determines the radiological safety and other conditions for the transportation of the material. Following the required preparatory work (e.g. packaging), the material is transported from the site.

3. MEASUREMENTS

3.1. EQUIPMENT AND SAMPLES

Possible application of NaI (∅40 × 40 mm^3), hemispheric (500 mm^3) CdZnTe, and high purity Germanium planar (1000 mm^2 × 15 mm) detectors was investigated. During the on site measurements portable electronics, mini multichannel analyzer, palmtop and/or notebook computer were used. The typical measurement time was in the order of ten minutes.

The legal transport of the radioactive material was simulated by high activity ^{192}Ir or ^{60}Co sources in lead or depleted uranium shielding. The smuggled material was simulated by a package of reactor fuel pellets containing low enriched or natural uranium (materials confiscated in earlier cases) and standards containing low enriched uranium.

3.2. MEASURED RESULTS

According to the primary purpose of the study, the on site measurements were concentrating on qualitative features of the seized material. The basic approach was to measure similar samples and arrangements by the different detectors. It is instructive to see spectra of 809 g UO_2 fuel pellets containing natural uranium measured by NaI (in figure 1) and hemispheric CdZnTe (in figure 2) detectors in the background of 4.8 TBq ^{192}Ir in the shielding of 48 kg depleted uranium.

The higher energy lines coming from the ^{192}Ir source (604.4 keV + 612.5 keV, 884.5 keV, 1061.55 keV) can be recognized in both spectra. However, the lower energy uranium lines (e.g. at 185.7 keV), coming from the natural uranium sample, can be seen only in the spectrum taken by the hemispheric CdZnTe detector. This feature remained valid for one fuel pellet (15 g) as well. The replacement of the ^{192}Ir by a 17.25 GBq ^{60}Co source resulted in substantially lower sensitivity. The presence of 1.712 kg of low enriched (about 2%) uranium pellets was detected by the hemispheric CdZnTe detector in 23 minutes measurement time.

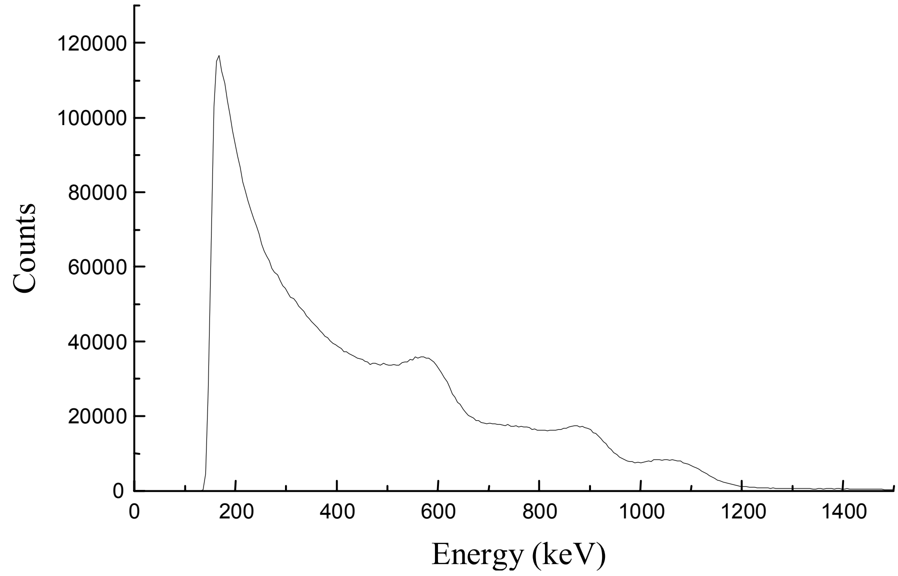

FIG. 1. Gamma spectrum of 809 g UO_2 fuel pellets containing natural uranium placed beside 4.8 TBq ^{192}Ir in the shielding of 48 kg depleted uranium, measured by NaI (∅40 × 40 mm^3) detector.

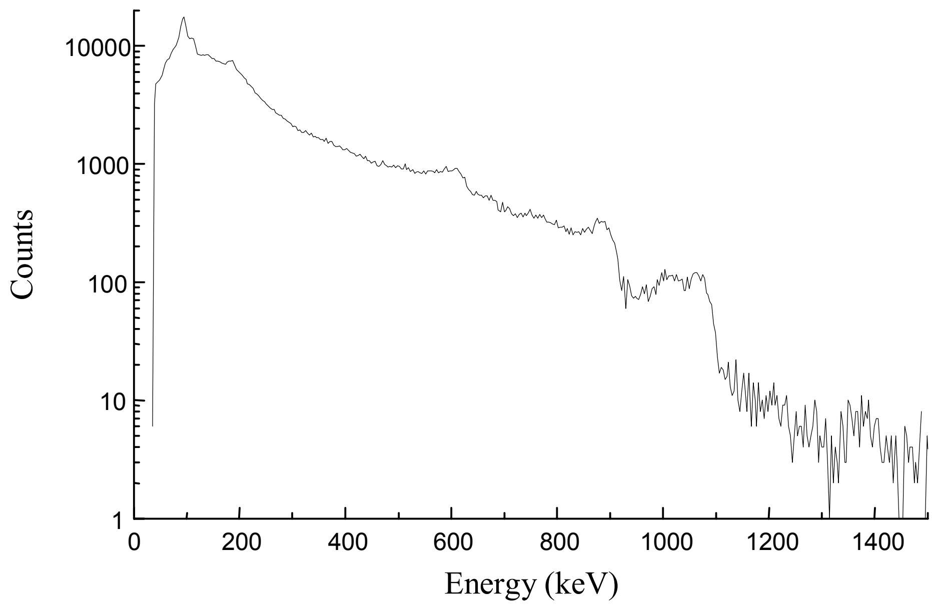

FIG. 2. Gamma spectrum of 809 g UO_2 fuel pellets containing natural uranium placed beside 4.8 TBq ^{192}Ir in the shielding of 48 kg depleted uranium, measured by a hemispheric CdZnTe (500 mm^3) detector.

During the simulation exercise presence of standards containing low enriched uranium (in the form of 200 g U_3O_8) had to be detected in the background of 0.346 TBq ^{192}Ir source in a lead shielding and an empty transport container, containing 53 kg depleted uranium as shielding material. The measurements were performed by high purity Germanium planar detector. The low energy lines of the ^{235}U (143.8 keV, 163.3 keV, 185.7 keV, 205.3 keV) in measured spectra proved to be a reliable indicator of the presence of the "smuggled" uranium. In this case the determination of the isotopic abundance (based on intrinsic calibration method) provided an additional confirmation — and at the same time categorization — of the material. The detection limit proved to be below 200 g for ten minutes measurement time. Although at this time it was negligible, it should be noted that the influence of the shielding material might distort the isotopic abundance.

4. CONCLUSION

The most important conclusion of the study was that the higher resolution of the measured spectra provides significant advantages. It should be noted, however, that at the beginning of the process there is a portal monitor with rather high detection efficiency. Contrary to the NaI detectors, both the hemispheric CdZnTe and the high purity Germanium planar detectors provided a reliable indicator of the presence of the "smuggled" uranium sample in the form of the low energy lines. In addition, the high purity Germanium planar detector made possible the routine and reliable on site categorization of the seized uranium sample in the background of the high activity radioactive source and the depleted uranium shielding as well.

REFERENCE

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulations for the Safe Transport Radioactive Material, Safety Standard Series No. TS-R-1, IAEA, Vienna (2000).

QUESTIONS AND ANSWERS

J. Fechner (Germany): Referring to the initial detection of illicitly trafficked HEU added to a licensed transport package, what is the minimum quantity of HEU necessary to trigger the portal monitor signal in order to initiate a more sophisticated analysis. Since the HP Ge or CdZnTe detectors will only start once the portal monitor detects radioactivity, this first signal is vital.

J Sáfár (Hungary): Even if the portal monitor does not indicate an elevated level of environmental radioactivity, whenever a legal transport of radioactive material crosses the border, the customs officer should check the vehicle with a hand held survey meter for peaks in dose rates at positions different from those of the legally transported packages.

N. Kravchenko (Russian Federation): Does your method detect NM that is inside a shielded container?

J Sáfár: No, but since the container will have a seal, we assume that the smuggled material is outside.

D. Brochard (France): Once you have detected the presence of smuggled NM, how do you perform the measurement to determine a first value of its mass and with what kind of detector?

J Sáfár: In a simple case, the lower limit can be determined by measuring the 1001 KeV line and disregarding the attenuation; the upper limit by weighing. If this is not sufficient, a more sophisticated approach should be taken. The main concern is not to get the exact weight of the material but to exclude a possible criticality.

EXPERIENCES FROM THE ITRAP PILOT STUDY

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Abstract. Detection and identification of radioactive substances is an important part of the overall strategy against illicit trafficking or inadvertent movement of radioactive substances. After a brief introduction to the topic, this paper discusses the framework which defines the characteristics of the detection effort in view of national policy decisions and technical considerations. Response in general and different alarm conditions are highlighted before a brief summary of the pilot study is offered. In the main part, lessons learned throughout various phases of the study are presented and put into perspective. Challenges and problems, both in the technical as well as in the procedural area are addressed. The paper concludes with a brief overview of current activities associated with international standardization and testing.

1. INTRODUCTION

Illicit trafficking and inadvertent movement of nuclear and other radioactive materials is not a new phenomenon. However, concern about such activities has increased remarkably in the last decade. Although the number of such incidents has risen, the overall extent of the problem is not restricted to Europe and not to nuclear proliferation. A few percent of these incidents involve so-called “special nuclear materials”, which may be used for nuclear weapons and therefore cause a threat of nuclear proliferation. The vast majority of these incidents, however, involve radioactive sources, low-enriched, natural or depleted uranium, which are not usable for weapons. There have been instances in which loss of control over radioactive materials has led to serious, even fatal, consequences to persons. Examples include unintentional incorporation of radioactive materials into recycled steel, recovery of lost radioactive sources by unsuspecting individuals, and deliberate purloining of radioactive material.

The ITRAP project (*Illicit Trafficking Radiation Detection Assessment Program*) — financed by the Austrian Government and executed by the Austrian Research Center in close cooperation with the IAEA, World Customs Organisation (WCO) and Interpol — aimed at finding international consensus on specifications for detection equipment and instrumentation as well as verification of such specifications in laboratory tests and field installations. Under the umbrella of the pilot project, 23 international companies participated in the study and many of them devised improvements of their monitoring equipment.

Specific sessions throughout this conference target various issues to avoid or at least minimize loss of control of radioactive substances, including the ‘defense in depth’ strategies. However, once preventive measures have been circumvented and when loss of control over radioactive substances must be suspected, the focus changes to various detection techniques in order to regain control and re-apply regulatory authority over said substances. Unauthorized possession, application, trading, or transportation of radioactive substances does constitute a case of illicit trafficking or inadvertent movement, which is of concern not only to the regulatory authorities but to many institutions involved in the process of regaining control, and, ultimately, to the general public.

The coherence between the regimes of prevention, detection and response has already been discussed elsewhere (see e.g. [1]). Detection itself is a multifaceted approach that entails much more than just the application of radiation measuring instrumentation. A number of sources lost from proper custody were detected by their pathological consequences on the individuals which handled them inadvertently. However, this paper addresses the lessons learned from the pilot study, the stumbling blocks, surprises, and relationship of these findings to other activities in the subject area.

In line with standard IAEA practice, in the following text the term 'radioactive material or substance' shall be used to refer to both radioactive sources, natural or anthropogenic radioactive substances, and fissile materials, specifically SNM (Special Nuclear Material).

2. FRAMEWORK

Detection and monitoring equipment — from a technical point of view — is not an issue that must be addressed independent of the proper framework of activities associated with exercising control over radioactive materials — as has already been discussed in previous conferences (see e.g. Dijon 1998, [2]). Individual situations and specific circumstances will call for tailored solutions, adjusting both the technical capabilities of the instruments employed and their application in the procedure of identifying a possible case of illicit trafficking or inadvertent movement as well. These decisions will be governed by an assessment of the threat potential (both quantitatively as well as regarding the characteristic assumptions for the probable target incidents), by the expertise and training level of the institutions involved (the human 'detectors'), and by the specific scenarios to be considered (e.g. scrap metal monitoring vs. airport passenger scanning). The following sections will outline a few of these considerations first, then focus on general technical issues of instruments, and finally attempt to derive general considerations from the pilot project for technical specifications and application procedures.

2.1. NATIONAL POLICY

The national policy defines the overall response plan in case of the loss of control over radioactive substances or suspected illicit trafficking/inadvertent movement. We are primarily concerned with the technical detection methodology, the ensuing actions once an alarm has been generated, and the associated requirements imposed on instrumentation. The national policy, however, goes beyond that. The term *design based threat* was coined to highlight the fact that assumed scenarios and threat potentials have to be carefully analyzed in view of given installations, working procedures, diversion potentials and overall detriment. This will have to be weighed against probability of occurrence and, of course, overall cost. Government agencies will generally pursue other goals than institutions or organizations, which will have to take measures to remain compliant with the requirements stipulated in their license for handling radioactive materials.

The consequences of such a careful analysis will therefore define what actually constitutes a threat (within the scope of application) and will have to be detected at a given checkpoint. The general concern is to avoid any hazard to health and environment by the substances illicitly trafficked and to detect 'small' quantities of SNM as part of the non-proliferation concerns. Radioactive substances associated with metal scrap (concealed sources) are usually not easy to detect and — though posing the largest commercial risk — are generally excluded from considerations in border control type environment, unless the source activity is so high to constitute a health hazard. Nevertheless, issues relating to metal scrap shall be addressed in one of the following sections.

2.2. DETECTION LIMIT — INVESTIGATION LEVEL

'Detection' is defined in the Draft Safety Guide [7] as a *"Conclusion based on measurement and the interpretation of the results*". Detection therefore consists of two important processes, the measurement of elevated radiation levels and the interpretation of these readings to constitute a case of illicit trafficking or inadvertent movement, screening out other possible trigger events.

One of the most important properties of any instrument in the measurement process is its detection limit. The detection limit is a value derived from laboratory tests of instrument performance, from controlled field tests, or — less reliably — from statistical calculations, defining the smallest signal where reliable detection can be made. 'Signal' depends on the nature of the instrument and may comprise the indication of a specific activity, a dose rate, or a relative reading. However, this issue is further complicated by the naturally occurring radionuclides in our environment and the statistics inherent in the process of detecting radiation. Any criterion (or selected detection threshold) for deciding if a particular shipment contains an illicitly trafficked radioactive material has to take into account the spatially and temporally varying background and the statistics of detection.

Under most scenarios, the result of a detection beyond a previously established alarm threshold will result in some kind of alarm indication and cause further action in order to interpret the event. Though individual response plans may prescribe specific routes of action, the general tendency will be to investigate the validity of the alarm and gather more information on this newly established 'case'. Therefore, it has been agreed to call the previously established alarm threshold — which causes an alarm — the 'investigation level'. Elevated readings below the investigation level do not necessarily rule out the presence of a radioactive material in a given situation; under pre-established guidelines such readings simply do not give rise to further investigation. Readings exceeding the investigation level do not necessarily indicate a case of illicit trafficking or inadvertent movement, however, they need to be further investigated.

On behalf of the ITRAP project, an investigation level of 100 nSv/h above background was adopted by consensus of international experts. This level is in the order of natural background radiation itself.

The agreement on a specific investigation level therefore is a decision based on national policy. It is derived from political and expert consensus, similar to other threshold settings (e.g. speed limit), and not primarily a detector related quantity. This level should be high enough to allow detection not to be adversely affected by variations in natural background radiation or from low levels of radiation originating from exempt practices or cleared radioactive materials in low quantities. Whatever the choice, it must be ascertained that the detection limit of the instruments used is below the selected investigation level. However, many natural or anthropogenic radionuclides will appear legally in quantities causing an alarm by exceeding the chosen investigation level. These may result from processes involving radioactive substances exempted from regulatory control or from substances excluded up to a certain activity concentration or total content. The various causes of alarming will be analyzed in the subsequent section.

2.3. ALARMING

Once the alarm has gone off some form of investigation is called for. However, before elaborating on the general concepts of interpretation and identification, the different causes of an alarm shall be tabulated.

2.3.1. True alarms

Considered from the point of view of the first responder having to react to the indication of an alarm status, a 'true alarm' is caused by an amount of radioactive material passing the detector. The signal processed by the instrument indicates radioactivity beyond the pre-established investigation level. This may be caused by legal shipments, inadvertent movement, or illicit trafficking and needs further investigations. True alarms are quantified by the detection probability.

2.3.2. False alarms

Contrary to the true alarm, a false alarm is caused by no radioactive material associated with goods or people passing the detector. It may be caused by variations in natural background, by poor statistics, by instrument malfunction, or by unknown reasons. Nevertheless, a detailed investigation must verify the alarm to be 'false', i.e. re-passing of the gate or manual scanning. Since all measures taken are time-consuming and will tend to obstruct normal operation, false alarms must be minimized by all means, since the credibility of the system will be compromised in view of the operating personnel. The quantitative measure is the false alarm rate, usually specified as fraction of time or fraction of passages through the gate. Generally speaking, the false alarm rate may be allowed to be higher with hand-held equipment than with fixed installed systems.

2.3.3. Innocent alarms

Innocent alarms are in fact true alarms caused by radioactive substances, which do not constitute a case of illicit trafficking. Also legal transports of radioactive materials may trigger an alarm, however, identification should be straightforward pursuant to transport regulations. Innocent alarms are typically caused by naturally occurring radioactive substances such as Potassium 40 or low quantities of Uranium or Thorium. Likewise, medical radionuclides administered to patients in nuclear medicine have been known to frequently trigger alarms, necessitating cumbersome interviews as to the cause of the elevated radiation level. Evaluations of border type scenarios have shown most alarms (up to 80% in specific situations) to be caused by natural radionuclides, thus creating a major nuisance for the operating personnel. An important step in verifying an alarm to be innocent is the identification of the radionuclide involved, since genuine "innocent" shipments, like e.g. artificial fertilizer, could also be used as a smokescreen for other activities.

2.3.4. Missed alarms

The last category is not an alarm situation, nevertheless it should be one. As discussed in the sub-section on statistics, even correct equipment specifications allow for a certain probability to miss an alarm that actually should have occurred. Missed alarms and false alarms are closely correlated; improving one without compromising the other usually leads to significant cost increases. Assumptions indicate a high percentage of cases of illicit trafficking or inadvertent movement that may have gone undetected.

2.4. ALARM RESPONSE

This paper does not focus on response measures. However, the instruments discussed and their characteristics must enable the detection process to achieve its goal, namely to ascertain that an attempt of illicit trafficking or inadvertent movement has occurred. As already outlined above, a logical first action will be to establish what kind of an alarm situation has evolved: true, false, or innocent (the missed alarm will go undetected).

In the case of an innocent alarm, actual radioisotopes or at least classes of radioisotopes must be identified (e.g. 'medical', 'natural'). Though some insights may be gained from shipping papers or interviews, the frequent occurrence of such alarms eventually leads to extended requirements for the instruments to enable such differentiation on the spot without involving cumbersome analysis or a laboratory procedure.

Once a true alarm has been verified and the *conclusion based on measurement and interpretation* has been drawn that a case of illicit trafficking or inadvertent movement exists, a general response strategy will be to assess the hazard of the situation, possibly isolate the shipment or person and conduct further measurements to pinpoint the exact location or source of the problem. Somewhere during this process the front line officer having detected the case will hand over responsibility to a specifically trained or more experienced 'responder' or to even more specialized institutions, depending on the complexity of the case and other influence factors. This strategy is defined specifically in the respective response plans. Regarding instrumentation, two requirements may be extracted from general response procedures:

- The nature of the alarm must be clearly identifiable, the interpretation must allow an unambiguous conclusion to allow a reliable detection.
- Localization and (possibly) identification of the source of the alarm must be possible.

Based on general radiation protection considerations, a third requirement may be formulated:

- The instruments must allow the operating personnel to observe appropriate protection measures.

3. ASSESSMENT PROGRAM

3.1. OBJECTIVES OF THE STUDY

An important element of this study was the harmonized establishment of a detection threshold for practical implementation at borders or similar checkpoints, the investigation level. However, equally important was the verification of agreed specifications in controlled laboratory conditions and in realistic operating environments (field tests). All crucial parameters, as *inter alia* the false alarm rate, were verified by a significant testing effort as compared to approaches based on statistical calculations only.

Apart from initial screening of equipment specifications to determine their basic compatibility with previously established guidelines and specifications, the pilot project consisted of a laboratory test and a field test. The objective of the laboratory test was to determine critical operating parameters (as e.g. alarm probability and false alarm rate) under strictly reproducible conditions, eliminating as far as possible other confounding influence factors in the laboratory evaluation. Close to 200 000 tests were performed on most stationary instruments alone to verify these parameters. With this limited set of operational characteristics forming only part of the overall performance properties, a field test under — as much as possible — realistic conditions was undertaken at the Austrian-Hungarian border at Nickelsdorf, this being the busiest road border crossing between the European Union (EU) and its eastern neighbour countries.

3.2. OVERVIEW

Details of the assessment program are found elsewhere [1, 3, 4]. Specific scenarios have been analysed [3] and another overview is presented in this conference [4]. The core of the testing program was focused on the radiological parameters *sensitivity* (detection probability) and *false alarm rate* with their associated confidence levels, as well as operational usability under realistic border monitoring conditions. Manufacturers of Commercial Off The Shelf (COTS) equipment were invited to participate in the testing program, and without their dedicated support this study would not have become a success. The range of equipment contained small devices (pagers and/or hand-helds), radionuclide identifiers, and stationary monitoring gates. The main findings, experiences and lessons learned shall be reported here.

4. LESSONS LEARNED

4.1. ACKNOWLEDGEMENT

The Austrian Research Center wishes to acknowledge the support received by the Austrian Ministries for Science, Traffic, Interior, Exterior, Finances under the coordination of the Federal Chancellery. The support and cooperation of the IAEA has made this project possible, however, the dedication of the manufacturers has made the project a success. To all of them we are greatly indebted.

4.2. TECHNICAL PRINCIPLES — ACTIVITY VS. DOSERATE

Instruments and systems to measure radioactive parameters are available for many different applications. We will restrict ourselves to typical applications associated with the problems of illicit trafficking or inadvertent movement, disregarding — unfortunately — a host of other potentially interesting techniques and systems. Monitoring is primarily considered at control points, e.g. at boundaries of nuclear facilities or at customs check points.

4.2.1. Detection Principles

A radiation detector converts information from gamma and/or neutron radiation into electrical pulses, thus allowing computation of various properties associated with the radiation received. Usually solid state detectors are involved (scintillation type detectors), since they yield more information per unit detector volume as e.g. gas filled devices (Geiger Müller tubes, ionization chambers). Almost all models are microprocessor controlled, allowing the presentation of the desired result in the most appropriate form. Examples would be a simple warning device on one side, yielding as result basically a YES/NO information, and spectroscopic equipment on the other side, yielding a complex spectrum for radioisotope identification purposes.

4.2.2. Detector Output

It must however be noted that contrary to most measuring devices, alarming systems (as e.g. most portals) provide as their main output a YES/NO signal only (alarm/no alarm). This alarm signal is associated with a specific probability. Testing for energy response, temperature response or electromagnetic disturbances may result in a significant testing effort, because the tracking of “response” — usually done by observing the effects of the influence quantity on count rate (or dose rate) output — must be translated to effects on the alarming capability if the instrument. Though some monitors provide an additional “count rate” signal, this constitutes an optional feature only and the value itself may be the result of complex, proprietary internal algorithms. The significant figure, based on alarm output only, is a possible influence on alarm probability. If, for instance, the alarm probability for a given situation was 50% at room temperature, this probability could be shifted for example to higher values at lower temperatures. In order to verify typical specifications in the range of just 5% to 10% maximum temperature response over the rated temperature range, elaborate setups and extremely voluminous test series have to be undertaken to establish statistical significance of the results.

4.2.3. Indication of intensity

Though agreement has been established internationally on the unit of measurement regarding radiation, relative information may be found more useful for a front line officer not necessarily well experienced in radiation physics. A number of instruments therefore features a relative scale (e.g. 0 to 9) with simple instructions associated with each indication (e.g. “if reading is 9, retreat until reading falls below 9”). Hence the display resembles a relative, often logarithmic indication of intensity, mostly based on gamma intensity.

4.2.4. Dose rate

The dose rate measured in Sievert/h (or Gray/h) is the chosen unit of radiation intensity. A specific dose rate value was also selected as the defining criterion for the setting of the investigation level. At first glance, this may seem sub-optimal, since the quantity to be controlled is the amount of radioactive substance, i.e. the activity (usually measured in Becquerel or the old-fashioned Curie). However, a source of specific activity may either be found or missed with the same detection equipment, depending on factors such as distance, shielding and geometry. Though still desirable to find all sources exceeding a specific activity, for the purposes of testing and comparing equipment and especially for setting reproducible levels of an investigation, the radiation intensity (i.e. dose rate) at a specific location is a much more reliable approach and has therefore been chosen as criterion for the investigation level in the IAEA Draft Safety Guide [5].

This was an important lesson. Other testing programs trying to characterize monitoring equipment by their capability to detect a certain amount of activity usually find themselves hard put to standardize their test environment. For example, monitoring for radioactivity contained in steel scrap might be performed by loading a typical truck with a shipment of steel frag of average density and burying a source with typical shielding arrangements at a certain depth. Detection capability will not only depend on the amount of scrap metal between source and detector, the “typical” assumptions may render this test unsuitable for a different installation, using other typical parameters. One concern might be that confounding factors could influence the test, e.g. one specific truck might cause problems due to electromagnetic interference. As relevant the question of the absolute quantity of activity contained in scrap is to the scrap recycling industry, the actual signal processed by the monitor is a radiation intensity seen by the detecting element, irrespective of the activity causing it.

4.2.5. Activity

As stated above, the specific amount of radioactivity (i.e. activity) is the quantity to be controlled under regulatory practices. However, the detection based on source quantity is feasible only in certain situations where both geometry, shielding, and type of radiosiotope are exactly known (or maybe controlled). Such is the case e.g. for pedestrian monitors at access control points in nuclear facilities. These monitors are characterized by the amount of SNM (Plutonium or **H**ighly **E**nriched **U**ranium, HEU) they may identify under worst case conditions. Under less defined circumstances, the detection system would have to either identify additional information required (e.g. the radioisotope concerned) or work on assumptions that may yield misleading results.

4.3. ALARM PROBABILITY

4.3.1. Statistics

Detection can only be accomplished with a certain probability at a specific confidence level. For instance, a specific source may be detected in 4 out of 5 passes (80%) at a confidence level of (typically) 95%, signifying that the system may even perform worse than 80% detection probability in rare cases. Manufacturers, testing laboratories, and field tests may specify the results at different confidence levels or for different detection probabilities, which makes them hard to compare, not only for the layman in statistics. Consequently, even after wise choices have been taken regarding the alarm threshold and in selecting the proper equipment, further investigation is required once the alarm sounds.

4.3.2. Detection Probability

Los Alamos National Laboratory has published a compilation of standards from the American Society for Testing and Materials (ASTM), applicable for certain monitoring applications [5]. Also, there is a number of excellent evaluations and reviews available from Los Alamos National Laboratory on the subject of SNM monitoring ([6], [7]). For their evaluation and testing procedures, Los Alamos has adopted a detection probability of 50% at 95% confidence level. This has significant impact on overall testing effort and shall be compared to the approach chosen in the ITRAP pilot study.

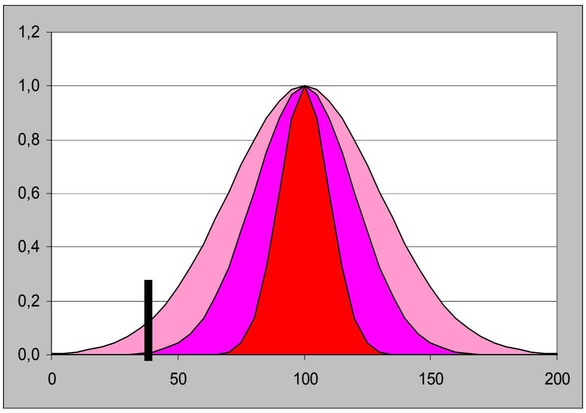

FIG. 1: Instrument dependent threshold setting to comply with a requirement of 99.9% detetcion probability.

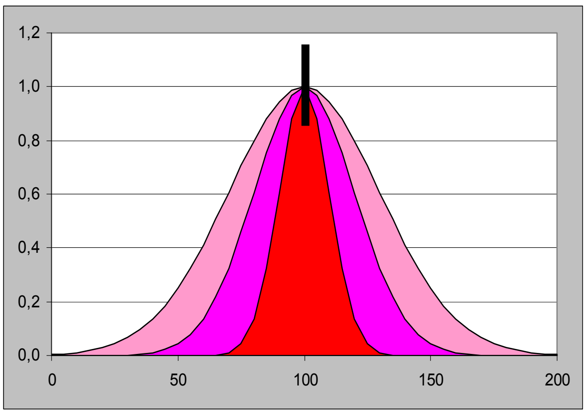

FIG. 2: Gaussian distributions of various shape.

For the following discussion, an ideal Gaussian distribution of monitor countrate shall be assumed.

Let us further assume that figure 1 represents the responses of 3 different monitors measuring a radiation intensity of 100 units. If these 100 units was the *nominal threshold* value tested at 50% detection probability, the instrument manufacturer would adjust the *instrument threshold* to exactly that value (black vertical bar). The intrinsic shape of the distribution is less important (as long as it is centered). Testing at 50% detection probability would verify proper performance for all systems.

Let us assume now that a different detection probability was required (for ITRAP, 99.9% were required for stationary systems). In order to comply with a test condition "alarm at intensity of 100 units", the events contained in the 3σ-tail on the low side must be observed. If the *instrument threshold* was set at 40 units (see black line in figure 2), the narrowly spread data would easily pass, the medium spread distribution would barely fulfill the test criterion of 99.9% detection probability, and the wide spread data would fail the test. The manufacturer/user would have to adjust a different *instrument threshold* to comply with the *nominal threshold* requirement for each instrument.

This difference in requirements on detection probability as compared with the Los Alamos approach caused some initial confusion, especially since the term "threshold setting" had to be differentiated between nominal value and instrument setting. It must be added that proper testing for 99.9% detection probability at 95% confidence level cannot be done without assumptions about the intrinsic properties of the instrument specific distribution function. Initially, none of the stationary systems would have passed the test. After an upgrade and adjustment phase, 7 out of 14 systems passed the test.

4.3.3. False Alarm Rate

For equipment intended to be operated by trained personnel (being non-experts in radiation instrumentation), the false alarm rate is of crucial importance. During ITRAP, a requirement was adopted of not more than one false alarm per 10 000 passages (10^{-4}). Based on a throughput of 5 000 to 10 000 cars per day on the field test site under consideration, this did seem reasonable. From background count rate monitoring, initial instrument settings were derived to comply with this criterion. Most systems failed initially. It may be assumed that a theoretical treatment based on idealized statistics did not take into account the spurious effects intrinsic to the detection process or the averaging algorithms within the instruments. Especially the combined requirement of setting the instrument alarm threshold safely beyond background fluctuations (approximately 4σ correspond to the 10^{-4} requirement) and maintaining the 99.9% detection probability at the nominal alarm level proved to be difficult.

Figure 3 reflects on this problem. For optimum performance detection-wise, the detection capability is stated as low as possible. In keeping with the 99.9% detection probability, the instrument threshold setting is represented by the dotted line in figure 3: high enough above background to comply with the false alarm rate criterion (false positives less than 10^{-4}), and well below the nominal threshold to fulfill the 99.9% (false negatives less than 0.1%). The corresponding settings expressed in multiples of σ would be 4σ and 3σ, respectively, for an idealized Gaussian system. Real world systems would generally perform worse than that. What general considerations may be deduced from that? For idealized Gaussian behavior, assumptions can be made on minimum settings based on background countrate, in compliance with the above stated criteria on false alarm rate and detection probability. Figure 4 depicts such a relationship, based on an idealized system, expressing the minimum *nominal alarm threshold* setting as a multiple of average background (lower curve) or as a multiple of average background fluctuation (upper curve). For a detector countrate of 1000 cps at background, a nominal alarm level of 20% beyond background maybe achieved, compatible with the requirements. The scrap metal problem will be addressed in section 4.7 quantitatively. From figure 4 it can be seen that nominal threshold settings a few percent above background necessitate large detection systems with high countrates.

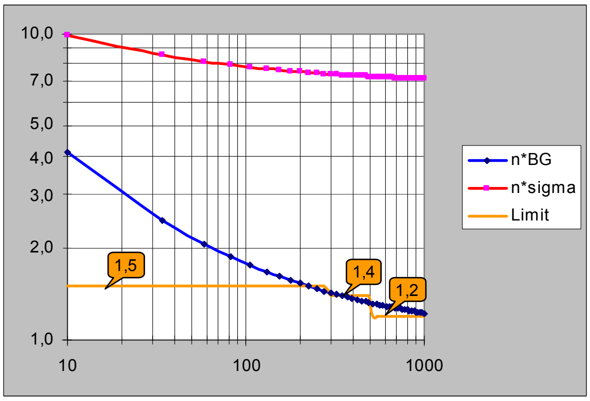

FIG. 3: Minimum alarm threshold setting.

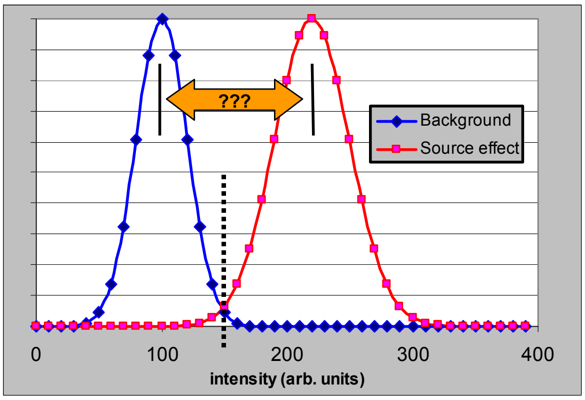

FIG. 4: Minimum settings for nominal alarm threshold, based on idealized system.

4.4. RESPONSE

Response to an alarm indication and proper measures to verify the alarm to be true and in fact caused by illicit trafficking or inadvertent movement is most important, as discussed in section 2.4. An important finding during the ITRAP study was that the legal basis for response also needs careful attention. In many countries the responsibility for maintaining safety at the border may be shared amongst different organizations or executive bodies (border police, customs guard, military establishment, etc). The basis for intervention in case of alarm delayed the field test part of the study for considerable time, until a consensus could be found on responsibilities and legal umbrella under the entities concerned. However, after these difficulties were overcome, a second element of concern was the officer at the border himself. Initially, a high percentage of alarms remained unattended (almost 50% for the truck lane, 35% for the bus lane). Careful analysis showed that corresponding handheld equipment to facilitate searches and the general experience of border personnel in this field did not provide satisfactory expertise to embark on possibly challenging or offensive interrogations. This was overcome by a second level training programme, specifically addressing the needs of operational response and the associated procedures in localizing sources and asking the right questions. The Draft Safety Guide [8] contains a specific section on response, which is based on practical experience and allows the structuring of tailored response procedures.

4.5. TRAINING & SUPPORT

Training — as mentioned in the preceding section — was an important element in getting overall results. Training had to address — inter alia — basic physical properties of radiation and shielding, an understanding of the dangers (or lack thereof) of ionizing radiation, measures of self protection, natural and artificial radioactivity. After the first training courses had been administered, a second batch of training had to be implemented to overcome problems in operational response and allow a more practical and procedure oriented approach.

However, the most important lesson was that expert support could not be neglected. The frequent occurrence of natural radioactive substances and the high rate of innocent alarms led to a strong need for expert availability for consultancy in tricky cases. To comply with this need in an economical way, telephone support was implemented by means of expert availability via a dedicated hot line. This was further improved by remote access to monitor system data via a mobile telephone link, to allow experts remote analysis of the case under consideration. This has helped not only to establish a common language between officers and experts, it has also led to a much greater confidence on behalf of the officers handling the cases in following the response procedures, because in problematic decisions they could always turn to an expert. This service was established consequently on a 24 hour basis, 7 days a week.

4.6. RESTRICTIONS AND EXCLUSIONS

As has been pointed out above, scrap metal imposes most stringent requirement regarding detection sensitivity. Publications by the Institute of Scrap Recycling Industries [8] recommend a minimum detectable amount of activity of Cesium 137, shielded to allow a surface dose rate on the container of 10 μSv/h, buried at least 1 m in loose iron scrap. The effective increase in dose rate at the outside of the vehicle based on these assumptions is a mere increase of 6 nSv/h under background conditions of typically 100 to 300 nSv/h. This constitutes an increase of background radiation level by 2% to 6%, depending on ambient level. Comparatively, monitoring gates for SNM are set to approximately 4% above background level. Investigation levels recommended in the Draft Safety Guide [8] will be finalized — after initial studies have been completed — in the range of 100 nSv/h thus being in the order of standard background levels.

It is obvious that under standard border conditions monitoring for radioactivity in scrap metal is not feasible. Large or unshielded sources constituting a health hazard to the general public will be found, however, shielded sources will require much longer measuring times or simply the unloading of the shipment. Thus the scrap metal problem on behalf of the scrap recycling industry has been excluded from considerations in the context of the ITRAP pilot project.

Similarly, monitoring for gram quantities of fissile materials, namely Plutonium and Highly Enriched Uranium, requires extremely high detection sensitivities. Since the gamma signatures of certain Plutonium isotopes are very week, SNM monitoring is often complemented by neutron detection techniques. As mentioned in 4.2.3, Los Alamos National Laboratories has addressed this problem in great depth and published a number of excellent overviews in this area ([8–10]). The latest category of personnel monitors achieve a detection capability for Pu in the order of fractions of a gram (solid sphere).

Since the radioisotopes being searched and the geometries are usually well defined, the detection limit is generally specified as activity or mass of SNM. Searching for fissile materials requires usually more stringent and elaborate monitoring procedures as compared to the procedures contemplated in the pilot study. In the study, the concerns for smuggling of fissile material could not be disregarded due to the implication in the context of non-proliferation efforts. On the other hand, cost considerations and throughput concerns were raised. This led to a requirement of neutron detection capability along with the basic gamma channel of traditional monitoring equipment, however, the detection limit was relaxed by orders of magnitude as compared to monitors deployed for perimeter monitoring of nuclear facilities. This was considered an approach commensurate with the threat potential both form fissile materials and orphan sources.

4.7. FURTHER DEVELOPMENTS

Many new developments have become available for monitoring applications in the context of border monitoring. Within the pilot study, the need has been highlighted to identify or at least classify radionuclides as part of the response procedure. Recently available hand-held radionuclide identifiers have therefore been evaluated. It was seen that still a large development effort remains to provide efficient instruments for non-experts under field conditions. Samewise, the problem of signal deterioration by shielding effects will have to be addressed in more detail. Instruments based on CdZnTe-detectors seem to be promising candidates [9].

5. THE ISO PROJECT

As a follow up to the discussed pilot project, Austria and the IAEA suggested a new work item proposal to the International Standards Organisation (ISO), Technical Committee on Nuclear Energy (TC85), to contrive an international standard titled “Monitoring for illicit and inadvertent movement of radioactive material”, based on the Draft Safety Guide and existing IAEA recommendations. In line with ISO procedures, national delegations were asked to agree to that proposal. Following a favorable result, invitations went out to all national committees to nominate experts to participate in the standards work. Some of the experts in this area, having provided tremendous input throughout the pilot project, have joined the ISO team and will allow a continuation of work. Similar projects are also pursued by IEC/SC45B.

6. CONCLUSION

The variety of instruments and detection techniques available to aid the efforts of combating illicit trafficking and inadvertent movement are numerous. General considerations and experiences may be drawn from the pilot study in order to assist specific implementations in this area. Important factors are the requirements adopted regarding detection probability and false alarm rate, but equally so the preparations for the officers responding to alarm scenarios in terms of training, definition of response procedures and support must be carefully observed.

REFERENCES

[1] K.E. DUFTSCHMID, Proc. IAEA Conf. On the Safety of Radiation Sources and the Security of Radioactive Materials, Dijon France, Sept. 1998, IAEA TECDOC-1045, IAEA-CN-70/B6, (1998).

[2] J.P. GAYRAL, Proc. IAEA Conf. On the Safety of Radiation Sources and the Security of Radioactive Materials, Dijon France, Sept. 1998, IAEA TECDOC-1045, IAEA-CN-70/R10, (1998).

[3] P. Beck, K.E. Duftschmid, *ITRAP — The illicit trafficking radiation assessment program,* Proc. IAEA Conf. On the Safety of Radiation Sources and the Security of Radioactive Materials, Dijon France, Sept. 1998, IAEA TECDOC-1045, 265 (1998).

[4] P. Beck**,** ITRAP, Illicit Trafficking Radiation Detection Assessment Program, Final Report, OEFZS-G -- 0005, Oktober 2000.

[5] C. Schmitzer, *Illicit Trafficking Scenarios and Detection Methodology,* Proc. IRPA Regional Congress on Radiation Protection, Budapest, Hungary, September 1999.

[6] P. Beck, C. Schmitzer, K. E. Duftschmid, R. Arlt; ITRAP — International Laboratory and Field Test Site Exercise for Radiation Detection Instruments and Monitoring Systems at Border Crossings, this conference.

[7] IAEA Draft Safety Guide on “Prevention, Detection of and Response to Illicit Trafficking in Radioactive Materials” (IAEA, 1998).
[8] Selected ASTM Standards on the Application, Evaluation, and Maintenance of SNM Portal Monitors, ASTM, reprinted at Los Alamos National Laboratory LA-UR-95-1770, (1995).
[9] FEHLAU, P.E., “An Application Guide to Pedestrian SNM Monitors”, Los Alamos National Laboratory, Los Alamos, New Mexico, USA; LA-10633-MS (1986).
[10] FEHLAU, P.E., “An Application Guide to Vehicle SNM Monitors”, Los Alamos National Laboratory, Los Alamos, New Mexico, USA; LA-10912-MS (1987).
[11] Radioactivity in the Scrap Recycling Process, Institute of Scrap Recycling Industries, Washington D.C. (1993).
[12] R. Arlt, A. Kovar, K.E. Duftschmid, M.Swoboda, P. Beck, W. Lewis; Improvement of equipment needed for the detection and characterization of nuclear material and radioactive samples at borders; this conference.
[13] R. Arlt, A. Kovar, K.E. Duftschmid, M.Swoboda, P. Beck, W. Lewis; Improvement of equipment needed for the detection and characterization of nuclear material and radioactive samples at borders; this conference.

A PROPOSAL FOR AN INTERNATIONAL TAGGING SYSTEM FOR RADIOACTIVE MATERIALS

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Abstract. This paper describes a proposal for establishing an international tagging system. To be called ITS-RM, it would label 'significant' radiation sources with a unique number at the point of production. This would be used to track them as they changed hands. The IAEA would hold a central register.

In an early paper [1] based on our experience with lost or abundant radiation sources [2], we have discussed the need of an international tagging system for radioactive materials for the purpose of insuring trackability, accountability and safety. In this paper we take our discussion further by presenting a proposal of establishing such an international tagging system for radioactive materials which we call ITS-RM.

The elements of ITS-RM:

- IAEA is to be the international authority in charge of ITS-RM.
- Each "significant" radiation source is to be labeled with a unique number at the point of production. This number is identified as ITS-RM number.
- The term "significant" can be defined in light of current international standards.
- As each source is naturally possessed by some legal notion or international entity, each time this entity is changed (e.g. the source is sold, resold, transported, decommissioned etc.) the process of changing hand is registered at IAEA via the ITS-RM number.
- No source is to change hands without triggering ITS-RM.
- Even if a source finds its way to a waste facility it will remain tagged indefinitely.

The requirement for ITS-RM:

- Legal requirement: this issue needs to be studied to find out weather anew international treaty needs to be established or ITS-RM can be applied under existing treaties.
- Organizational requirements: This can be easily done with the framework if IAEA and national counterparts.
- Consultation requirements; ITS-RM can only work if it is done through complete consultation and cooperation with manufactures.

Old and current sources:

- An effort is to be made to survey and tag current sources:
- Priorities will be given as follows: first to new sources second to current sources the comes last old sources, particularly those in storage facilities.
- ITS-RM is not to compete with any existing safety system, national or internationally, to the contrary is to support safety.

ITS-RM advantages are many but in particular we have:

- Trackability even if somebody does not cooperate.
- Accountability of sellers, buyers, users and waste managers.

- Knowledge about the international holdings of radioactive materials.
- Ultimate Safety from theft from illicit trafficking, lost or abundant sources.

ITS-RM Cost:

It will have only some minimum cost for the organizational aspect since the IAEA framework is already there.

REFERENCES

[1] M.Bahran, "Radiation Sources are out there", a contributed paper to the IAEA International Conference of National Regulatory Authorities with the Competence in the Safety of Radiation Sources and Security of Radioactive Material, Buenos Aires, Argentina,11–15 December,2000.

[2] NATEC internal reports, Sana'a, Republic of Yemen, 1999, 2000.

QUESTIONS AND ANSWERS

C. Adesanmi (Nigeria): How can this international tagging system be applied to unsealed sources such as liquid or powder radioactive material or contaminated waste?

M. Bahran (Yemen): For the moment, we have the IAEA TECDOC as a guide.

METHODOLOGY FOR EVALUATING PORT VULNERABILITY TO NUCLEAR SMUGGLING

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Abstract. The effectiveness of measures at ports and borders to detect illicit trafficking are evaluated using a methodology developed within the 'Second Line of Defense' programme. It is based upon that used for determining the effectiveness of physical protection measures and identifying potential weaknesses at fixed storage locations, but the methodology has been adapted to take account of special requirements of border and port detection. By using a quantitative approach, vulnerabilities and solutions at ports and borders can be better understood.

1. INTRODUCTION

The proliferation of nuclear weapons threatens us all. To address this, protective measures and international agreements have been established with the intent to prevent or detect any group attempting to obtain weapons of mass destruction. These include controls on information and technologies deemed critical to the development of weapons of mass destruction, and controls on access to weapons-useable special nuclear material, primarily uranium and plutonium.

Attempts to bypass these controls on access to special nuclear material have been highlighted in the recent past by several examples of illicit trafficking of nuclear material. The ability of the international community to deter and intercept this traffic may be crucial to the success of the non-proliferation regime.

The Department of Energy of the US Government has undertaken an international program to strengthen the ability to detect, and thereby prevent, the illicit trafficking of special nuclear material. This program is named, "the Second Line of Defense," which acknowledges the first line of defense the controls to illicit access to special nuclear material provided by nuclear facilities tasked to protect it.

Within the program, there is an effort to identify potential weaknesses in port and border crossing protection vis-à-vis illicit trafficking of special nuclear material, and determine means to adequately address these weaknesses. A procedure to accomplish this is well-known in the physical protection community perform a vulnerability analysis. The vulnerability analysis process is well-defined and its effectiveness proven over time; however, the process has not been applied to illicit trafficking.

Due to the enormous difference between protection of material at a fixed facility, and the prevention of illicit trafficking through a border crossing or port, it is likely that the methodology pursued to identify weaknesses and corresponding solutions for a fixed facility may not apply to illicit trafficking. If so, upgrade activities may not be optimal, resulting in potential for wasted effort, excessive costs, or both.

2. OBJECTIVE

The objective of this paper is to present a methodology for evaluating the effectiveness of measures to prevent illicit trafficking at border crossings, and at air and sea ports. The methodology was developed within the Second Line of Defense program to provide a systematic, defendable means to identify effective measures to improve protection against illicit trafficking.

3. STANDARD PHYSICAL PROTECTION SYSTEM EVALUATION METHODOLOGY

The methodology for determining physical protection effectiveness, and identifying potential weaknesses and corresponding upgrades at a fixed facility is defined below. This methodology is promoted by the IAEA and taught at the IAEA-sponsored International Training Course on Physical Protection.

1. Identify, in detail, the special nuclear material and locations to be protected. This step entails listing all special nuclear material, its form (solid, powder, liquid, gas), its size and weight, and any other information important to its protection.
2. Identify the characteristics of an adversary that may want to steal the material. These characteristics include training of the adversary, adversary knowledge of the targeted material and the protection system, equipment or weapons employed by the adversary, scenario sophistication in terms of planning and execution, and numbers and specialties of adversaries, including insiders at the facility.
3. Determine the consequence of the loss of the SNM defined in step 1. These consequences rank the severity of loss for each material, and provide the opportunity to rank and grade the protection provided to each.
4. Define all possible paths that the adversary could follow to execute a theft of SNM. Along each step of these paths, all obstacles to the adversary and possible detection means would be identified.
5. Quantify the protection system in terms of probability of detection at each step, and amount of delay for each obstacle the adversary must overcome to achieve his objective.
6. Build a timeline comparing the time required for an adversary to proceed along a path with the expected time of arrival of the response force. To do this, some consideration for the expected start time of the response forces must be defined. At each step of the path, the adversary encounters some potential for detection, and the guard response is initiated whenever the adversary is detected. As the adversary proceeds undetected along the path, the cumulative probability of detection, and therefore the likelihood that the guard force has initiated its response, grows. The cumulative probability continues to grow until the adversary has proceeded far enough along the path that the time remaining for the adversary to complete the path (and the theft act) is less than the time needed for the guard force to respond and stop the adversary. The maximum cumulative probability while there is still sufficient time for the guards to successfully interrupt the adversary is used as a measure of the probability the adversary will be interrupted during the theft attempt.
7. Determine the probability that the guard force, if interrupting the adversaries, would succeed in preventing the adversary from the completing the theft attempt. This includes assessing the training, equipment, numbers, weaponry, and tactics of the guard force; and comparing those to the numbers, tactics, weapons, and scenario of the adversary defined in task 2.
8. Combine the probability of adversary interruption by the guard force, and the probability that the guard force can prevent, in an engagement, the adversary from completing the theft.

The process described above is based on assumptions that may not apply to illicit trafficking. These differences will be outlined in the next section.

4. DIFFERENCES BETWEEN FIXED SITE SECURITY AND PORT SECURITY

The features of fixed site protection include the following:

- The material being protected is in a known location, and protection features are based upon this knowledge.
- Access to the material, since it is in a known location, is tightly controlled through choke points. These controls include access by authorized personnel only; checks for contraband including SNM monitors, metal portals, and X ray machines; and personnel searches to prevent material from leaving the known location.
- Extensive perimeters with alarms and assessment are installed to funnel all personnel and vehicles through these choke points. These perimeters provide assurance that the choke points cannot be by-passed.
- The protection around the material is applied in layers. For example, the material might be stored in a building with perimeter detection and access controls and contraband detection through the choke points. The building would in turn be surrounded by a fence, which is instrumented with sensors and cameras. The choke point through the fence might include personnel access controls and metal and SNM detection.
- The protection is a primary function and is well integrated among facility operators, facility security, and off-site police.

The features of port or border crossing protection include the following:

- The target is material in an unknown location, at an unknown time, and is constantly moving.
- Although there are choke points, they are not as rigid due to port operations. For example, due to the throughput needs of port, intrusive rigorous searches on entry or exit are impractical.
- Although a perimeter exists, there is no detection along the fence funneling personnel through the choke point.
- There is only a single layer of protection.
- There is separation of responsibility for smuggling among guards, customs, and border patrol.

These differences reveal several issues when directly adapting the methodology for fixed sites to illicit trafficking. First, there are no tightly defined choke points through which material would have to pass during an illicit trafficking event. Next, the material location is unknown and therefore it is difficult to apply several layers of protection around it. Additionally, there is no defined, quantified detection database for suspicious acts at a port. Finally, timeliness is less important, but the accuracy of alarms is more important. Therefore, the response time of the guards is less important, and the false alarm rate of sensors far more important.

These differences drive the need for a modified methodology.

5. PROPOSED ANALYSIS METHODOLOGY

The following methodology, developed within the Second Line of Defense program, is proposed, as follows:

1. Define threat capabilities of the expected adversaries. This includes equipment, types of adversaries, and knowledge, including knowledge of handling of special nuclear material.

2. Define possible adversary activities, in fine detail, that may result in detection. These include detection while traversing boundaries, including SNM monitors, searches by guards and casual observation by employees; or detection while performing suspicious acts, primarily based on casual observation of employees.
3. Assign relative qualitative estimates of detection (Low, Medium, High) to the possible detection activities. These are assigned in relation to each other considering what is known about port activities using pair-wise comparison and grouping and like probabilities.
4. Define a comprehensive list of all paths an adversary can follow to smuggle material through the port. From these paths, develop scenarios based upon the adversary capabilities. These scenarios will describe potential adversary capabilities from start to finish, eliminating any implausible actions or events.
5. Reduce each scenario to a set of fundamental tasks the adversary must accomplish to succeed. For example, the scenario might define that the adversary will penetrate the perimeter through the main personnel entrance. To do this, he will need to obtain an access badge, appropriately conceal the material to be smuggled, and choose his time of entry to maximize success. Therefore the tasks are: (1) obtain an entry badge; (2) hide his material; (3) deceive the guard; and (4) bypass any material detection.
6. With each of the tasks defined in step 5, identify corresponding detection activities. For the example in step5, these might be: (1) police detection of false badge manufacture; (2) guard search based on suspicious activity; (3) guard detection of false badge; and (4) SNM, metal, X ray, or search detection of material. Each of these detection mechanisms should have been previously defined and assigned a qualitative effectiveness rating (Low, Medium, and High) in step 3.
7. Assign a numeric value to each qualitative value assigned to the detection activities in step6 according to a look-up table. For example, a Low might equate to a 0.25 probability of detection. Table I gives a recommended set of quantitative values. The quantitative value is assigned to permit summing of several unlike potential detection activities.
8.

Table I. Recommended Quantitative Values

Qualitative Value	*Very Low*	*Low*	*Moderate*	*High*	*Very High*
Quantitative Value	0.05	0.25	0.50	0.75	0.95

9. Sum the detection activities associated with a specific scenario. These detection potentials are summed to estimate the cumulative effect of several sequence potential detection mechanisms. The potentials are summed according to the equation:

$$\mathbf{P_T = \{1 - \sum (1 - P_N).}$$

Where: P_t is the total detection potential for an adversary path, and
P_n is the individual detection potential at a particular location or time.

10. Transform the final numeric cumulative detection potential of a path for an adversary to a qualitative measure. This transformation accurately reflects the relative rather than mathematical nature of the estimate of effectiveness. Table II includes a suggested relationship between quantitative and qualitative measures.

Table II. Conversion from Quantitative to Qualitative Measures

Quantitative Value	*0.00–0.10*	*0.10–0.35*	*0.35–0.65*	*0.65–0.90*	*0.90–1.00*
Qualitative Value	Very Low	Low	Moderate	High	Very High

By following this methodology, a measure of the estimated system effectiveness for each defined scenario and adversary can be determined.

6. VALUE OF METHODOLOGY

The methodology provides a protection specialist or program manager with a means:

- of comparing the effectiveness of different scenarios;
- of identifying potential problem areas, and corresponding potential upgrades;
- of measuring the overall impact of potential upgrades and, therefore confidence in value of upgrades, and a comparison of different upgrade options;
- of documenting and justifying the decision process for expenditure of funds.

7. SUMMARY

Currently, upgrades are implicitly addressed using an upgrade model defined and proven for fixed sites. This model cannot be directly applied to illicit trafficking due to the inherent differences between fixed site protection and trafficking through a border crossing or port. Therefore, the upgrades defined by the methodology may not be as effective as expected, and other upgrades with impact may not be identified.

A modified methodology adapted to illicit trafficking has been developed. The new methodology permits a better understanding of the vulnerabilities and solutions to port issues.

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the US Department of Energy under contract DE-AC04-94-AL85000.

QUESTIONS AND ANSWERS

N. Kravchenko (Russian Federation): Are you planning to develop a computer programme for assessing the effectiveness of the equipment at border crossing points?

D. Ek (USA): To date, there has been no discussion about producing software to assist customs to evaluate their systems but this will be considered.

A 'TUBELESS' PORTABLE RADIATION SEARCH TOOL (PRST) FOR SPECIAL NUCLEAR MATERIALS

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Abstract. Nuclear Safeguards and Security Systems LLC (NucSafe) has produced a briefcase packaged Portable Radiation Safety Search Tool (PRST). It detects Special Nuclear Materials (SNM) by measuring neutron and gamma rays. The neutron sensors are comprised of scintillating glass fibers and Bismuth Germanate (BGO) is used as the gamma ray detector.

Nuclear Safeguards and Security Systems LLC (NucSafe) has produced a briefcase packaged Portable Radiation Search Tool (PRST) for the IAEA Safeguards Group (Figure 1). The PRST detects Special Nuclear Materials (SNM) by measuring neutrons and gamma rays. Neutron sensors are comprised of scintillating glass fibers, which provide several advantages over conventional ^{3}He and $^{10}BF_3$ tubes. These ^{6}Li glass fiber sensors offer higher neutron sensitivity, increased dynamic counting range, eliminate transport and operational hazards, and have significantly less microphonic susceptibility than gas tubes.
Bismuth Germanate (BGO) is used as the gamma detector due to its higher intrinsic efficiency relative to Sodium Iodide (NaITl) detectors. Since gamma spectrometry *senso stricto* is not a system requirement, gross gamma counting in six regions of interest was designed for the PRST search functions.

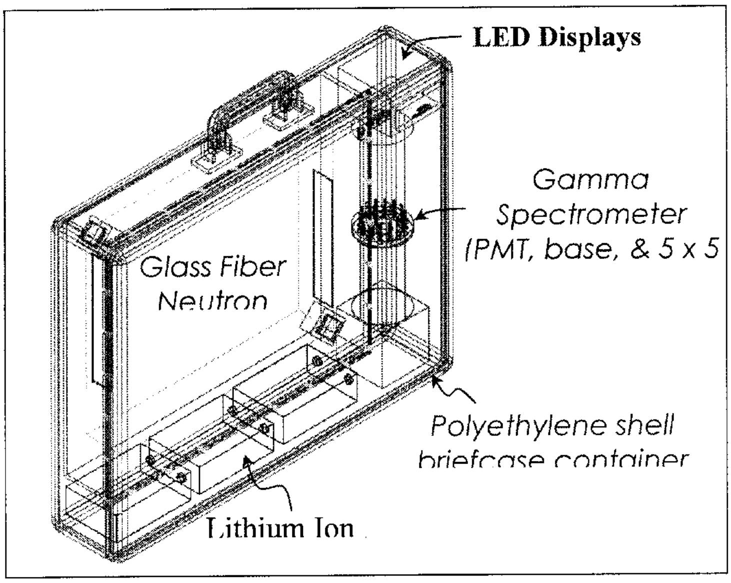

Figure 1. Modified 3D CAD drawing of the NucSafe PRST. The system has been designed to be as modular as possible. Neutron and gamma ray sensors are removable and easy to replace with alternate sensor/detection sub-systems.

The system must be as light as possible and is now ~8 kg with an overall size of 46 × 36 × 15 cm. The unit uses smart lithium ion batteries that may be exchanged with a fresh pack or recharged during operation. Operating time with fully charged batteries is 8 to 10 hours. The PRST does not require an external computer for operation. Onboard electronics allows the system to integrate data over multiple counting times and provides over-sampling and peak detection and hold for short alarm events. Users can independently adjust a number of parameters including set points for neutron and gamma channel alarms, but system operation is very simple.
PRST neutron sensors contain 5 layers of glass fiber ribbons *vice* the 3-layer glass fiber panels used in NucSafe SNM monitors for vehicles, portals, and freight. Five layers provide the additional sensitivity needed since detector areas are limited by portability requirements for the PRST. Monte Carlo (MCNP) modeling has demonstrated that moderation is more important than detector active area in attaining the highest intrinsic efficiency for a given mass of neutron glass fibers. These and other Monte Carlo and first principal calculations used to determine SNM detection limits shall be presented; *e.g.*, assuming a 0.014 n-cm^{-2}-sec^{-1} nominal neutron background, the intrinsic neutron efficiency is 20% for this 506 cm^2 glass fiber sensor.

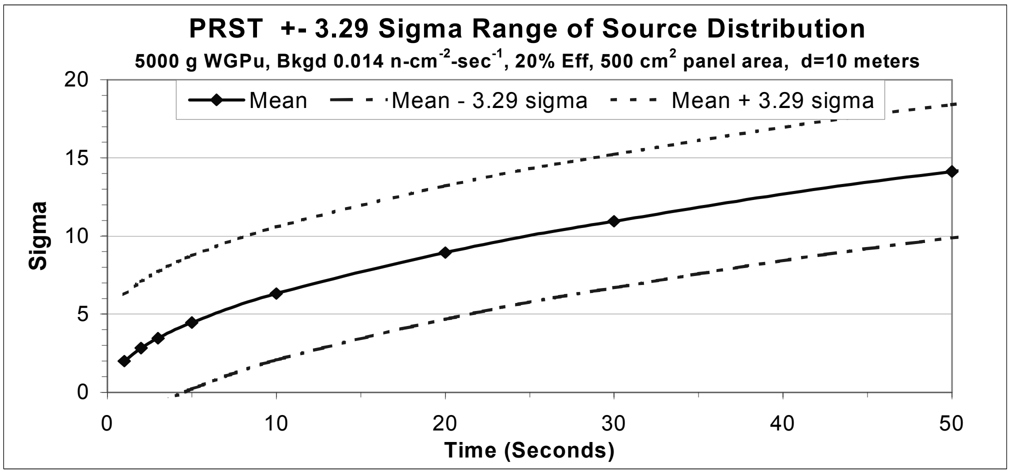

Figure 2. A plot of net counts divided by background standard deviation (Sigma) versus time shows that 5 kg of WGPu can be detected at 10 meters within seconds.

Figure 2 shows that the glass fiber PRST detects neutrons from 5 kg of Weapons Grade Pu (WGPu) at a distance of 10 meters within seconds. Accounting for Poisson variability of data and an alarm set point of 4.4 sigma over background, required for setting a reasonably low false alarm rate, WGPu is unquestionably detected at 10 meters within 18 seconds. These models have been validated with empirical data collected using WGPu and ^{252}Cf sources.

Neutron measurements of 4 WGPu sources acquired with the NucSafe PRST and also with a ^{3}He tube system are plotted in Figure 3. The glass fiber and tube systems were packaged in nearly identical briefcases, but the fibers can be better moderated. The glass fiber sensor is about twice as sensitive to neutrons as the ^{3}He tube system for equivalent detector masses.

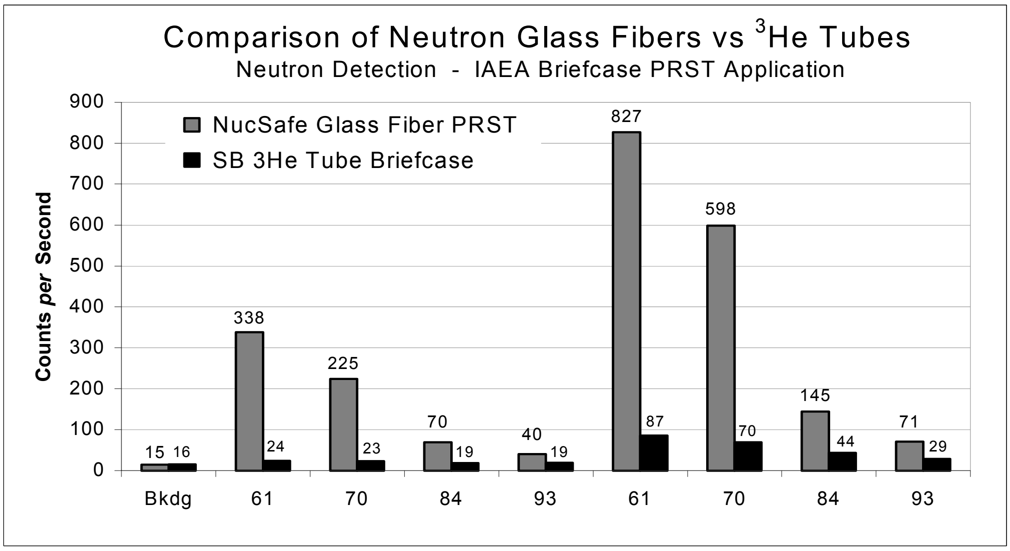

Figure 3. Comparisons of data collected with a glass fiber neutron sensor with those from 5 ^{3}He tubes at 3 atmospheres measuring 25 cm in length by 2.5 cm in diameter.

In summary, the NucSafe PRST offers improved performance, reliability, safety, and may be transported on commercial carriers. This new solid-state sensor system provides the ideal tool for IAEA and UNSCOM inspectors, as well as other law enforcement and customs agencies, for use in counter-terrorism, detecting illicit trafficking, and SNM search applications.

NATIONAL RESPONSES
(Session 9)

Chairperson

M. BAHRAN
Yemen

Keynote Address

PREVENTION OF THE USE OF LEGAL TRAFFICKING FOR NUCLEAR MATERIAL AND RADIOACTIVE SOURCE SMUGGLING

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Abstract. Preventing illegal movement of fissionable and radioactive materials (FRM) across customs borders involves two main tasks: (1) detecting undeclared movement of FRM through customs control points, and (2) preventing smuggling of undeclared types or quantities of FRM within declared radioactive shipments. Equipment and procedures for detecting undeclared FRM are fairly well understood but, unfortunately, experience shows that smuggling within legal shipments also occurs. In most countries, however, no customs measures are in place to deal with the issue. The Russian Customs Service has acquired some experience by using high-resolution gamma-ray spectrometers in conjunction with a database on the structural characteristics of all Russian-certified FRM containers. Customs control of legal radioactive shipments is not addressed adequately in the current IAEA technical documents on illicit trafficking, and additional work is needed in these areas: testing various manufacturers' gamma spectrometers for customs use; creating an international database on FRM shipping containers; investigating the use of high-resolution detectors that do not require liquid nitrogen, and certifying methods for quantitative measurement of FRM in known containers.

Опыт Российской Федерации в организации таможенного контроля за делящимися и радиоактивными материалами (ДРМ)

Кравченко Н.Э.– заместитель начальника Управления спецтехники
и автоматизации таможенных технологий,
руководитель службы таможенного контроля за
делящимися и радиоактивными материалами (ТКДРМ)
ГТК России

В течение вот уже 6-ти лет таможенная служба Российской Федерации решает новую для себя функцию предотвращения незаконного перемещения через таможенную границу ДРМ. Это была ответная мера правительства Российской Федерации после инцидента с плутонием в аэропорту г.Мюнхена в 1994 году.

Реализация этой новой функции осуществляется решением 2-х основных задач:

1. Обнаружение на пунктах пропуска лиц, товаров и транспортных средств с незаконно перемещаемыми ДРМ.

2. Организация таможенного оформления и таможенного контроля ДРМ (экспорт, импорт, транзит) с целью недопущения контрабанды ДРМ путем их подмены или количества, не соответствующих декларируемым в ГТД.

Выполнение этих задач невозможно без наличия адаптированных для таможенного контроля технических средств обнаружения и идентификации ДРМ и подготовленных специалистов таможенников.

Эффективность деятельности

Количество фактов пресечения незаконного перемещения товаров с повышенным уровнем ионизирующих излучений и ДРМ в 2000 году возросло в 100 раз по сравнению с 1995 годом и это связано не с всплеском в этом году незаконных перевозок, а с эффективностью деятельности российской таможенной службы:

80% — первичное обнаружение техническими средствами и

80% из всего количества выявленных фактов незаконного перемещения — ввоз товаров на территорию Российской Федерации и транзит через ее территорию.

Основные направления организации радиационного контроля (РК)

Показаны на примере Шереметьевской таможни.
(1 задача)

На практике решение этих задач реализуется по следующим организационно-техническим направлениям:

а) Организационные меры

В Шереметьевской таможне сформирован отдел, в состав которого включены специально подготовленные в области радиационного контроля сотрудники, обученные работе на радиометрической и спектрометрической аппаратуре. Эти специалисты входят в состав дежурных смен, осуществляющих таможенное оформление и таможенный контроль, и обеспечивают постоянный радиационный контроль пассажиров, их багажа, транспортных средств и товаров, пересекающих государственную границу. Круглосуточный режим работы наших специалистов позволяет оперативно и квалифицированно принимать меры по локализации выявленного источника излучения и исключению непосредственного контакта сотрудников таможни, обслуживающего персонала аэропорта и остальных пассажиров с объектом излучения.

б) Технические меры

К ним относятся оснащение и применение в повседневной деятельности технических средств радиационного контроля, которые подразделяются на:

- стационарную аппаратуру первичного радиационного контроля (САПРК);
- переносные приборы для проведения дополнительного РК;
- спектрометрическая аппаратура для контроля легально перемещаемых ДРМ.

Описание алгоритма таможенного контроля делящихся
и радиоактивных материалов (ТКДРМ)

Применяемый алгоритм таможенного контроля делящихся и радиоактивных материалов включает в себя три этапа:

I этап — этап первичного РК — обеспечивается стационарными таможенными системами обнаружения ДРМ «Янтарь», установленными на линии таможенного контроля, рядом с досмотровой рентгеновской техникой (ДРТ). Эта аппаратура работает в непрерывном автоматическом режиме и согласована с остальными элементами общей системы таможенного контроля. Такая схема обеспечивает тотальный РК всех объектов, пересекающих таможенную границу, и позволяет оперативно выделить из общих пассажиро- и грузопотоков источник излучения. В случае срабатывания системы «Янтарь» таможенное оформление пассажира приостанавливается и наш сотрудник приступает ко второму этапу радиационного контроля.
Следует отметить, что одной из особенностей 1-го этапа радиационного контроля является видеозапись объекта излучения с помощью видеокамер, установленных непосредственно на стойках системы «Янтарь», которая осуществляется автоматически при ее срабатывании с последующим выводом изображения на печать. В случае необходимости, такая фотография (на ней также зафиксированы номер монитора, дата и время события) может быть использована в дальнейшем для последующего судебного преследования правонарушителя.

II этап — этап дополнительного РК — обеспечивается действиями нашего сотрудника с применением переносных приборов и сводится к решению следующих вопросов:

- выяснение причин срабатывания САПРК;
- поиск и локализация источника излучения в багаже пассажира;
- измерение максимального уровня МЭД на поверхности багажа и оценка ситуации с точки зрения радиационной опасности для окружающих;
- контроль наличия поверхностного радиоактивного загрязнения багажа пассажира;
- первичная идентификация обнаруженного радиоактивного источника.

Дополнительный радиационный контроль начинается с устного опроса пассажира на предмет наличия у него в багаже радиоактивных источников. При отрицательном ответе наш сотрудник приступает к выполнению действий в той последовательности, которая изложена выше. При обнаружении в багаже источника излучения записываются паспортные данные пассажира, составляется на основании результатов радиационного контроля протокол о нарушении таможенных правил, оформляется документально задержание источника излучения, который помещается на временное хранение на склад радиоактивных грузов.

В целях обеспечения радиационной безопасности персонала, а также пассажиров дополнительный радиационный контроль выделенного объекта проводится в специально оборудованных кабинах, расположенных в стороне от пассажиропотоков.

III этап — этап углубленного радиационного обследования — обеспечивается аккредитованными в этой области экспертными организациями в целях получения заключения по выявленному источнику излучения.

Эксперт на основании результатов экспертизы должен ответить: является ли обнаруженный источник излучения радиоактивным материалом. Основным критерием признания материала радиоактивным является превышение величины удельной радиоактивности, установленной в Товарной номенклатуре внешнеэкономической деятельности (ТН ВЭД) для товаров, включенных в товарную позицию 2844, которая составляет 74 Бк/г. Данный критерий соответствует международным требованиям и не противоречит классификации таких товаров, применяемой во внешнеэкономической деятельности. Результаты этого этапа используются при проведении процессуальных действий в ходе расследования по факту правонарушения.

Необходимо отметить, что наряду с реальными источниками излучения в виде предметов, валюты и т.д., выявляемых сотрудниками таможни, фиксируется большое количество пассажиров, прошедших курс лечения радиофармпрепаратами в медицинских учреждениях. Такие биологические объекты излучения нами рассматриваются как один из вариантов потенциального использования этих людей в качестве перевозчиков контрабанды ДРМ. Поэтому дополнительный радиационный контроль для такой категории пассажиров проводится по отдельной методике, которая включает в себя контроль наличия подтверждающих лечение медицинских документов и проведение измерений МЭД как по всей поверхности тела, так и в области больного органа. Никаких санкций к таким пассажирам не применяется, процедура контроля проводится также в спецкабинах, корректно и достаточно быстро. Личный досмотр пассажира может быть применен в крайних случаях при наличии достаточных оснований для его проведения.

Приведенная выше технология применяется для решения первой задачи.

Вторая задача моего доклада осветить проблему пресечения контрабанды при легальном (экспорт, импорт) перемещении ДРМ. К сожалению, практика российской и других таможенных служб показывает наличие таких случаев. А с учетом отсутствия в таможнях большинства стран технологий такого контроля, делает угрозу такого вида контрабанды практически реальной и безнаказанной и при этом трудно обнаруживаемой. Ответственность за это несут таможенные службы.

Следующие аргументы подтверждают этот вывод.

1. Компетентные национальные органы в области ядерной безопасности отвечают только за соблюдение условий безопасной перевозки ДРМ. При экспорте (импорте) проверка соответствия декларируемым данным в таможенной декларации фактически перемещаемым ДРМ — функция таможен во всем мире. Эта функция контроля начинается после регистрации таможенной декларации.
2. Товар (ДРМ) при предъявлении таможне находится в спецконтейнере (нельзя увидеть и подсчитать). С помощью дозиметров определяется только уровень безопасности перевозок.
3. Участие таможни в режиме экспортного контроля в настоящее время во многих странах — это проверка только документов (лицензий и деклараций) и при этом эффективна только с законопослушными получателями (отправителями) ДРМ. Инструментального контроля фактически нет.
4. Бороться с этим видом контрабанды техническими средствами, устанавливаемыми (стационарные и переносные) на пограничных пунктах пропуска — бесполезно. Обнаруживается техническими средствами только факт наличия излучения (нет идентификации). Предъявляется документ, что перевозчик перевозит любой ядерный или радиоактивный материал и таможня пропускает такой товар.

Нужны другие средства и другая организация работы таможни.

Российский опыт в этом вопросе и его практическая эффективность.

Сначала об инструменте контроля. Создан и используется уже 4 года гамма-спектрометр с детектором из особо чистого германия СКС-50, который позволяет, не вскрывая контейнера, проводя измерения гамма-излучения, определить что в контейнере находится:

1) такой-то радиоактивный материал и его количество;
2) обогащение урана по U-235;
3) процентное содержание Pu-239 в плутонии, т.е. те данные, которые декларируются при экспорте.

Отличие этого спектрометра от других известных в мире, тем что он имеет базу данных всех сертифицированных в России контейнеров для перевозки ДРМ (конструктивный материал, толщина), таким образом его программный продукт производит измерения с учетом поглощения гамма-измерения в известных материалах. Программа проста — работает таможенник и не надо визуально анализировать спектр.

Теперь об организации технологии такого контроля.

Задачи:

- минимизировать количество таких, достаточно дорогих спектрометров;
- минимизировать количество подготовленных специалистов таможенников.

В Российской Федерации организационно право легального оформления ДРМ предоставлено 18 таможням. Алгоритм контроля представлен на 2-х схемах (экспорт, импорт), рис. 1.3.2 и 1.3.3.

Эффективность

В 2000 году 30% нарушений выявлено при легальном экспорте и импорте ДРМ.
Примеры: в 1999 году производственное объединение ПО «Маяк» перемещало для научных целей Pu-239 без лицензии, в 2001 году (февраль-март) в таможню г.Екатеринбурга из другой страны самолетом прибыло два контейнера. В сопроводительных документах указывалось, что они пустые. Российской таможней с помощью спектрометра выявлено наличие в одном из контейнеров иридия-192. Ведется следствие, проинформирована таможенная служба страны-отправителя.

Проблемы и предложения

МАГАТЭ оказывает большую помощь таможенным и пограничным службам. Подготовлены 2 технических документа: по детектированию и реагированию.

Однако, есть еще проблема, в решение которой вклад такой организации как МАГАТЭ был бы очень важен.

Это — идентификация обнаруженного источника ионизирующего излучения неразрушающими методами в условиях таможенных органов.
2 аспекта:

1. На пограничном пункте пропуска — первичная идентификация (ЕРН, техногенный, ядерный материал, медпрепарат).

2. Идентификация и определение количественных характеристик радиоактивного товара, перемещаемого в известном контейнере (экспорт, импорт).

Эти два аспекта не нашли конкретного отражения в техническом документе МАГАТЭ «Незаконное перемещение радиоактивных материалов, предотвращение, обнаружение и реагирование» и требуют дополнительных работ по следующим направлениям:

1. Тестирование гамма-спектрометров различных производителей с целью возможности их использования для таможенных целей.
2. Создание международной базы данных спецконтейнеров, предназначенных для перевозки ядерных и радиоактивных материалов. Необходима электронная версия (наименование, толщина стенок, конструктивный материал, рекомендуемая точка измерения), которая могла бы использоваться в любом гамма-спектрометре, используемом для таможенных целей и быть адаптированной с программным обеспечением.
3. Рассмотреть возможность использования вместо детекторов с ОЧГ — альтернативных, с целью исключения использования в эксплуатации жидкого азота.
4. Проведение сертификации методов измерения количественных характеристик ДРМ, находящихся в известном контейнере.

Реализация этих вопросов помогла бы таможенным службам повысить эффективность таможенного контроля ДРМ и пресечения их контрабанды.

QUESTIONS AND ANSWERS

S. Erickson (USA): Did the 500 interceptions of radioactive material include innocent items such as medical isotopes and natural material, or was it all contraband and contaminated materials?

N. Kravchenko (Russian Federation): They didn’t include medical preparations; they did include nuclear material such as pellets from the nuclear fuel cycle, and contaminated metal scrap, building material, medical equipment and consumer goods. We did not detect any weapon usable material.

K. Singh (India): a) What are the legal provisions for nuclear/radioactive material smuggling offences under Russian law? b) Do the Russian customs authorities provide training to customs officers from countries other than the CIS and the Baltic States?

N. Kravchenko: a) Article 188/2 of the Russian Criminal Code deals with smuggling: any illicit transboundary movement of NM can incur a prison sentence of up to seven years. b) Such courses have existed in the Russian Defence Ministry’s training centre since 1995 and two years ago they started in our customs academies in St. Petersburg and Vladivostok. Training materials were elaborated with the collaboration of US DOE, and the courses are being developed with assistance from the IAEA.

J. Koziel (Poland): To what extent is the frontier between the Russian Federation and Belarus equipped to control movements of radioactive material?

N. Kravchenko: There are no controls between the Russian Federation and Belarus but there are between Belarus and Poland.

J. Fechner (Germany): Your approach for improving detection and assessment of radioactive consignments is promising and the idea of an international database on transport containers is a good one, which deserves further support. Germany would be prepared to share German container data with the Russian customs organization in exchange for data on Russian containers. What is the professional background of your customs officers who receive special training for doing Ge-gamma spectrometer measurements?

N. Kravchenko: In my service, these specialists must have a strong technical background. They receive three weeks of training, which enables them to work effectively, with retraining every three years.

U. Mirsaidov (Tajikistan): Are detailed analyses made of confiscated nuclear material?

N. Kravchenko: Yes, with the involvement of specialist organizations.

ASSISTING EASTERN EUROPEAN COUNTRIES IN THE SETTING UP OF A NATIONAL RESPONSE TO NUCLEAR SMUGGLING

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Abstract. Since the mid-90's, ITU assisted national authorities in revealing the intended use and possible origin of seized nuclear materials. Existing tools, used in the characterisation of nuclear fuels, were adapted to this task; other analytical techniques, together with an appropriate methodological approach, were developed. From a joint effort within the P-8 International Technical Working Group (ITWG) on Nuclear Smuggling, a Model Action Plan resulted, which included the Nuclear Forensic Methodology as developed by ITU, as a complementary measure to assist a state. In the frame of TACIS/PHARE support, we tested this concept together with the concerned authorities of the Czech Republic, Hungary, Bulgaria and Ukraine. Based on the above, a new initiative is being developed for all thirteen future Member States of the European Union. A general meeting to start-up the support projects, organised at ITU on November 9 and 10, 2000, was attended by two representatives per country. All presented their national situation with respect to nuclear smuggling (real cases, response...) and committed to support the implementation of a structured approach both to improve the national situation and to seek for cross-border collaboration.

1. INTRODUCTION

Illicit trafficking on nuclear material continues to pose a global proliferation and safety risk. On the P8 summit meeting in Moscow, April 96, the following recommendation was made: "Illicit trafficking of nuclear material is a public safety and non-proliferation concern. We recognised the importance of this issue at our meetings in Naples and Halifax. As risk continue to exist, we have agreed on, and released, a program for preventing and combating illicit trafficking in nuclear material to ensure increased co-operation among our governments in all aspects of prevention, detection, exchange of information, investigation and prosecution in cases of illicit nuclear trafficking. We call other governments to join us in implementing this program." In the meeting of the ITWG in Vienna on June 8. and 9. 2000, the interest for international support to counteract such smuggling was stressed once more and a reference Model Action Plan (MAP) for this purpose was agreed upon (Table I).

In the Resolution on the communication from the commission to the Council and the European Parliament, COM(94)383–C4-0227/94, published in the Official Journal of the European Communities, C211, dated July 22nd 96, it is stated that:

- "for the newly formed states of the former Soviet Union a model should be developed, which integrates the national (upgraded) technical assistance into states law enforcement";
- "to complement the national technical capability with international assistance it should be agreed on a permanent assistance available in case the technical capabilities of the concerned state are insufficient";
- "an international R&D program on nuclear forensic techniques should be set up to improve and generalize upcoming investigations".

The majority of cases, so far, have involved only small amounts of fissile materials or material of little use for weapon purposes. Nevertheless, cases of illicit trafficking continue to occur. Hence, the EU Member States step up their co-operation in the area of nuclear smuggling and "to assist effectively countries of origin and transit in taking action on the ground".

For transit countries, assistance activities are foreseen in particular in the following areas:

- material origin identification with the assistance of EU research installations including assistance in analytical measurement training,
- assistance to efficient co-ordination among transit countries including setting up of a data bank of nuclear materials,
- agreements for implementing of the ITWG "Model Action Plan" through international co-operation,
- identification of possible assistance needs e.g. training and/or equipment upgrade,
- implementation of training and/or equipment upgrade.

Table I. Structure of model action plan for seized/found radioactive or nuclear material

1. Detection, cordoning off and guarding of the site by the law enforcement service
2. The competent service must confirm the nuclear or radioactive nature of the material and determine whether a nuclear or radiation hazard exists.
3. The central authority which is authorized to initiate the action plan must be informed
4. On-site, the following actions should take place:

* Health Physics examination for occupational and public radiation hazard.
* Law enforcement actions to check for booby traps and preservation of evidence, chain of custody.
* On-site categorisation of seized material by mobile NDA instrumentation.
* Store material safely until transportation.

5. The following investigations are to be foreseen at the specialised national laboratory:

* checking for booby traps before unpacking.
* preservation of evidence and classical forensic analysis of non radioactive material.
* detailed investigation according to laboratories capabilities (visual, quantity, sampling, nuclear properties etc).
* first query with nuclear materials database to guide in-depth investigations.
* in-depth analysis of material in a specialised laboratory to characterise the material to such an extent that the identification of the origin, intended use and last legal owner becomes possible.

6. If the national laboratory is not in a position to carry out certain analysis a sample of the material could be shipped to an external specialised laboratory.
7. The results are compared with an appropriate database, possibly resulting in further investigations.
8. An analytical "expert opinion" of the analysed seized material is to be written for the national law enforcement authorities where the seizure occurred.
9. A synopsis and evaluation of all evidence is to be made by the national legal authority
10. The case will be treated by the national courts and closed.
11. The material should be returned to the last legal owner in accordance with an international agreement and existing non-proliferation legislation.
12. If the material's owner cannot be determined or the material cannot be returned because of the international situation a use or disposal of the material is decided according to relevant legislation.

2. PAST EXPERIENCE IN THE CHARACTERISATION OF SEIZED NUCLEAR MATERIAL

In order to characterise material to the required extent, a new methodology — nuclear forensics — had to be developed. The methodology follows the principle of diagnosis; i.e. the progressive steps of the investigation are guided by the results of the preceding steps, according to which the tools and techniques for the further investigation are selected. This is explained in more detail in the paper presented by I. Ray during this conference.

3. THE MODEL ACTION PLAN AND STRUCTURE OF THE SUPPORTING ACTIVITIES

The Model Action Plan referred to above contains the methodology about how to respond to a real case of seizure of nuclear material. In order to arrive at the recognition and acceptance of this methodology in a particular country, a dedicated effort is required to familiarise all involved authorities with the subject matter. For this purpose, the logical sequence of actions to combat illicit trafficking of nuclear material is to be explained, as illustrated in figure 1. A fact-finding mission in the country is the subsequent step in order to determine the existing national situation with respect to the issue. The organisation of demonstration exercises on real seized nuclear material helps to establish the national situation and allows to define the required training. The latter training can be organised on a general level, when e.g. oriented towards police force, custom officers or government officials, or can be highly specialised on the dedicated nuclear material analysis and investigation techniques, when oriented towards the nuclear specialists.

Determining the competent service, providing the nuclear experts, is of key importance in order to focus the support activities, such as equipment upgrading and familiarisation with the nuclear materials database. The structure of a typical support programme and the role of ITU in such support is indicated in figure 2.

4. EXPERIENCE IN IMPLEMENTING THE MODEL ACTION PLAN BY RUNNING DEMONSTRATION EXERCISES AND ORGANISING DEDICATED TRAINING

In the frame of Phare projects, ITU executed support projects in the subject area with the Czech Republic, Hungary and Bulgaria. With TACIS funding, an extensive support project was executed with Ukraine. With direct JRC funding, new support projects are now being established with all future Member States to the European Union. A return of experience on the Ukrainian project is discussed below.

In collaboration with the Ukrainian Ministry for Environmental Protection and Nuclear Safety and the Finnish Radiation and Nuclear Safety Authority (STUK), a Handbook for the Ukrainian Nuclear Regulatory Administration on the appropriate response procedures, in line with the Model Action Plan of the International Technical Working Group, was developed. In order both to gather the essential input for this handbook and to validate the initial procedures, a demonstration exercise was organised in Odessa, using real seized nuclear material. The detection, radioprotection, criminal investigation and nuclear material characterisation were executed on the spot, involving all relevant authorities and using highly sensitive mobile equipment for the determination of the isotopic composition of the real material. Western participants came from IAEA, Scotland Yard, STUK and ITU (figure 3). For this exercise the portable equipment was brought to the spot by the ITU representatives and operated by the trained spectrometrists from the Institute for Nuclear Research (INR).

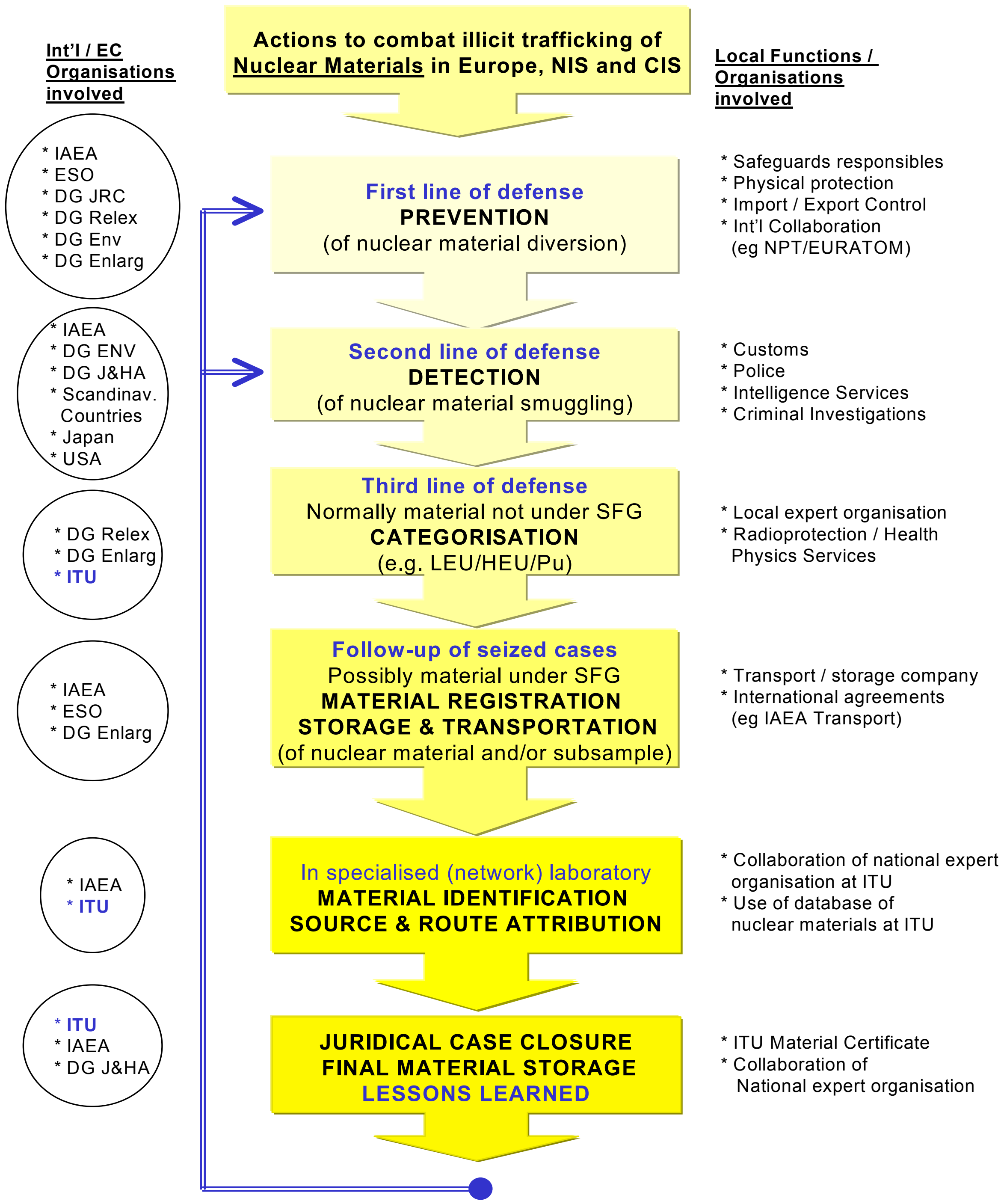

FIG. 1. The logical sequence of actions to combat illicit trafficking of nuclear material.

Based on this experience, and in order to prepare the ground for a profound discussion on the specificities of the Ukrainian response to a real case of illicit trafficking, a 3-day training course on the subject matter was organised in Kiev, attended by more than 20 participants from all concerned national organisations. Discussion sessions and practical demonstration exercises during this training convinced most participants about the added value of a national translation of the "Model Action Plan".

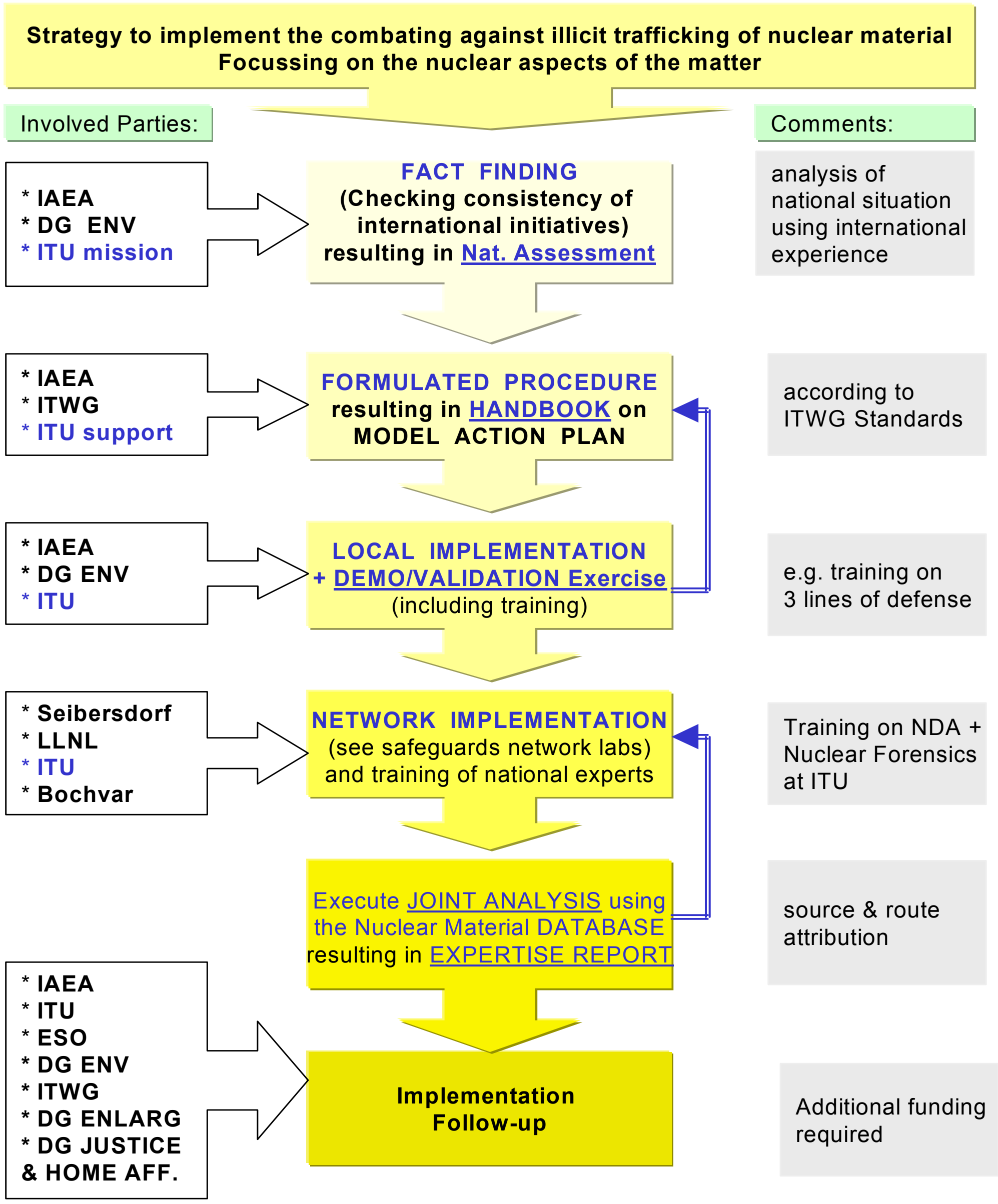

FIG. 2. The structure of a typical support programme and the role of ITU in such support.

FIG. 3. To the left: A. Berlizov (Institute for Nuclear Research, Kiev) measuring enriched U pellets with a portable gamma spectrometer and verifying absence of neutron irradiation. To the right: Unpacking of the material under controlled conditions.

The role of ITU in the “identification” of the nuclear material was further illustrated by training 4 scientists from INR during a week at ITU on the major relevant techniques available at ITU for the nuclear forensics analysis i.e.:

- non-destructive analysis (K-edge, X ray fluorescence, neutron counting and gamma spectrometry);
- chemical element analysis by titration;
- isotopic analysis by isotope dilution thermal ionisation mass spectrometry;
- impurity analysis by inductively coupled plasma mass spectrometry;
- microscopic analysis for morphology, crystal structure etc. by scanning and transmission electron microscopy;
- the use of the nuclear materials database as a guidance tool for the forensic analysis strategy and the evaluation of the obtained results.

The writing of the Ukrainian specific “Handbook on the response to illicit trafficking of nuclear material” was accomplished during a “catalyst meeting” in the STUK premises in Helsinki during 3 days, with 8 high-level representative from the major services involved namely (figure 4):

- The Physical Protection and Safeguards Office, Department of Nuclear Regulation, Ministry for Environment and Natural Resources (MENR) of Ukraine.
- The Kiev Scientific Centre “Institute for Nuclear Research”.
- The Security Service of Ukraine.
- The Ministry of Health of Ukraine.
- The office of legal and normative regulations for nuclear and radiation safety, Department of Nuclear Regulation, MENR
- The Division Internal Troops of the Ministry of Internal Affairs of Ukraine.
- The Main State Ecological Inspectorate of Ukraine.

FIG. 4. Catalyst meeting in Helsinki to write the Ukrainian Handbook for responding to cases of illicit trafficking of nuclear materials (participants to the left and signature of the protocol to the right)

After a description of the role and responsibilities of all involved organisations, the Handbook formulates in a chronological manner, all relevant actions to be taken, the organisations in charge and the special features to be focussed on during the specific action. It is meant to be a procedure, to be available to all local offices having identified responsibilities in a real case of illicit trafficking of nuclear material. The Handbook was therefore also translated into Ukrainian. This Handbook now serves as a model for the training purposes and for preparing national response plans for other countries in the future.

5. INTERNATIONAL COLLABORATION AND ITU CONTRIBUTION

As indicated in figure 1, both a number of international organisations and other Directorates General of the European Commission are involved in the actions to combat illicit trafficking of nuclear materials. Close contacts are held with IAEA since the start of the ITU activities in this area, and a network of analytical/nuclear forensic laboratories (in analogy with the Network of Safeguards Analytical Laboratories) is under preparation. The transport of a sample of the above-described real case of nuclear material seizure in Odessa by IAEA to Seibersdorf and to ITU will serve as a test case in this respect. It will be analysed with Ukrainian participation at ITU in order to compile an “expertise report” on the material, which can be used for juridical purposes in Ukraine.

A collaboration is also being established between Europol and ITU, based on complementary skills in the overall “forensic analysis” and because it can be expected that in quite a few cases, cross-boundary and/or organised crime are involved in the smuggling of nuclear material.

ITU maintains also the contacts with the other Directorates General of the European Commission (e.g. Environment (Env), External Relations (Relex), Enlargement (Enlarg), Justice and Home Affairs (J&HA) and Energy — the latter represented by the European Safeguards Office (ESO)) in order to increase the synergy between the running actions in this area and to achieve an optimum implementation of the required support.

With the same overall objective as the one described above, all thirteen future Members States to the European Union were approached. The final goal is also here to achieve an efficient collaboration in the identification of the nuclear material and therefore both the closure of the juridical case in the concerned country and the reduction of the probability for reappearance of similar cases, by providing input to the first and second line of defence. A general meeting to start-up dedicated projects, organised at ITU on November 9 and 10, 2000, was attended by two representatives per country. All presented their national situation with respect to nuclear smuggling (real cases, response...) and committed to support the implementation of a structured approach to both improve the national situation and to seek for cross-border collaboration.

BIBLIOGRAPHY

21st ESARDA Symposium on Nuclear Material Management, May 4–6,1999 Seville (Spain).

Bibilashvili Yu., Kositsyn V., Chorokhov N., Chkaboura I., Dolgov, Yu., Koch L., Mayer K. Methodology of the Analysis of Nuclear Materials of Unknown Origin at VNIINM Moscow, Proceedings EUR 18963 EN (1999) 821–829.

Dolgov Yu., Bibilashivili Yu., Chorokhov N., Schubert A., Janssen G., Mayer K., Koch L., Installation of a Database for Identification of Nuclear Material of Unknown Origin at VNIINM Moscow, Proceedings EUR 18963 EN (1999) 831–838.

Schubert A., Mayer K., Schenkel R., Koch L., The Bilateral Workshop on Nuclear Forensics 1998, held by ITU Karlsruhe and VNIINM Moscow, Proceedings EUR 18963 EN (1999) 839–844.

QUESTIONS AND ANSWERS

J. Fechner (Germany): Do your activities related to the assessment of the national situation concerning the combating of illicit trafficking of NM and other radioactive substances concentrate on all aspects of prevention, detection and response, or on categorization of the seized radioactive material and subsequent forensic analysis?

P. Daures (EC): In the frame of these projects, we focus on on-the-spot categorization and identification of NM, areas where ITU provides real added value. We do not deal with prevention and detection. On the other hand, fact finding missions are also used to verify existing legal bases for combating illicit trafficking and to meet all involved authorities.

S. Erickson (USA): Professional criminals may try to disguise the smuggled material by mixing in adulterants or treating it chemically. Could this defeat the identification techniques?

P. Daures: This presupposes that the criminals are also nuclear chemists, which so far has not been the case. Nevertheless, identification of NM involves many different, complementary, accurate analytical techniques. Combining them with the ITU database, we are still confident of being able to determine the origin and intended use of seized material.

J. Jalouneix (France): You mentioned prevention, detection and categorization as lines of defence. From a more practical point of view, what about prosecution as the third line?

P. Daures: This will come only after categorization. One must first know if the seized material is radioactive and, if so, whether it is weapon grade. Then the prosecution procedure can start, with forensic analysis and identification.

DOMESTIC CO-OPERATION IN COMBATING ILLEGAL NUCLEAR TRAFFIC: EXPERIENCE OF THE EMERGENCY SERVICE CENTRE[1]

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Abstract. Since 1990, the issue of illegal nuclear traffic has been recognized and some initiatives for its combating have been taken in Poland. The governmental decision on development and implementation of an effective detection system has received support and close co-operation in matters related to the enforcement of the domestic law between services responsible for detection and entities to be in charge of prevention and response tasks has been shaped. This paper presents domestic co-operation in combating illicit nuclear traffic and tries to assess its results based upon the experience of the Emergency Service Centre (ODSA) at the Central Laboratory for Radiological Protection (CLOR).

I. INTRODUCTION

The need for domestic co-operation in combating illicit trafficking in nuclear and radioactive materials appeared and was recognized in 1990 in Poland. Then, the first inter-ministerial decisions were taken to strengthen co-operation between the nuclear safety and radiological protection bodies and the law enforcement services and to expand detection capabilities at border crossings. It was decided to equip gradually all border checkpoints with indigenous portal radiation monitors to detect all attempts of imported commodities with abnormal radiation levels.

To follow-up of the 1990's initiative, the National Atomic Energy Agency (NAEA), which is the regulatory and control body for peaceful use of nuclear energy, concluded agreements on mutual co-operation with all law enforcement services: the Border Guards, the Customs Board, the Police and the State Security Office. From the technical point of view the authorized unit to provide assistance under the concluded agreements has been mainly the Emergency Service Centre (ODSA) based at the Central Laboratory for Radiological Protection (CLOR). ODSA/CLOR activities in that respect are supervised by the National Atomic Energy Agency.

II. WHY CLOR

CLOR is the leading national laboratory established to protect workers and the general public from the harmful effects of ionizing radiation. This task CLOR realizes by routine activities, scientific studies and sound advice to individuals, governmental and private entities. Having expertise and technical capabilities CLOR has been entrusted responsibilities closely related to the illicit trafficking issue and they include:

The Emergency Service Centre (ODSA)

- The Centre of Radioactive Contamination Measurements,
- The National Warning Point for early notification and assistance in the case of a nuclear accident or radiological emergency.

[1] The views expressed in this paper remain the responsibility of the authors.
[2] The authors wish to express their gratitude to James G. Yusko (from Pennsylvania Department of Environmental Protection, Pittsburgh, USA) for his comments and help in making this paper readable.

ODSA was established in the mid-60s, as the national response service in the case of any radiological emergency. The Centre performs its duty around the clock and its fundamental responsibilities are to:

- collect notifications on radiological emergency events,
- serve as a source of advice or first aid to the users of radiation sources, the law enforcement officers and others,
- provide assistance in case of a seizure or suspicion about a seizure of unknown radioactive material,
- co-ordinate response action,
- keep records and submit reports on radiological events to the NAEA,
- maintain databases of all licensed sources and their users.

The Emergency Service staff is experienced in collaborating with the law enforcement officers, but when the situation requires, they can also receive a support from the designated experts of CLOR or in-field actions, or in further laboratory identification of the seized material.

The identification and analysis of radioactive sources and nuclear material seized at the border or within the territory of Poland have been carried out by CLOR. The Laboratory uses alpha, beta and gamma spectrometry for analysis of unknown radioactive substances and high-resolution gamma-ray spectroscopy for uranium samples. Although there are no capabilities for a nuclear forensic analysis of the seized material nevertheless, CLOR experts are asked for their expertise and participation in the legal investigation procedures.

III. REASONS TO INCREASE DETECTION SYSTEM

With Poland's transformation process and geopolitical changes in the region a certain proliferation risk of nuclear materials or radioactive sources could have occurred in Poland. Although the country has well-developed regulations in place, including accountability and control systems over nuclear material, radiation sources and devices, the need to enforce the control activities and to strengthen co-operation among the nuclear safety and radiological protection bodies and the law enforcement forces appeared. Since the dissolution of the former Soviet Union greater attention has been given to the problem.

Then, besides the importation of the post Chernobyl contamination transports Poland experienced:

- lost and vagabond nuclear materials or radioactive sources from the former Soviet/Russian military bases deployed in Poland[3] (May 1995, the police found a container with two Cs-137 sources, of activity 1.9 GBq and 78 MBq, stolen in 1992 from the Russian military base in Borne-Sulimowo. The seizure was in a private apartment.),
- tourism trafficking in radioactive materials (November 1993, seven Sr-90 sources, of activity 37 MBq each, seized at the border checkpoint. Sources were hidden under the seat in the Ukrainian tourist bus.),
- orphan sources in recycled metals (June 1992 one or more sources of Cs-137 melted in steel mill at Ostrowiec. The approximate activity of the source or sources was 37 GBq.),

[3] The withdrawal of Russian troops was completed on 17 September 1993.

- contaminated manufactured products (December 1995, steel spare parts for agriculture equipment contaminated with Co-60, activity about 1000 kBq/kg. July 1997, agriculture equipment contaminated with Co-60, up-to 200 µGy/h. Both cases at the Czech border),
- contaminated valuables, likely on purpose (June 1993, gold and platinum contaminated with I-131 seized at Ukrainian border. December 1993, US dollars with Zr-95 contamination seized at the Czech border),
- transport of contaminated metal scrap due to demolition of extractive industries, old products with incorporated Co-60 or deliberate disposal.

IV. INVOLVEMENT IN COMBATING ILLEGAL NUCLEAR TRAFFIC

The Polish National Atomic Energy Agency is the regulatory authority and the contact point for illicit trafficking of nuclear materials and other radioactive sources. The NAEA, as mentioned earlier, concluded agreements on mutual co-operation with all law enforcement bodies. The scope of those agreements is dependent on the range of interest and kind of involvement in those activities of the contracting parties. The main intention was to recognize the need for co-operation in matters related to the enforcement of the domestic law and to establish the mutual assistance between the contracting parties as well as their subordinate services.

The task of combating illegal nuclear and radioactive traffic has been entrusted to:

- the Border Guards and Customs services — at the borders,
- the Police and State Security services — mainly within the country.

Some contribution to that action also developed from the recycling metallurgical scrap plants, which decided to install portal radiation monitoring devices to protect their products from the presence of radioactive isotopes. This voluntary action was strengthened by the Minister for Economy[4], who imposed an obligation on all entities involved in metal scrap processing to control and eliminate dangerous (including radioactive) objects from metal scrap.

The duty of the co-ordinator in providing an immediate assistance in the case of a seizure or a suspicion about a seizure of unknown radioactive material is performed the Emergency Service Centre (ODSA) at the Central Laboratory for Radiological Protection (CLOR).

All assistance and services under the co-operation agreements are performed free of cost by ODSA/CLOR.

The chief agency needing advice, consultation, expertise, support in detecting and response activities and many other related services is the Border Guards, who operate the portal radiation devices deployed at the border checkpoints. As of 2001, there are about 130 such devices deployed in Poland for each means of transportation. They cover Polish eastern border (with Ukraine, Belarus, Lithuania and the Russian Federation) and a majority of the crossing points with the other neighbouring countries. The Border Guards also use some 600 hand-held dosimeters and surface pollution meters (Polish origin) and 250 US radiation pagers.

Activities of the Border Guards are also supported by customs officers, who are equipped with some 400 hand-held instruments (Polish origin) for detecting radiation in luggage. The

[4] Dziennik Ustaw (Journal of Laws) No.3, 2000.

customs services possess also a few items of X ray equipment (Heinmann) for detection in voluminous containers.

An undeniable aid in some seizure actions of ‘orphan’ sources was information available from the database on all licensed radiation sources and their users. This was established and maintained by ODSA/CLOR upon data provided by the users of sources and by the licensing and controlling body, which is the NAEA. The law imposes the obligation of keeping records of ionizing radiation sources at facility level and at state level.

All seizures were carried out by the law enforcement services with ODSA assistance in detection and response actions. The identification of the seized radioactive sources has been performed by CLOR.

V. NOTIFICATIONS ON SEIZURES OR POTENTIAL SEIZURES

All users of radiation sources and the law enforcement officers are obliged to inform ODSA about incidents with involved radioactive material.

According to the applied procedure by ODSA, a notification on a seizure or a suspicion about a seizure of unknown radioactive material gives the grounds to start an assistance action. The notification is registered and analyzed first by the officer on duty before any action is taken. Submitted notifications and their follow-up actions could become a source data to draw some conclusions and to analyze illicit events with involved radioactive materials in Poland.

For the purpose of this paper, a simplified classification of the law enforcement forces involved in combating illicit nuclear traffic has been applied. All law enforcement bodies contributing to the seizures have been divided into 3 groups:

(a) Border Forces covering Border Guards and Customs.
(b) Police Forces covering Police and State Security.
(c) Others covering Local Security Forces [especially at metal recycling facilities and in some cases also forces mentioned in point a or b, if it refers to accidental found at their own premises during a new equipment testing exercise].

The assumed classification has resulted in altered picture of the real collaboration between those services and ODSA; however, it provides better account of the nuclear illicit traffic as a phenomenon.

The authors selected only those registered notifications, which could have been closely related to illicit nuclear traffic. Further analysis has been done upon those selected notifications and ODSA response actions. Some notifications were referred to fraud actions, others were false alarms, and others were contaminated metal scrap, steel products or plants. 32 cases out of 119 selected notifications were considered as important or serious cases, also from radiological protection point of view, and most of them could be related to criminal activities. The number (32) does not include a melting case; lost or stolen items; or stolen and recovered materials/items.

VI. SERIOUS CASES

Selected serious cases and some statistics related to the real seizures are shown in the tables.

Table I. Seizures of radioactive cases, 1992–2000

Year	Number of cases	Percentage of cases
1992	2	6,25
1993	8	25,0
1994	2	6,25
1995	5	15,6
1996	2	6,25
1997	6	18,75
1998	3	9,4
1999	2	6,25
2000	2	6,25
Total	**32**	**100**

Table II. Seizure of radioactive cases registered at CLOR, 1992–2000

Nuclear material	Radioactive source	Contaminated valuables	Waste	No documents
9	13	4	2	4

Table I presents the number and the percentage of cases for the period from 1992 to 2000.

The distribution of cases by categorization of incidents shows table II.

Besides two typical categories of nuclear material and radioactive sources, three more categories of seizures have been distinguished, which provide more information on cases.

The table contains 4 cases with dangerously contaminated precious values as gold and works of art, or US dollars. The contamination was with J-131 or Zr-95 and was likely done on purpose.

Information under the title ‘Waste’ refers to criminal cases according to Poland’s law. It contains one criminal case with a tiny amount of Am-241 and Th-232 and another with the seizure of 12 abandoned smoke detectors with 740 kBq of Pu-239 each.

Data titled ‘No documents’ refers to nuclear material or radioactive sources transported through the border and seized due to the lack of necessary documents. They were illegally transferred, but can be classified as an inadvertent movement.

Among the radioactive sources, there were two cases of locating a source due to a new equipment testing exercise at their own premises, one by the police (Sr-90 with activity about 740 MBq) and the other by the Border Guards (Cs-137 of 37 GBq).

Table III. Percentage of cases by services registered at CLOR, 1992–2000

Total [%]	**Border forces**	**Police forces**	**Others**
100	34,4	50	15,6

The share of forces contributing to the seizures registered at CLOR is presented in table III. Its results are related to the earlier assumed classification of services responsible for combating illicit nuclear traffic.

The seizures of all nuclear materials were accomplished by the police forces.

As of 2000, the whole action taken for combating illegal nuclear traffic resulted in the following seizures (roughly):

(a) 21 kg of depleted uranium.
(b) 8 kg of natural uranium.
(c) 1 kg of low-enriched uranium (LEU).
(d) 40 sealed sources (Cs-137, Sr-90 and Co-60), the biggest was Cs-137 with activity of 37 GBq.

Worth mentioning also are two cases, which involved LEU, because of their similarities. The first happened in March 1995 and contained 57 fuel reactor pellets with about 2% enrichment, the second happened in April 1997 and took 1 similar pellet. In both cases, police arrested criminals.

There was one registered incident involving a stolen and regained Ir-192 source of activity about 148 GBq.

Additionally, ODSA registered a dozen or so of cases with contaminated scrap and other goods.

VII. CONCLUSIONS

- Poland, despite of its well-developed regulations in place as well as accountability and control systems over nuclear material, radiation sources and devices, has registered some illicit cases with involved nuclear and radioactive materials.
- The early recognition of the illicit trafficking issue and domestic co-operation among the law enforcement forces and the nuclear safety and radiological protection bodies contributes to preventive measures and to limiting or even diminishing the number of occurrences.
- The increased awareness of the law enforcement forces and well-protected borders enhanced detection system in Poland. It might change a transit route of illicit trafficking.
- It is possible that some radioactive materials may be still hidden or abandoned within Poland.
- The use of radioactive isotopes to contaminate precious values (gold, works of art) or money (US dollars) seems to be especially dangerous and gives evidence about easy access to such substances.
- Orphan sources may be discovered in the country due to the termination of industrial plants, which had used or stored them.

- Cases with fraud with intent to sell radioactive materials may give evidence about a nuclear market.
- The high awareness of all forces involved in combating illicit nuclear traffic and the maintenance of the emergency response readiness has become a necessity even in a well-protected country as Poland.

QUESTIONS AND ANSWERS

S. Plachkova (Ukraine): a) Does Poland's legislation provide for criminal liability for illicit trafficking in nuclear and other radioactive material? b) Do you know of any cases of legal proceedings and sentencing? c) What can you say about the adequacy of penalties?

G. Smagala (Poland): a) Yes, illicit trafficking can be punished by one to ten years of imprisonment. b) There have been some cases where CLOR experts were asked for assistance in the legal procedures. c) I believe Poland has an adequate penalty system for illicit trafficking.

PROGRESS IN THE ACTIVITIES ON PREVENTION AND COMBATING OF ILLICIT TRAFFICKING OF NUCLEAR MATERIAL IN LITHUANIA

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Abstract. The paper gives a general overview of the progress, which has been done in the activities on prevention and combating of illicit trafficking of nuclear material in Lithuania. It describes the measures, which were taken to strengthen nuclear material accounting and control and physical protection. The current status of the national legislation and the functions of institutions involved in control of nuclear material and combating of illicit trafficking are discussed.

1. INTRODUCTION

Lithuania similar to many countries did not avoid a new type of a crime smuggling of nuclear materials, which has been observed in 1990's. Most serious case in Lithuania happened in 1993 when fresh fuel assembly was stolen from Ignalina NPP. This assembly contains approximately 124 kg of UO_2 (enrichment 2%). Approximately 100 kg of the pellets from this assembly was found later in several peaces at different places of Lithuania. This case served as a strong stimulus to strengthen prevention measures of Illicit trafficking. The legal basis was created and governmental institutions were obliged with special duties related with nuclear material. The laws and regulations set the order for the shipment and handling of nuclear material. The penalties for violation of these laws and regulations specified in Penal Code and Administrative Code were made stricter.

2. PREVENTION MEASURES

2.1. IMPROVEMENT OF THE STATE SYSTEM OF ACCOUNTING FOR AND CONTROL OF NUCLEAR MATERIAL

The State system of accounting for and control of nuclear material (SSAC) is very important element in prevention of the illicit trafficking. The Governmental Resolution Nr. 955 was passed in September 1997, obligating all economical entities and organizations to report to State Nuclear Power Safety Inspectorate (VATESI) about whole activity related to nuclear material. Following the provisions of the Law on Nuclear Energy, the Regulations of Accounting for and Control of Nuclear Material at Nuclear Facilities and LOFs [1] was issued by VATESI on 10 December 1997, which regulates in detail the nuclear material accounting at the facility (nuclear and non-nuclear facilities) level. The fully computerized nuclear material accountancy and reporting system was created on State level and at Ignalina NPP. At Ignalina NPP the system gives possibility to find the concrete location of each fuel assembly in minute. The responsible person coordinates all operations of the movement of the nuclear fuel. Lithuania extended its international obligations by ratifying Protocol Additional to the Safeguards Agreement (entered into force on 5 July 2000).

2.2. STRENGTHENING OF THE PHYSICAL PROTECTION SYSTEM

The physical protection of nuclear material and nuclear facilities is another important element in prevention of illicit trafficking. The national requirements of physical protection are formulated in Regulations for Physical Protection of Nuclear Facilities [2] passed by VATESI on 12 February 1997. The State system of the physical protection in Lithuania was improved significantly following the INFCIRC 225/Rev.4 [3]. The most significant improvements were made at Ignalina NPP. A new alarm and CCTV systems were installed at the perimeter, the important organizational and technical measures have been taken to strengthen the defence in depth. To evaluate the State System of Physical Protection the Lithuania requested and the IAEA organized the IPPAS mission to Lithuania in 1999. That was very important event, which gave stimulus for the farther improvement of the State system of physical protection. Almost all recommendations for the improvement of the physical protection of Ignalina NPP are implemented. The realization of the other recommendations of the mission is going now: the amendment of the Law on Nuclear Energy is in the stage of co-ordination; the revised version of the Regulations for Physical Protection of Nuclear Facilities will be issued in near future. These additional measures eliminate the possibility of the theft of nuclear material from the nuclear facilities and minimize the possibilities for sabotage.

3. COMBATING OF ILLICIT TRAFFICKING

3.1. CO-OPERATION OF STATE AUTHORITIES

The extensive co-operation of the State authorities and coordination of their activities is very important in prevention and combating of illicit trafficking. The main document, which regulates handling of illegal material and activity of various governmental institutions, is the Order of Handling of Illegal Radioactive Materials and Contaminated Objects. Summarizing provisions of this document and other laws and regulations, one can define the main functions of institutions involved in control of nuclear material and combating of illicit trafficking: Ministry of Environment, Radiation Protection Center, Police Department, Clandestine Proliferation Intelligence Center branch of Police Department, Border Police Department (Border Protection Service since 1 May 2001), Fire Protection and Rescue Department, VATESI, Civil Protection Department, Institute of Physics, Prosecutor’s office, State Security Department, Customs Department and Ministry of Economy. The Ministry of Environment is entrusted with organization and coordination of activities when illegal radioactive material or contaminated object is found. The Clandestine Proliferation Intelligence Center, which coordinates activity of various departments of the Ministry of Internal Affairs, was established seeking for effective combating with illicit trafficking. The Border Protection Service is charged with obligation to perform the radiation control at the border. VATESI has been appointed as a contact point to the IAEA Illicit Trafficking Database. In 1996, VATESI and the Ministry of Internal Affairs signed an agreement on collection and sharing of information related to the illicit trafficking. As the result of cooperation of various institutions, the national database on illicit trafficking there was created at VATESI. The informal cooperation between above mentioned institutions play also very important role in combating of illicit trafficking.

3.2. TECHNICAL AND INSTRUMENTAL CAPABILITIES

The technical and instrumental capabilities for the radiation control on the borders and for the analysis of seized material were increased. The four stationary control systems (Ludlum 3523 type) for the vehicles were installed on the main border crossings (two more should be installed this year) and, in addition, Border Protection Service has 130 hand-held devices (Ludlum 12SA). Ministry of Environment and Radiation Protection Center have gamma dosimeters, mobile gamma spectrometers, neutron detectors and stationary alpha and beta spectrometers. Clandestine Proliferation Intelligence Center is equipped with dosimeters, mobile gamma spectrometer. In each Police Commissariat, there is at least one person responsible for activity related to illegal transportation of radioactive and nuclear materials.

The Institute of Physics, the only scientific institution in Lithuania where experimental nuclear physics is a subject of scientific research and of practical application, purchased the gamma and alpha spectrometers of leading Canberra and EG&G Ortec companies and extended capabilities of the nuclear spectroscopy. Code package SCALE 4.3 is available in assessment of radiation and nuclear safety characteristics as well as in modeling the isotopic composition of nuclear material. The analysis of nuclear material seized in Lithuania have been performed in this institute. The institute also took part in the comparative plutonium Round Robin test.

4. TRAINING

At the beginning of creation of the legal and organizational basis for nuclear material control, physical protection and for combating of illicit trafficking, there was a lack of qualified specialists in these fields. This problem was solved by training courses organized by the IAEA, the US Department of Energy, Los Alamos and Sandia National Laboratories, World Customs organization and Interpol. Every year, since 1996, our border control officials are participating in the training courses, which are organized by Finland, on radioactivity monitoring at the border. It is very important that the trainers were trained and they are able now to organize the training of other staff on sites.

5. PENALTIES FOR ILLEGAL USE OF RADIOACTIVE SUBSTANCES

According to the Lithuanian Penal Code illegal procurement, storage, use, transfer or destruction of the radioactive materials (ionic radiating sources, radioactive and nuclear substances in any state or existing in any other form in an installation or in a manufactures products) is charged to imprisonment of an offender for the period of at most five years. If the said acts inflicted death of people or were the cause of other serious consequences the offender is charged to imprisonment for at most ten years. Violation of storage, use, registration, conveyance and other regulations related to the radioactive materials in the case when such acts might inflict death of people or might be a cause of other serious consequences is charged to imprisonment of an offender for at most three years or correction labour for at most two years or a fine. If the said acts inflicted death of people or they were the cause of other serious consequences, the offender is charged to imprisonment for at most ten years. Radioactive material plunderer is charged to imprisonment from three to ten years. Threatening to commit robbery of the radioactive materials with the purpose to induce the state, international organization, physical or juridical person to do or not to do a certain act is charged to imprisonment of an offender for at most three years.

Infringer of the requirements for environmental protection against radioactive materials is charged to a fine from 500 to 5000 Lt (The Lithuanian Administrative Code).

6. CONCLUSION

The aforementioned progress was achieved mainly owing to very important assistance from Sweden, Finland, Norway, UK, USA, and other countries, which was coordinated by IAEA or provided on bilateral cooperation basis.

REFERENCES

[1] Regulations of Accounting for and Control of Nuclear Material at Nuclear Facilities and LOFs, State Nuclear Power Safety Inspectorate (VATESI), Vilnius (1997).

[2] Regulations for Physical Protection of Nuclear Facilities, State Nuclear Power Safety Inspectorate (VATESI), Vilnius (1997).
[3] INTERNATIONAL ATOMIC ENERGY AGENCY, The Physical Protection of Nuclear Material, INFCIRC/225/Rev.4, IAEA, Vienna (1999).

QUESTIONS AND ANSWERS

S. Erickson (USA): a) By the four border systems you mentioned, do you mean that four crossings have been covered or that four portal monitors have been installed in total? b) Can you characterize the incidents that have occurred at your borders?

A. Stadalnikas (Lithuania): a) Four portal monitors are installed at four different border crossings and two more should be installed this year. b) There have been incidents with contaminated metal scrap and radioactive sources. No border incident has involved NM.

G. Bunn (USA): What did the IPPAS mission do? Who came? What financial assistance resulted?

A. Stadalnikas: The IPPAS mission evaluated the State system of physical protection, including legislation, the activities of the competent authorities and the physical protection of Igualina NPP. Physical protection experts from four countries and from the IAEA Legal Division came. Mr. C. Price from the UK was the team leader. As a follow-up to the IPPAS mission, a workshop on adversary timeline assessment was held at Igualina NPP with support from the IAEA and the USA. The USA provided financial support for the purchase of radiocommunication equipment.

V. Lapshyn (Ukraine): What is the role of the Institute of Physics in the physical protection system.

A. Stadalnikas: The institute analyses NM seized in Lithuania and provides transportation and storage of the seized radioactive material.

TECHNIQUES AND ROUTINES TO RESPOND TO ILLICIT TRAFFICKING OF NUCLEAR MATERIAL IN SWEDEN

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Abstract. The main results from a study of the national capabilities to detect and respond to illicit trafficking of nuclear material in Sweden are presented. The study finds that Sweden has a limited capability to detect and respond to an event involving illicit trafficking of nuclear material. There is room for improvements, in particular in the area of fixed installed detector systems, neutron detection, and the establishment of formal routines.

1. INTRODUCTION

In this report the main results from a study of the national capabilities to detect and respond to illicit trafficking of nuclear material in Sweden are presented [1]. The study has been performed by the Swedish Defence Research Agency (FOI) on behalf of the Swedish Nuclear Power Inspectorate (SKI).

It should be pointed out that one of the most important means to prevent illicit trafficking of nuclear material is to make sure that the physical protection is sufficient at the storage site. This issue is not discussed further in this report, since this report rather concentrates on the problem of the domestic detection and analysis capacity of nuclear material.

The focus of the study is set on technical issues such as radiation detectors and other analysis capabilities, but the report also includes a survey of the present routines that are applied in a case of illicit trafficking. The survey has been performed through interviews with representatives from the Swedish customs, SKI, the Radiation Protection Institute (SSI), and other national authorities, laboratories and companies involved in detection of radioactivity.

The high number of seizures of radioactive material in countries having a better detector capability than Sweden indicates that illicit trafficking of radioactive and/or nuclear material is still a problem. Sweden has so far not experienced many incidents involving illicit trafficking of nuclear material. However, we do not know how many incidents that really have occurred.

2. PRESENT SITUATION

2.1. DETECTORS

Sweden has a 2200 km land border to Norway and Finland, and the 2800 km sea border includes several large harbours, both in the Baltic sea and in the Nordic sea.

Over 11 million international passengers travel trough Arlanda, the largest airport in the Nordic countries, each year. Until the beginning of the 90´s the border control had no resources to detect radiation emitted from nuclear or radioactive material (in this case only gamma and/or neutron radiation is relevant).

As a result of the increased number of cases involving radioactive and even nuclear material after the dissolution of the Soviet Union, the custom officers in Sweden were equipped with hand-held gamma intensimeters a few years ago. In total 58 instruments have been distributed along the Swedish borderline. This is the only detector equipment available at the Swedish custom control. The intensimeter detects gamma radiation and displays the radiation dose rate in μSv/h (see figure 1). No fixed installations for gamma and/or neutron detection are used at Swedish borders today.

Hand-held intensimeters can also be found at other official institutions, such as the Swedish Radiation Protection Institute (SSI), the Rescue service, the Swedish Defence Research Agency (FOI), and in the Swedish armed forces.

FIG. 1. The intensimeter (RNI 10/R) used by the Swedish customs.

The majority of experience in fixed detection system can be found at metal scrap yards and ironworks. All ironworks in the country that reuse iron scrap have, or will soon have, some form of detection capacity. During recent years, many cases of contaminated iron scrap have been reported to SSI but most cases have been traced back to natural radioactivity such as radium contaminated oil pipes or caesium originating from the Chernobyl accident. A few times, radiation sources originating from medical use, or measurement instrumentation have been found. One example is two Am/Be neutron sources (2.2 GBq each) found in 1999. The sources were discovered in a metal scrap container, and found in a fixed gamma detector installation.

If a radiation dose rate of more than twice the background (the background is approximately 0.1 μSv/h but varies depending on geological conditions) or more than 0.7 μSv/h is detected, the custom officers are advised to contact the Swedish Radiation Protection Institute (SSI), which is the authority responsible for the first handling of the goods. If the specimen is found to be nuclear material, SKI is contacted.

2.2. RESOURCES FOR NUCLEAR FORENSIC ANALYSIS

The detector equipment found today at Swedish borders cannot be used for isotopic identification. More advanced equipment such as gamma spectrometers are needed to be able to perform such a measurement. Such detectors can be found at SSI, FOI, Studsvik Nuclear, and selected hospitals, universities and industries.

In a situation where a sample containing nuclear material has been seized, it will most probably be necessary to perform a more detailed forensic analysis. There are a few laboratories in Sweden having advanced analysis capabilities (like high resolution mass spectrometry) that can be used in nuclear forensic analysis. One problem in this context is the amount of material that these laboratories are allowed to handle. Only a few sites have permission to handle more than 15 g of nuclear material. In cases involving larger samples of nuclear material, additional permission might be needed.

3. PROBLEMS AND NEEDS

The study shows that Sweden today has a small capacity to disclose a smuggling attempt of nuclear materials. The limited detection capacity that exists is not sensitive enough for this purpose, and is not used in an optimal way.

The border control has no fixed installed systems for cars, trucks, boats or trains which is needed to achieve a continuous control. The hand-held equipment used today is only used occasionally and is not sensitive enough for the purpose of detecting illicit trafficking of nuclear- or other radioactive material. The experience of fixed installed systems in Sweden can however be found at several private steel scrap companies, which have installed fixed installation equipment on their own initiative. There are today no official regulations forcing to control imported metal scrap with respect to contamination from radioactive substances.

The Swedish border control has no resources for detection of neutron radiation. The detection of neutron radiation is especially important to be able to detect plutonium (weapons grade plutonium emits about 50 000 neutrons/second/kg, while weapons grade uranium emits approximately 1 neutron/second/kg).

Regarding the specific topic of forensic analysis of a sample of nuclear material, the study finds a need for introducing routines involving national and international institutions with advanced analysis capabilities. It might be difficult to find motivation for a relatively small country like Sweden to keep the analysis capability for all kind of nuclear forensic investigations. A formalized contact with international laboratories would therefore be of great value. It is, however, important that certain analysis techniques, such as identification of isotopic and elemental composition, is performed nationally.

The Swedish customs has no legal right to perform routine control on goods transported from another country within the EU (except for drugs, weapons etc.), therefore Sweden has to trust in a good control of the outer EU borders. Sweden thus also has a responsibility, as a EU-member, to have an efficient border control to non-EU countries to secure the inner market.

4. SUGGESTED ACTIONS

The survey clearly shows that improvements in Sweden's capacity of responding to illicit trafficking are necessary. Fixed installations for detection at the most critical boarder controls are the most effective way to improve our capacity for detecting nuclear material. Hand-held instruments are not sufficient enough and are not practical to use continuously.

These fixed installed systems are however quite expensive. A fixed installed detector system for lorries with capacity of both gamma and neutron detection costs about 300 000 SEK (~30000US$). An initial pilot study with a fixed installed system at a critical border crossing is therefore suggested in order to better assess how frequent the illicit trafficking actually is over Swedish borders and to be able to better estimate the needed detection capacity.

Today, a national capability for an initial analysis of seized material exists, but action plans describing the handling of the material should be resolved. Establishment of formal routines for handling and analysis of seized materials, and formalisation of the contacts with international analysis laboratories are also identified as important factors to be improved. Furthermore, relevant education of the custom officers is needed.

REFERENCE

[1] *"Smuggling av Radioaktivt material — Sveriges förmåga till detektion och analys",* Anders Ringbom and Lena Spjuth, SKI report, to be published (in Swedish).

QUESTIONS AND ANSWERS

L. Berthagen (Sweden): a) What happens if I call SSI outside office hours or if I can't get through? b) Why perform a pilot study when this has already been done in other countries (e.g. the IAEA test studies at Vienna airport and on the Hungarian border). c) Why not take more direct actions leading to results? We could learn from Denmark, which spent the same amount of money on six Nucsafe Guardian systems, to be used in Denmark and surrounding countries, as we spent performing costly investigations.

B. Ringbom (Sweden): a) There's an emergency number. b) The pilot study mainly concerns the performance of detection equipment and is specific to the situation in Sweden. c) I'm not a legal expert, but I think that this could lead to complications because of being inside Schengen.

ORGANIZATION OF CUSTOMS CONTROL OF FISSIONABLE AND OTHER RADIOACTIVE MATERIALS

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Abstract. The paper describes the radiation monitoring measures and inspection procedures used by the State Customs at Sheremetyevo airport. Following their full deployment in 1999, the number of incidents detected rose from 2 in 1997 to 90 in 2000. The efficiency of the radiation monitoring will be increased in the near future by integrating the nuclear monitors into a single information network.

1. INTRODUCTION

Among the routine inspection tasks of customs offices are tasks stemming from international commitments of the Russian Federation to prevent proliferation of nuclear weapons and material that can be used for making these weapons. These tasks are:

- radiation monitoring of all vehicles, passengers, their luggage and goods crossing the state border;
- inspection of fissionable and radioactive materials (FRM) legally transported by participants in the foreign trade activities with a view to checking that the declared data fully correspond to the actual radioactive cargo.

We show how these tasks is solved at the international airport Sheremetyevo.

2. MAIN ORGANIZATION DIRECTIONS OF RADIATION CONTROL

In practice, these problems can be solved in the following organization-technical directions:

(a) Organizational measures

The Sheremetyevo customs office has a department whose personnel is specially trained in radiation monitoring and can operate radiometric and spectrometric instruments. These specialists are included in shifts on duty responsible for customs clearing and inspection and carry out continuous radiation monitoring of passengers and their luggage, vehicles and goods crossing the border. They work on the 24-hour basis, which allows quickly and skillfully localizing the detected radiation source and avoiding direct contact of customs officers, airport personnel, and passengers with the radioactive item.

(b) Technical measures

They include provision and everyday use of radiation monitoring instrumentation, classified as

- stationary equipment of primary radiation monitoring (SEPRM);
- hand-held instruments for additional radiation monitoring (RM);
- spectrometric equipment for control of legal FRM transport.

3. DESCRIPTION OF CUSTOMS PROCEDURE FOR RADIATION MONITORING

The customs procedure for monitoring of fissionable and radioactive materials is divided into three stages:

3.1. FIRST STAGE: PRIMARY RM

It is carried out by stationary FRM detection systems Yantar for customs applications installed on the customs inspection line next to the X ray inspection equipment (XIE). These systems operate on a continuous automatic basis in co-ordination with the other elements of the general customs inspection system. A scheme like this provides comprehensive RM of everything that crosses the customs border and allows radiation sources to be quickly detected in the total traffic of passengers and goods. If the Yantar system produces an alarm signal, the customs clearance of the passenger stops and our officer turns to the second stage of radiation monitoring.

It should be mentioned that at stage I the alarm-causing item is recorded by video cameras fixed on the Yantar racks and automatically switched on in the case of alarm. The recorded picture is then printed out (with the number of the monitor, date and time of the event) and can be used for ensuing legal procedure.

3.2. SECOND STAGE: ADDITIONAL RM

It is carried out by our officer who uses hand-held instruments. His tasks are:

- to find out the cause of alarm produced by the SEPRM;
- to seek and localize the radiation source in the passenger's luggage;
- to measure the maximum exposure dose rate (EDR) on the luggage surface and to assess the situation in terms of radiation hazard for the surrounding people;
- to check the passenger's luggage for surface contamination;
- to perform primary identification of the detected radioactive source.

Additional radiation monitoring starts with the interrogation of a passenger in order to find out whether the latter is carrying radioactive sources in his luggage. If the answer is negative, our officer starts the above-described procedure. If a radiation source is found in the luggage, the passport data of the passenger are taken, a record of evidence of customs regulation violation is drawn, and documents are issued for the radiation source detention, which is temporarily stored in the radioactive cargo warehouse.

For radiation safety of the personnel and passengers additional radiation monitoring of the located object is performed in special booths apart from the main passenger routes.

3.3. THIRD STAGE: PROFOUND RADIATION EXAMINATION

It is carried out by licensed expert organizations to draw final conclusions about the detected radiation source. The expert should infer basing on the results of the examination whether the found source is a radioactive material. The principal criterion of the radioactivity of materials is the excess of the value of specific radioactivity, fixed by the Customs Inspection for foreign trade activity in the Russian Federation for goods listed in pos. 2844 and which is 74 Bk/g. This criterion corresponds to international requirements and does not contradict the classification for such goods used in the foreign trade activity. The results of this stage are used during legal procedures in the course of investigation of the case of regulation breaking.

It should be noted that together with the actual radiation sources such as goods, currency, etc. localized by our service, a lot of passengers are detected which have received radiotherapy treatment in hospitals. We considered these biological radiation objects as one of the possibilities for potential FRM smuggling. Therefore, an additional radiation monitoring for these category of passengers is performed using a different procedure, comprising a check of medical papers confirming the treatment and measurement of EDR over all the body surface, as well as in the region of a diseased organ. These passengers are not subject to any sanctions, the monitoring procedure is carried out in special booths, decently and rather quickly. Personal search of a passenger can be applied as an extreme measure if there are enough reasons for doing it.

This scheme is used to fulfil the first of the above nonproliferation tasks. As to the other task, i.e. control of legal FRM traffic, the scheme is as follows: stage 1, check of documentation followed by standard customs clearance and inspection procedures, and stage 2, direct inspection of the FRM.

4. INSPECTION OF LEGALLY TRANSPORTED FISSIONABLE AND RADIOACTIVE MATERIALS

Check of documentation consists primarily of checking the permission documents (licenses, permits of State Atomic Inspection), certificates permitting transport of FRM, certificates for container design, quota papers, and other documents required for customs inspection.

In the course of customs inspection with spectrometric instruments without opening the containers the correspondence of the declared radionuclides, their amount, uranium enrichment level to the transport documents is verified and compliance with the FRM transport safety regulations is checked. In addition, packages with FRM are weighed and X rayed with the X ray inspection equipment. If any discrepancy is found in the parameters of the goods, customs clearing is suspended and a statement of customs regulations breaking is made up. The regulations-breaking item is handed in to one of the appropriate licensed laboratories for expert’s examination and based on the expert’s conclusion a decision is taken to start legal proceeding against the regulations breaker.

This is the scheme of customs radiation monitoring at the international airport Sheremetyevo.

5. EFFICIENCY OF CUSTOMS RADIATION MONITORING AT THE INTERNATIONAL AIRPORT SHEREMETYEVO

The efficiency of the scheme is illustrated by the following figures. In 1997, when appropriate technical means and trained personnel were lacking, there were only 2 events of detecting items with a rather high radioactivity level in the luggage. In 1999, after the entire radiation monitoring system was fully deployed (i.e. the flight checkpoint was equipped with technical means of RM, personnel was trained, special technologies and algorithms were developed), there were 61 events of radiation detection, and in 2000 there have been 90 events, including breaches of legal FRM traffic regulations through disagreement of declared and actual parameters.

6. CONCLUSION

We believe that the above-considered organization of radiation monitoring allows effective and quite reliable control of and adequate response to possible illicit transport of FRM through the airport Sheremetyevo to other countries, including CIS.

In the near future we plan to increase the efficiency of the radiation monitoring by integrating the currently operational customs-used stationary FRM detection systems into a single information network capable of providing simultaneous video-aided continuous nuclear monitoring at three terminals (Sheremetyevo-1, Sheremetyevo-2, Sheremetyevo-Cargo) with display of information at the workstation of the duty customs inspector.

MEASURES AGAINST ILLICIT TRAFFICKING OF NUCLEAR AND OTHER RADIOACTIVE MATERIALS IN SLOVAKIA

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Abstract. This presentation contains short description of measures used in Slovakia to combat illicit trafficking of nuclear and other radioactive materials. Though prevention is the most effective measure, especially suppression measures are described as a mean how to cope with insufficient protective measures applied in some countries. Some proposals are formulated how the situation could be further improved.

1. INTRODUCTION

Starting with political changes in the East and the Central Europe in the beginning of nineties we are facing a new type of crime — smuggling of nuclear and other radioactive materials. Being aware of serious impact of this new phenomenon on proliferation and radiation safety risk the government of Slovakia issued several resolutions focused on measures for combating it. These were mostly concentrated on detection at the state border as well as inside the state and subsequent safe handling of confiscated material. However, the most important is a system of measures how to prevent removal of material into illegal use.

2. DESCRIPTION OF SYSTEM

The main goal of the described system is to allow safe and effective utilization of nuclear and other radioactive materials under surveillance of responsible state authorities as well as recover materials that were removed form legal utilization despite the preventive measures.

2.1. PREVENTION

Prevention is the most effective and the cheapest way how to overcome problems. An important precondition for prevention is existence of a national (or state) system for controlled utilization of nuclear and other radioactive materials completed by effective physical protection of these materials and facilities involved and supported by sufficient low enforcement.

2.1.1. Accounting of materials

A state system of accounting for and control of nuclear materials in Slovakia has its origin in the former Czechoslovak Republic. The system has been built according to the IAEA INFCIRC/153 requirements and due to its long-term effectiveness and reliability it was accepted by the government of Slovakia. A fact that the IAEA inspectors never have recognized any unaccounted nuclear material could be the best proof of its quality. The system is based on reports of nuclear material users to the Nuclear Regulatory Authority of Slovakia (ÚJD SR), which is regulatory authority in this field. Information on inventory changes reported in this way is subsequently controlled by the ÚJD SR inspection, and a real status of the inventory is controlled every year by physical inventories. The IAEA inspectors independently verify changes in the inventory and results of the physical inventories.

Similar system is used for other radioactive materials — regulatory authority in this field is the Ministry of Health but this system is not under international control.

2.1.2. Physical protection

Physical protection system in Slovak nuclear installations is based on principles applied for development of advanced physical protection systems used in western installations. Technological systems and nuclear materials, according to their sensitivity, are categorized into three categories — first one is the most sensitive. The first category technology and material is located into inner area, lower category is located into protected and guarded area.

Guarded area of the most sensitive installations is limited by barriers in the form of isolation zone equipped with two independent detection systems and is monitored by TV system. Protected area is limited by barriers equipped with single detection system and is monitored by TV system. Inner area is located inside buildings with concrete walls equipped with detection on doors, protected windows and ducts.

Entrances are equipped with locked doors, doors with magnetic lock or turnstiles controlled by card readers. Entrances into inner area are guarded.

The physical protection system is controlled through sophisticated software supplied by system vendor. The software runs on efficient PC based computers located at the main control room.

The system is operated by installations operators. Entrances are guarded by security guards, which also perform mobile patrol inside the installation. The Police create response forces.

2.1.3. Legislation

The Act No. 130/1998 on Peaceful use of nuclear energy regulates utilization of nuclear material and nuclear energy and states requirements on physical protection.

The details on use of nuclear material and requirements on physical protection are anchored in

- Regulation No. 198/1999 on Accounting and control of nuclear materials.
- Regulation No. 186/1999 on Physical protection of nuclear facilities and nuclear materials.
- Regulation No. 284/1999 on Transport of nuclear material and radioactive wastes.

The Act No. 272/1994 on Protection of health of people in its later modifications regulates handling with other radioactive materials.

The Act No. 547/1990 creates frame for export control of nuclear material, nuclear related and dual-use material and technology. Its new version, which will be issued in this year, is fully compatible with EU legislation.

After the first few events of illicit trafficking in Europe the Criminal Code of Slovakia has been amended and the illegal possession of nuclear and radioactive material is treated as a crime and involved persons may be heavily punished.

2.2. SUPPRESSION

Suppression follows when preventive measures have been broken (either inside of state or in neighbor countries). Its purpose is to detect illegally owned material and return it back to a legal owner or to dispose it safely.

After first few trafficking incidents on the territory of Slovakia the government recognized seriousness of the problem. Based on its resolution No. 538 from 1995 a group of experts from involved ministries elaborated a system of measures how to cope with this phenomena. This system covered:

- detection of illegally transferred radioactive material at a border or inside the territory of Slovakia ;
- handling and processing of confiscated material;
- radiation protection of involved persons;
- improvement of analytical instrumentation in laboratories of the Ministry of Interior and of the Ministry of Health.

2.2.1. Detection

Based on experience gained during application of the group's proposals the system was several times modified according to governmental resolutions No. 537/97, 36/98 and 559/98. The measures were applied in two steps. Within the first step some portal detectors were installed at the border with Ukraine, some police and customs officers were equipped with handheld and personal dosimeters. As the second step portal detectors have been installed at all border crossings with Ukraine and at two border crossings with Poland. Police and customs officers were equipped with handheld and personal dosimeters at all border crossings.

Detection at a border

According to a decision of customs authorities detected material can be returned back to the country of origin or it can be confiscated. In the case of confiscation a special group of the Civil Defense Authority (CDA) is called in. Its duty is to carry out basic identification of the material and to apply, together with customs officers, necessary radiation protection measures. The event is reported to the Police, which perform investigation.

Detection inside a state territory

Inside a state territory the trafficked material is mostly confiscated by the Police. The Police authority usually relies on intelligence information. As in the previous case a special group of the CDA identifies the material and together with police officers applies necessary radiation protection measures.

2.2.2. Final analysis

According to the group's proposals laboratories of the Ministry of Health should be equipped with instrumentation capable of comprehensive analysis of the confiscated material. Due to problems with restricted budget this intention is still not performed. For this purpose services and co-operation with specialized laboratories of some Slovak universities, the IAEA and EC Joint Research Centre are employed.

2.2.3. Co-operation

Based on the group's analysis and real experience it was clear that the combating could be effective only when all involved state authorities would co-operate.

- the Customs authorities and the Police co-operate in investigation of events;
- the CDA co-operates with the ÚJD SR (nuclear material) and the Ministry of Health (other radioactive material) on identification of confiscated material;
- on the base of an agreement between the Ministry of Interior (Police, Civil Defense) and the Slovak Power Plants (SE) the SE's facility specialized on decommissioning, radwaste treatment and spent fuel handling (SE VYZ) will carry out transport, storage and preparation of confiscated material into a form suitable for disposal.

Special form of co-operation is co-operation between the Police of Slovakia and police authorities of surrounding states and INTERPOL. This is the most effective way how to detect trafficked material inside a state territory (in the case of alpha emitters maybe the only way) and really the intelligence information of the Police allowed to confiscate trafficked material almost in all events on the territory of Slovakia (see Table I).

Certain form of international co-operation is participation of Slovakia in the IAEA programs in this field, mainly contribution to the IAEA database on illicit trafficking of nuclear and other radioactive materials (the ÚJD SR is a point of contact).

2.2.4. Legislation

It was not necessary to create special legislation — existing legislation fully covers all parts of the system. Reading of relevant paragraphs of the Criminal Code has been formulated more strictly. Also some laws had to be modified to find out financial support for confiscated material handling.

2.3. POSSIBLE IMPROVEMENTS

During several years exploitation the system proved its effectiveness and reliability. Due to development of methods and procedures of traffickers its improvement is inevitable and is concentrated on

(a) instrumentation
  - portable detectors capable to identify immediately confiscated material (customs, the ÚJD SR);
  - more sensitive personal detectors (pagers) for customs and police officers;
  - upgrading of portal detectors to detect neutrons;
  - modernization of instrumentation of the Ministry of Health laboratories;

(b) training — training courses for customs and police officers and their management.

3. CONCLUSION

Illicit trafficking of nuclear and other radioactive materials is an international type of crime and as such it can be defeated only by co-operation of the whole international community. The government of Slovakia is ready to offer all experience that was collected during its short history.

Table I. Nuclear and other radioactve materials confiscated in Slovakia

Date and location	Material description	Amount of material
October 1993 Trnava	fuel pellets enr. 3%	860 g
September 1994 Slovenské Nové Mesto	fuel pellets enr. 3%	920 g
April 1995 Poprad	metal natural uranium	18 kg
October 1996 Podbrezová	radioactive sources Co 60	~600 MBq
February 1997 Zvolen	fuel pellets enr. 3%	2360 g
December 1997 Trnava	uranyl nitrate	5,33 kg
August 1999[a] **Pohronský Ruskov**	container made from depleted uranium with radioactive source Co 60	28 kg
March 1993 Zvolen	yellow cake	2,5 kg

QUESTIONS AND ANSWERS

D. Ionescu (Romania): For less developed countries, which lack sufficient resources, do you think that sharing some resources with neighbours would increase efficiency in combating illicit trafficking?

S. Bezák (Slovakia): Slovakia is in this position and finds co-operation with neighbouring countries and with international institutions very useful. There is good co-operation between the customs authorities of Slovakia, Poland and Hungary, and police authorities co-operate effectively within Interpol and Europol. The IAEA (regional project RER/9/060) and other international organizations assist with training and equipment.

S. Parrish (USA): How many of the seizures that you mentioned were the result of detection at the border and how many resuted from other police operations?

S. Bezák: All were possible thanks to police intelligence; not to accidental detection. The 1996 event actually occurred at the Austrian–Italian border, where radioactivity in scrap metal from Slovakia was detected. The scrap was returned to Slovakia.

S. Pkachkova (Ukraine): In Slovakia, how is co-ordination between organizations combating illicit trafficking achieved? Is there any special co-ordinating body?

S. Bezák: There is no co-ordinating body. Each involved institution (e.g. police, nuclear regulatory authority) has its clearly defined responsibilities, and its activities are triggered by acquiring information (e.g. about detection) from another involved institution (e.g. customs).

J. Montmayeul (France): With regard to the financial implications of illicit trafficking, what solutions has your country found, for example, for orphan sources?

S. Bezák: The scope of our system has increased with the modification of legislation on the fund for decommissioning nuclear installations, handling spent nuclear fuel and radioactive waste, and disposing of confiscated material. The system can now cover orphan sources, other abandoned radioactive material and also institutional radioactive waste.

COMBATING ILLICIT TRAFFICKING OF NUCLEAR MATERIAL AND OTHER RADIOACTIVE SOURCES IN BULGARIA

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Abstract. The long history of the Republic of Bulgaria is a proof of its importance for the commercial and military interests of the nations that have conquered and exploited the country through the ages. It is clear that it is the connecting node of two continents, Europe and Asia. It is a natural stop in the movement of goods for transcontinental commercial purposes as well as a natural resting-place for the movement of armies during the ancient and medieval times. The geopolitical situation that currently exists in the Republic of Bulgaria may form the condition for illicit trafficking. This paper gives a short description of the efforts of the Government of Bulgaria to combat the illicit trafficking of nuclear material and other radioactive sources.

INTRODUCTION

The general principle in the legal instruments in the field is providing security of radioactive materials and public safety of radiation sources. All acting legislative acts are based on European and other International Conventions and Treaties on the use of atomic energy and on the commitment that in Bulgaria the atomic energy should be used only for peaceful purposes. The co-operation with the other countries in that field would be under the terms of the Treaty on Non-proliferation of Nuclear Weapons.

The legal instruments regulating the regime of registration, handling, storing, use and disposition of radioactive materials are as follows:

- The Treaty on Non-proliferation of Nuclear Weapons.
- The Vienna Convention on Civil Liability for Nuclear Damage.
- The Act on Use of Atomic Energy for Peaceful Purposes/1985.
- The Regulation for Implementation of the Act on Use of Atomic Energy for Peaceful Purposes/1986.
- The Rules for Gathering, Keeping, Processing, Storage and Disposition of Radioactive Waste on the Territory of the Republic of Bulgaria.

The Act on Use of Atomic Energy for Peaceful Purposes/AUAEPP/was adopted in 1985. It regulates the use, the right of property, the management of use, the government control, the civil liability for nuclear damage and the administrative and criminal responsibility of the persons in charge of management and of using atomic energy. The last amendments to the act took place in 1995 and concerned the right of property, control and accounting of radioactive materials. Now only the special nuclear materials are exclusive property of the state, while the other ionizing radiation sources may be property of legal and physical persons too. These new provisions to the act have caused the adoption of the new section V in the **Criminal Code,** concerning higher criminal responsibility of the persons in charge of handling and control of such materials.

The Committee on the Use of Atomic Energy for Peaceful Purposes (CUAEPP) co-ordinates government policies in the field of use of atomic energy.

The Inspectorate on Safe Use of Atomic Energy within the CUAEPP provides government supervision and control on safe use of atomic energy in interaction with the other authorized specialized controlling agencies.

In 1998 there has been established the *Standing Commission for Co-ordination, Information Exchange in the Field of Proliferation.* The members of this commission are officers from the National Service for Combating Organized Crime (NSCOC), the National Security Service, the Border Police and the General Department of Customs, the Ministry of Economics and the Committee on the Use of Atomic Energy for Peaceful Purposes (CUAEPP).

II. COMBATING ILLICIT TRAFFICKING OF NUCLEAR MATERIAL AND OTHER RADIATION SOURCES. EXPERIENCE AND TRENDS

The *Ministry of Interior (MoI)* is authorized to provide control on radioactive materials on the sites, where they are used and stored and in the time of their transportation. As the illicit trafficking of nuclear materials is a great concern of our government and the MoI, in the early 90's a special operative and investigation section has been set up within the *National Service for Combating Organized Crime,* which deals with non-proliferation of nuclear materials.

We consider any case of diversion of radioactive materials as a possibility for a single state or terrorist groups or organizations to ignore the international convention for non-proliferation of radioactive materials. In addition the radioactive materials in combination with the conventional explosive substances may be used to create a panic or to cause radioactive contamination in residence areas or water sources and in this way poses a threat to the public health and the environment.

These factors determine the high degree of public threat of all kinds of nuclear crimes and that is why the domestic and the international communities are aware of them.

The Republic of Bulgaria is mostly a transit country for the alleged illegal trafficking of nuclear and radioactive materials. That is why the law enforcement authorities try to be active partners of the competent international and national authorities in the concerned countries.

The analysis of the criminal acts involving radiation sources and radioactive materials in Bulgaria for the period 1992–2000 has outlined the following factors, which have caused the rise of this specific new type of crime.

In the first place, the decay of the USSR and the consequent economic stagnation in the former socialist countries in Central and East Europe have led to dismissing of a lot highly qualified scientists and specialists, employed before in nuclear, military, missile-aviation and space industries and Research Centres, and Institutes. The criminal organizations have envisaged the great potential of these professionals and their likely incorporation in future illegal/criminal activities. Further the criminal organizations have demonstrated notable interest in high technologies, know-how, materials and equipment, involving radiation sources and radioactive materials, as necessary prerequisites for profitable eventual illegal/criminal production or transfer in the countries under embargo.

In the second place the inadequate legislative practice in force in the early 90's for the new social and economic situation in the country in transition and the legal nihilism, demonstrated by most of the people and the parties, dealing with radioactive materials.

In the third place the loose control over the entire process of keeping, storage and handling of such materials in the early 90's have favoured some unscrupulous elements to make use of illegal trafficking in nuclear and radioactive materials.

The criminals involved in illicit trafficking in nuclear and radioactive materials are in general foreign profiteers, operating in co-operation with Bulgarian nationals and companies. These materials are usually subject of smuggling and re-export in the Middle East countries and in the countries put under embargo.

The approaches and methods in detection and identification of smuggled radioactive materials applied in the operative practice include first of all, examination of the reliability of the source and the obtained information, the appearance, colour and other specifications of the substance.

Special attention is drawn to the initial use of the offered substance, in which field it has been used (kind of application, type of used equipment), weight, inscriptions and symbols on packing (containers), certificate of chemical expertise etc. If it is possible, information on the process and place of enrichment of the substance is collected.

The more common of the recorded cases involving radiation sources and radioactive materials in Bulgaria are as follows:

- In October, 1992 a number of 140 Plutonium radiation sources, "buttons", have been seized in hotel "Sheraton" in Sofia. The investigation has revealed total amount of 0.02 g Pu, which can be considered as a radioactive material, but it can not be used for military purposes. The substance had been placed there deliberately by an English news reporter for the need of a journalist investigation of a fiction channel for smuggling radioactive materials to an unknown Arabic country with the intent to discredit Bulgaria. The investigation has not confirmed such a channel.
- In February 1994 four capsules with Radium have been seized in Plovdiv. The measured radiation emission has been insignificant.
- In July 1994 two containers with Uranium acetate and two containers with Mercury oxide have been seized. Both substances pose a threat to people, but they are not weapon-usable.
- In 1994 one metal container with 0.5g Uranium oxide has been seized in Sofia. The expertise has confirmed the substance poses a threat to people, but it is not weapon-usable.
- In October 1994 four metal containers with an alloy of Alluminium, Manganese, Magnesium have been seized by Custom officers in a Turkish bus, but no radiation sources have been detected.

On the grounds of the available information the following conclusions can be done:

In the period until 1996 the demand on radiation sources and radioactive materials of various types and kinds for the purposes to be transferred to the countries under embargo has been considerably high. Most of them originated from the Russian Federation and Ukraine and have been smuggled to the Western Europe or Middle East countries, as the offered prices were too high and the demand at the domestic market was nearly absent. In the period 1996–1998 the number of recorded cases of detection or smuggling of radiation sources and radioactive materials has suddenly fallen. The available information on such cases has decreased too.

In 1999 there was a case of transit trafficking of U-235 through the border cross control point in the city of Rousse. In addition 19 containers with Strontium and Americium of the type "Gamarid" have been stolen. They have been in possession, handled and stored by a company. The analysis of the registered cases involving radioactive materials has displayed that in the most of the cases some individuals and companies had tried to speculate and to realize fraudulent deals, offering and selling some times innocuous or false radioactive materials. The seized substances generally originated form civil facilities and are used in sensors, gauging and calibration appliances, and are not weapon-usable. There are not any registered cases of detecting or seizure of U-235, Pl-239 or any other weapon-usable radioactive element. Nevertheless some of the seized materials are emitting dangerous radiation for people and environment.

III. CONCLUSION

The geographical situation of Bulgaria at the crossroads between Europe and the Middle East has specified it as one of vulnerable transit countries for illicit trafficking of radiation sources and radioactive materials from Europe to Middle East countries.

That is the reason to consider the crimes involving radioactive materials as posing a serious threat to the health and public security of people, and environment and to support any effort to co-operate and integrate with all concerned international organizations and special enforcement forces in dealing with this serious threat.

MEASURES AGAINST ILLICIT TRAFFICKING OF NUCLEAR MATERIAL AND RADIOACTIVE SOURCES IN BELARUS

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Abstract. Illicit trafficking of nuclear and radioactive materials is a multidimensional safety and security issue. Situated in a high-risk trafficking area, Belarus considers the task of combating illicit trafficking essential to ensure state security, public health and environmental protection. There have been a series of activities underway in Belarus to prevent, intercept and respond to it. At the international level the International Atomic Energy Agency (IAEA) in close co-operation with World Customs Organization and Interpol plays an important role in a number of bilateral and multilateral activities aimed at stopping illicit trafficking. Belarus has always been a strong supporter of these activities, being conscious of the fact that illicit trafficking is fraught with both proliferation implications and public exposure potential.

1. INTRODUCTION

After the Chernobyl accident in 1986 nuclear programs were abandoned in some countries including Belarus. Thus, a decision was made to shut down and decommission the IRT research reactor. Activities on the “Pamir” transportable NPP had been ceased, and it was decommissioned. The operation of 2 critical assemblies was halted with the fuel unloaded and put into storage.

In spite of the fact that there are no NPPs, no nuclear and other radioactive materials mined and produced in Belarus' territory, a considerable amount of nuclear and other radioactive materials located at “Sosny” Academic Scientific and Technical Centre (ASTC) gives rise to a possibility of illicit trafficking.

Besides, Belarus' geographic location increases the risk of illicit trafficking. The country is situated in the centre of Europe being a transit state. 2 out of 10 major transeuropean corridors cross its territory. Belarus' border with Ukraine, Poland, Latvia and Lithuania is an external one of the CIS Customs Union, in whose Member States, in first place, the Russian Federation and Kazakhstan nuclear and other radioactive materials are massively mined and produced. Their significant part is legally and illegally transported to the west by the shortest route across Belarus' territory. In addition in some Chernobyl-contaminated areas there are exclusion and resettlement zones, where one cannot rule out a possibility of radioactive waste being smuggled to and disposed of there. Belarus is also close to the recently shut down Chernobyl NPP that is now a dangerous storehouse of nuclear and other radioactive materials.

2. MEASURES TAKEN AT THE NATIONAL LEVEL

In order to combat illicit trafficking Belarus takes measures

- to strengthen nuclear and radiation regulatory infrastructure;
- to upgrade accounting, control and security of nuclear materials and radioactive sources;

- to improve control over their import/export;
- to detect and react to their illegal uses and cross-border movements and to analyze confiscated material;
- to provide training opportunities for both State regulatory and facility personnel;
- to enhance the exchange of information among all the concerned, etc.

Below some of the measures are elaborated on in more detail.

2.1. PHYSICAL PROTECTION

To prevent illicit trafficking, it is indispensable to have a well-developed system of physical protection against the theft or unauthorized diversion of nuclear material and against sabotage of nuclear facilities. It is a matter of common knowledge, that the responsibility for establishing and operating a comprehensive physical protection system for nuclear material and facilities within a state shall rest entirely with the Government of that state.

In Belarus all nuclear materials, including HEU, are located at “Sosny” ASTC. Radioactive waste is disposed of at the “Ekores” repository. Through Regulatory Resolution On Measures for Physical Protection of Nuclear Materials issued by the Council of Ministers of Belarus in 1993, the Committee for Supervision of Industrial and Nuclear Safety (Promatomnadzor) was appointed as the authority responsible for ensuring physical protection of nuclear materials and facilities and was tasked to develop and approve relevant normative documents. In 1994 Promatomnadzor issued the Order On Ensuring Physical Protection of Nuclear Materials during Use, Storage and Transportation that was in line with then relevant IAEA recommendations.

The system of physical protection at ASTC “Sosny” includes elements of the "old" system set up in 1984, and the “new” one installed in 1996 as a result of a multilateral co-operative effort between Belarus, Sweden, Japan and USA. The main technical components of the system are:

- detection system including magnetic, microwave and infrared sensors;
- video-surveillance system;
- system of access delay including electronic blocking devices;
- system of authorized access including magnetic cards; and
- system of computerized control over all components and communication system.

Discussions between potential donor states are taking place regarding various security upgrades, particularly to the protected area where main security sensitive buildings are located.

In 2000 Promatomnadzor requested an International Physical Protection Advisory Service (IPPAS) mission from the IAEA. The scope of the mission was to appraise Belarus’ legal and regulatory structure for physical protection and evaluate the implementation of physical protection measures at “Sosny” ASTC. Alongside with other recommendations IPPAS mission stressed the need to revise relevant normative documents putting them in line with the IAEA recommendations and highlighted the importance of developing and maintaining a Design Basic Threat (DBT). Promatomnadzor is now working on it in co-operation with all the concerned as well as on upgrading the system of physical protection in general using limited national resources.

2.2. ACCOUNTING FOR AND CONTROL OF NUCLEAR MATERIALS

A primary deterrent to the theft of nuclear materials is a strong State System of Accounting and Control (SSAC) that recognizes the complementary nature of material accounting and control and physical protection regulations and associated procedures. Material accounting and control is designed to assure that the location of all nuclear material in a state is known and confirmed through periodic inventory taking. Through Regulatory Resolution On Measures to Fulfil Provisions of Treaty on Non-Proliferation of Nuclear Weapons issued by the Council of Ministers in 1993, Promatomnadzor was designated as the national competent authority responsible for the establishment and maintenance of the SSAC. The system accounts for all the nuclear material meeting the criteria defined in the Safeguards Agreement with the IAEA. The system includes two levels: i.e. on-site accounting and control and state accounting and control exercised by Promatomnadzor. Apart from reporting to the Agency, the system also provides for national tasks being accomplished: control over uses of nuclear material, its physical protection, access control etc. Promatomnadzor is also a central communication point in the case of a loss, unauthorized use or seizure of nuclear materials. It should be noted that the existing system was set up with extensive assistance of donor states.

2.3. ACCOUNTING FOR AND CONTROL OF OTHER RADIOACTIVE SOURCES

The Comprehensive State System of Accounting for and Control of ionizing radiation sources was set up through Regulatory Resolution issued by the Council of Ministers in 1999. In accordance with the Resolution Promatomnadzor is designated as the competent body for establishing and maintaining the Comprehensive State System of Accounting for and Control of ionizing radiation sources and all the users are to register their sources at Promatomnadzor. Promatomnadzor laid down requirements for submitting information on a source itself, its owner, and timing of reporting. All the sources meeting the established criteria are registered in the MS Access controlled database of Promatomnadzor irrespectively of their ownership. At the moment approximately 55 500 sources belonging to 1208 users are registered, sources of 73 users are excluded from the control. The main types of sources are: radioisotope smoke detectors, accelerators, sealed sources, X ray apparatus, gamma-defectoscopes, etc. The database allows both tracing a concrete source, and acquiring information on a single user. Promatomnadzor informs the Ministry of Internal Affairs so that control over the guarding system and requirements for security of ionizing radiation sources is ensured.

2.4. EXPORT/IMPORT CONTROL

Export-import measures also belong to those aimed at preventing and intercepting illicit trafficking of ionizing radiation sources, nuclear substances and materials are included into the List of Articles Moved across the Customs Border of Belarus with Restrictions. Such restrictions include, inter alia, a requirement to get a permit to move these articles from/to Belarus' customs territory. Through Regulatory Resolution of the Council of Ministers On the Establishment of Prohibitions and Restrictions on the Movement of Articles across the Customs Border of Belarus adopted in 1997 Promatomnadzor issues the above permits.

In 1998 the Law On Export Control came into force. According to Article 7 of the Law articles subject to export control (specific goods) include goods, technologies and services related to nuclear fuel cycle and production of nuclear weapons and nuclear explosives as well as dual-purpose commodities. The subsequent Regulatory Resolution on the Improvement of the State Control over the Movements of Specific Goods (Works, Services) across the Customs Border of Belarus was adopted in 1998. It approved 2 Orders: On

Licensing of Export/Import of Specific Goods (Works, Services) and On Official Registration of Commitments to Use Exported/Imported Specific Goods (Works, Services) for Declared Purposes and Organization of Control over the Fulfilment of These Commitments). Under the above acts a license from the Ministry of Foreign Affairs is also needed when nuclear material is concerned in addition to the permit issued by Promatomnadzor.

2.5. DETECTION OF ILLEGAL CROSS-BORDER MOVEMENTS

The detection of illegal cross-border movements is a crucial component of combating illicit trafficking. The system of border control calls for qualified staff and technical equipment of border checkpoints. Unfortunately, only 8 out of 32 road checkpoints are now equipped with portal monitors. None of 19 railway checkpoints is equipped with portal monitors. There are no mail and luggage portal monitors at international mail offices and the Minsk National Airport.

Should an incident occur at the customs border, the customs authorities themselves investigate the case, which may result in taking criminal proceedings. Representatives of Promatomnadzor generally take part in the investigation.

2.6. INVESTIGATION OF ACCIDENTS

Promatomnadzor, Ministry of Health and, if needed, Ministry of Internal Affairs and Ministry of Labour are informed of any radiation incident involving a loss or occasional detection, unauthorized uses of nuclear and radioactive material. Following such cases a special commission is established. Headed as a rule by an official from Promatomnadzor, the commission makes a narrow inquiry into the facts and compiles an act of investigation. Based on the act, measures are taken to address the case and to prevent it from recurring. If needed, the Prosecutor's Office is approached to commence prosecution.

3. FURTHER CONSIDERATIONS

Despite a series of measures taken at the national level to combat illicit trafficking in Belarus, there are still certain problems to be addressed. In this respect the following steps may be proposed to strengthen the existing capabilities and improve the effectiveness and efficiency of the relevant activities so that national priorities are met in a cost-effective manner:

- to revise the national normative documents on physical protection to bring them in line with the up-to-date IAEA recommendations;
- to develop DBT as a basis for evaluating the effectiveness of current physical protection measures and in deciding what further upgrades are warranted;
- to develop a maintenance plan for the system of physical protection that includes the necessary spare part inventory required to maintain the system and to seek financial support for its implementation;
- to improve the national system of mutual notification of incidents involving ionizing radiation sources by setting uniform requirements for information to be submitted and through establishing a computer database to register all the incidents;
- to upgrade the laboratory under Promatomnadzor conducting primary measurements and identification of detected ionizing radiation sources;

- to explore a possibility of setting up a national laboratory capable of conducting complex measurements for identification of revealed nuclear material, including destructive analysis; such a lab can be founded at existing research institutes and scientific centres;
- to further train and retrain personnel; and
- to develop technical capacities of border checkpoints.

QUESTIONS AND ANSWERS

L. Zenyuk (Ukraine): What can you say about Belarus' international co-operation in combating illicit trafficking?

O. Piotoukh (Belarus): All national activities are supported by the IAEA through its TC programme. Belarus strives to co-operate internationally by implementing international treaties to which it is a party; participating in discussions on revising the CPPNM; contributing to the ITDP; working closely with the customs authorities and regulatory bodies of countries in the region; and furthering the exchange of ideas at seminars and conferences.

J. Fechner (Germany): Did you have information on the 55 000 radioactive sources and their 1208 users that existed when the State's register of these sources was installed? If not, how did you get the various users to register their sources?

O. Piotoukh: We had a registry of sources before the MS Access controlled database was set up in 1999. We used it to establish a database where all users were to register their sources free of charge or be made to pay a fine.

ORGANIZATION OF THE WORKS IN THE RUSSIAN FEDERATION FOR ILLICIT TRAFFICKING NUCLEAR MATERIALS PREVENTION

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Abstract. The paper describes the programme for preventing and combating illicit trafficking in nuclear materials including legislation, the penal remedies, and the responsibilities of the various government agencies and ministries. The Laboratory for Identification of Nuclear Materials of an Unknown Origin (LINMUO) has been established within the framework of co-operation between Minatom and the Joint Research Centre of the European Commission. The future programme involves improving the protective system at nuclear facilities in the Russian Federation and equipping customs points with radiation monitoring techniques.

Program for Preventing and Combatting Illicit Trafficking in Nuclear Materials
(Moscow Nuclear Safety and Security Summit — April, 1996).

Three basic elements of the Program [1]:

1. Reliable and safeguard storage of nuclear materials and effective measures of their guard, control and accounting for prevention of illicit trafficking.2. Joint intelligence, customs and law-enforcement measures for prevention of international transportation and sale of the stolen materials.
3. Joint efforts on identification both removal of the illicit proposal and demand for fissionable materials with the purposes of counteraction to criminal elements.

The program envisages assistance to an exchange of the scientific information and data with the purposes of identification of origin, history and runways of intercepted nuclear materials.

Legal basis for handling of nuclear materials (NM) & radioactive substances (RS) in the Russian Federation

Federal Law "*On use of atomic energy*" dated on November 21, 1995 [2] determined main principles:
- all NM are found only in the federal property;
- NM may be used only by legal entities with permits (or licenses), issued by government agencies.

Penal responsibility for illegal handling of NM & RS:

- illicit purchase, storage, use, transfer or destroy of NM & RS (Penal code, article 220) [3] up to 10 years imprisonment (depends from danger of crime);
- theft or extortion of NM & RS (Penal code, article 221) — up to 10 years imprisonment with or without confiscation of property, or max 1000 × minimal salary level (depends from danger of crime).

Legislation for Prevention of Illicit Ttrafficking of Nuclear Materials

– Federal Law “*On use of atomic energy*”.
– Decree of the President of the Russian Federation "*On high priority measures for upgrading NM accounting and safety of NM*" dated on September 15, 1994 N 1923.

– “*Provision on the State Accounting and Control of Nuclear Material*” approved by Ordinance of the Government of the Russian Federation dated on December 15, 2000 No. 962.

The government agencies dealing with prevention of illicit trafficking [4]:

1. Ministry of Russian Federation for Atomic Energy is responsible for:

- Development and functioning state system NM and RS accounting & control.
- Physical protection at facilities where disposal about 90–95% all NM in the Russian Federation.
- Interaction with IAEA Database on Illicit Trafficking of Nuclear Materials and Other Radioactive Sources as contact point.
- Interaction with IAEA for Convention on Physical Protection as contact point.
- Coordination activities & interactions between various agencies on prevention Illicit Trafficking of Nuclear Materials in the Russian Federation.

2. Ministry of International Affairs is responsible for:

– coordination international activities in framework Program for Preventing and Combatting Illicit Trafficking in Nuclear Materials.

3. Gosatomnadzor of the Russian Federation (Federal Nuclear Regulatory Agency) is responsible for:

– Oversight activity for the NM accounting and control system, physical protection of NM, RS, radioactive wastes.

– Issue licenses for the activities in the field of nuclear energy use to provide safety.

4. State Customs Committee is responsible for:

– Control for legal transfer NM & RS across the state borders and prevention of smuggling NM & RS.

5. Ministry of Health Affairs is responsible for:

– Control for radiation safety of population.

6. Ministry of Emergency Situations is responsible for:

– Localization of seized NM & RS and them transfer to the temporary storage.

7. Ministry of Internal Affairs is responsible for:

– Security of nuclear facilities and investigation of criminal cases connected with unauthorized removal of NM & RS.

8. Federal Security Service is responsible for:

– Preventing attempts of illegal trafficking, criminal investigation in the field of nuclear material smuggling.

9. External Intelligence Service is responsible for:

– Prognostication of threats non-proliferation regime, including illegal transfer of NM.

The order of interactions Facilities, Ministries, Agencies on preventing illicit trafficking of NM & RS:

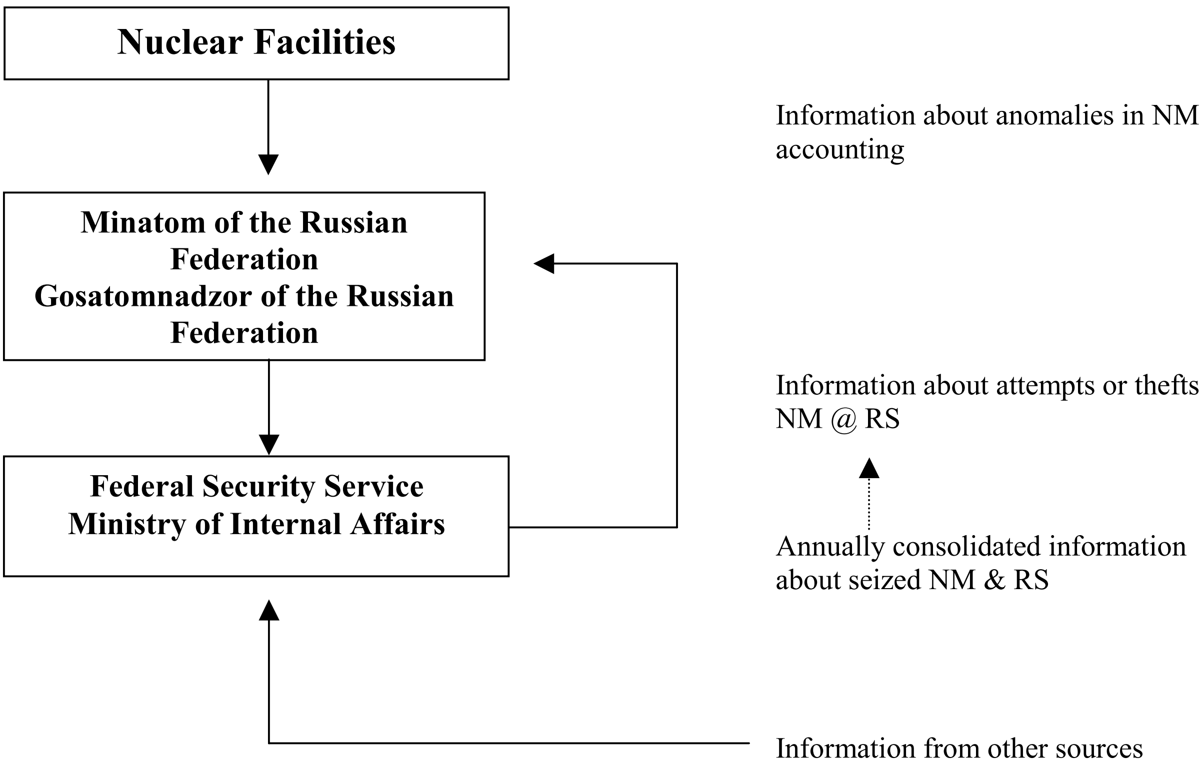


FIG. 1. Identification and determination of seized NM origin

Within the framework of co-operation Minatom of the Russian Federation and Joint Research Centre of European Commission in the institute of Inorganic Materials by name of Academician Bochvar (Moscow) are organised a Lab for identification of nuclear materials of an unknown origin (LINMUO).

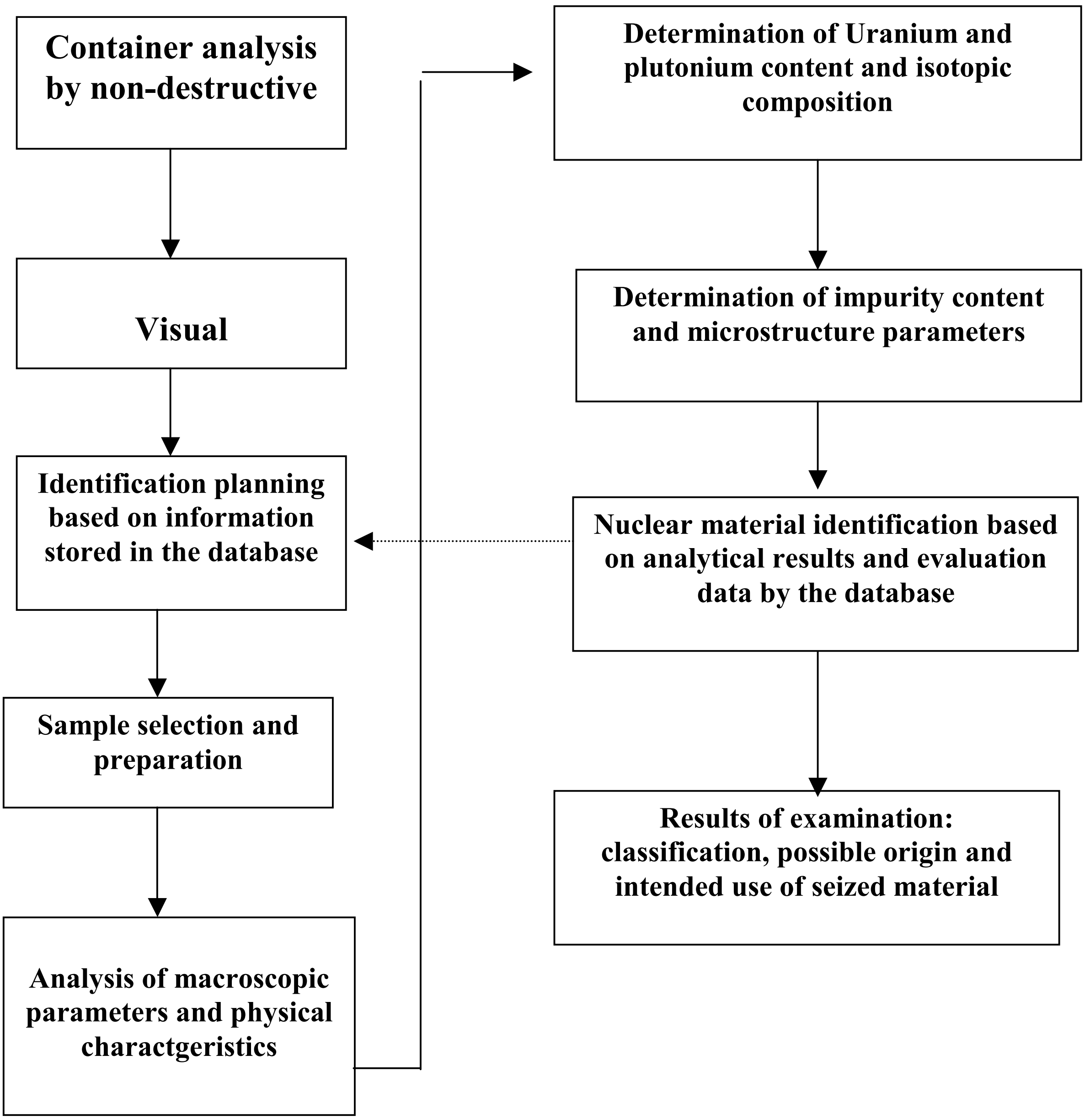
Tasks LINMUO:

- identification of fissile materials of an unknown origin and issue of experts conclusions about its origin;
- making and support of the database under the list, properties, performances and origin of fissile materials;
- making and support of bank fissile materials samples;
- realization of arbitration analysis of nuclear materials;
- realization of inter-laboratory comparisons and international experiments for maintenance of uniformity of measurements.

The database of nuclear fuel materials

Jointly by Institute of Transuranium Elements (Karlsruhe) and Institute of Inorganic Materials by name of Academician Bochvar (Moscow) is created the database for analysis of materials of an unknown origin. It included the known data oп all nuclear fuel materials of the Russian origin and European industry, besides it is added with information from the references oп a nuclear fuel cycle of nuclear fuel manufacturing other countries.

Flow chart for main stages of identification



MAIN DIRECTIONS WORKS FOR PREVENTION ILLICIT TRAFFICKING NM IN RUSSIAN FEDERATION

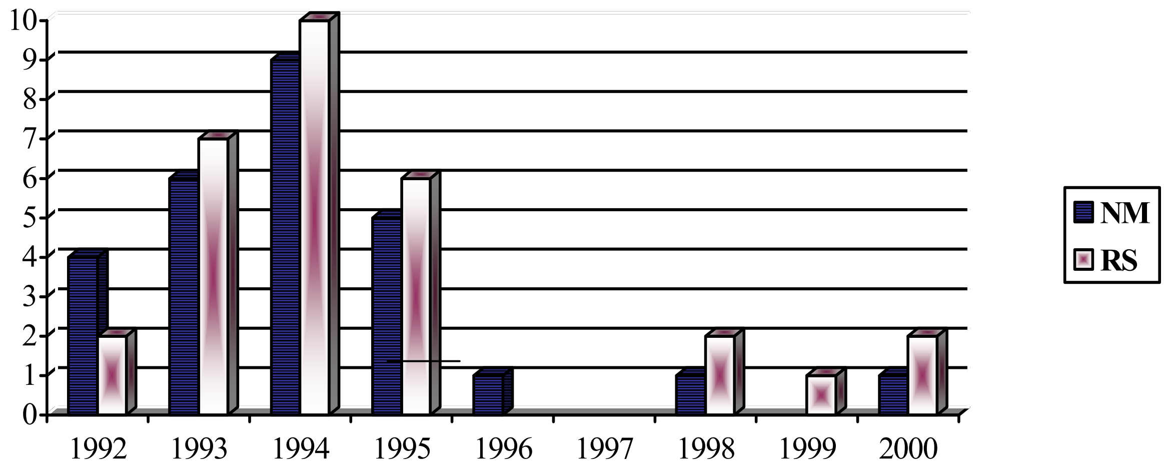
1. Improving system NM accounting and control, physical protection ("First line defense")

"First line defense" is program for improving protective system nuclear facilities in the Russian Federation. In framework this program facilities are equipped with modern techniques: access control, TV-systems, radiation monitoring, computerized system NMAC, C/S equipment, physical protection techniques & so on.

2. Equip customs points at the borders radiation monitoring techniques ("Second line defense")

Main customs points are equipped with radiation monitoring techniques. It is installed about 250 items (portable, fixed, transportation).

Database on Illicit Trafficking of Nuclear Materials and Radioactive Sources in the Russian Federation



CONCLUSION

1. In the area of assurance of nuclear security in the Russian Federation, one top-priority area involves the upgrading of the national system of MPC@A.
2. In summarizing the basic results of the work done in the years just past (1994–2000), one must note that RF Minatom specialists have done a great deal of the work in the area of upgrading the system for ensuring the safety and security of nuclear materials, and the leading role in that area belong to the scientists and specialists who were previously engaged in defense work.
3. The effectiveness of the work done is confirmed particularly by the fact that since 1995, there have been no thefts (such as took place in 1992–1994) or attempts at unauthorized use of NM at RF Minatom enterprises.

REFERENCES

[1] Program for Preventing and Combatting Illicit Trafficking in Nuclear Materials, (Moscow Nuclear Safety and Security Summit — April, 1996).
[2] Federal Law Russian Federation "*On use of atomic energy*" (November 21, 1995 — No. 170-ФЗ).
[3] Penal code Russian Federation (June 13, 1996 — № 63-ФЗ).
[4] "*Provision on the State Accounting and Control of Nuclear Material*" approved by Ordinance of the Government of the Russian Federation (December 15, 2000 No. 962).

QUESTIONS AND ANSWERS

V. Lapshyn (Ukraine): What happens to confiscated material? Who is responsible and who pays for its storage?

N. Kravchenko for V. Erastov (Russian Federation): Confiscated NM is stored in special storage facilities provided by the authorities. The costs incurred are reimbursed by the offender after the court case.

S. Parrish (USA): Do you analyse NM seized in other CISs? Specifically, are you co-operating with Georgia on the HEU seizure of April 2000?

V. Erastov: We analyse NM seized on Russian territory but sometimes other countries ask us to assist them, which is the case for that seizure in Georgia.

EFFORTS OF TURKEY IN COMBATTING WITH ILLICIT TRAFFICKING OF NUCLEAR MATERIALS AND OTHER RADIOACTIVE SOURCES

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Abstract. Illicit trafficking of nuclear materials and other radioactive sources creates both Non-Proliferation problem and also a radiation hazard risk for the law enforcement officers, public and the environment. Since the illicit trafficking and trading of nuclear materials and other radioactive sources have been increasing over the past few years, it is very important to take immediate measures for preventing these activities. Turkey, as a country having a unique position at the crossing points of the two major routes, one connecting the Black Sea to the Mediterrenean and the other connecting Europe to Asia and the Middle East, is situated on the routes of illicit trafficking. Thus, Turkey attaches great importance in combatting with the illicit trafficking and strongly supports all efforts in this field. After the IAEA resolution GC(XXXVIII)RES/15 requesting Member States "to take all necessary measures to prevent illicit trafficking in nuclear materials" had been adopted, Turkey gave full support to the IAEA Programme on Combatting Illicit Trafficking of Nuclear and the other Radioactive Materials and also took some measures for combatting such trading. Regulatory activities regarding nuclear and radiological safety, including safeguards and physical protection in Turkey, are under the responsibility of the Turkish Atomic Energy Authority (TAEA). The TAEA ensures that the licensed activities do not cause any unreasonable risk to the public and to environmental safety, and they do not impair the common defence and security interests of Turkey. TAEA was established by the Act No. 2690 of 9th July 1982 and replaced the Turkish Atomic Energy Commission created by the Act No. 6821 in 1956. The Act No. 2690 authorizes the TAEA to carry out the activities connected with the fullfillment of Turkey's obligations arising from international agreements of in the field of safeguards and physical protection. This paper covers the efforts and coordination role of the TAEA regarding illicit trafficking of nuclear materials and other radioactive sources. TAEA's planned activities and the measures planned to be taken to prevent uncontrolled movement of such materials are presented. The co-ordinative work of TAEA with other relevant organizations, such as customs officers, police and ministries, is also introduced.

1. INTRODUCTION

Since Turkey shares borders with several countries of proliferation concern (Iran, Irak, Syrian Arab Republic) and with of the former Soviet Union (Armenia, Azerbaijan, and Georgia), it continues to merit international attention from the point of view of nuclear smuggling. Additionally, its increasing economical relationship with Central Asian Countries may provide opportunities for the smuggling as well. Thus, Turkey attaches great importance to combatting against illicit trafficking and strongly support all effort in this field.

Nevertheless, that Turkey may be a significant transshipment route for nuclear smuggling particularly from the former Soviet Union (FSU) as being asserted by various sources is somewhat controversial. Even though Turkey's geographic setting could make it an attractive route for all kind of smuggling, a detailed examination of past illicit nuclear trafficking incidents which were confirmed officially or not uncovers the fact that most of the incidents were insignificant with respect to proliferation concern. In most of the reported cases the situation comprises frauds involving Osmium, Red Mercury and Sneak Poison or alleged high enriched Uranium or Plutonium. Furthermore, it was found out that in almost every instances offenders involved in the incidents were peddlers or "amateurs" who acquired the nuclear-claimed materials before identifying potential buyers and even without having any accurate knowledge of the materials themselves. However, it is apparent that more sophisticated smuggling attempts other than reported incidents may have escaped detection.

Fortunately, the past illicit nuclear trafficking incidents in Turkey took place in a amateur and non-organized way. Moreover, no nuclear crime such as nuclear terrorism other than smuggling has been committed by any radical or terrorist group or organization until this time. Bearing in mind Turkey's severe past experience with terrorism, Organized Crime Department of Ministry of Internal Affairs of Turkey stresses on the fact that previously mentioned risk of nuclear crime may call attention of crime groups or radicalists which could be prospective users of nuclear materials or radioactive sources in their actions beside pretending nuclear crime against public.

Apart from proliferation concern, misuse or unauthorised use or diversion of radioactive sources may lead serious injures or danger to public when necessary prevention measures and controlling infrastructure are not implemented or strengthened as Turkey had this kind of distressing experience in 1999 at Ikitelli-Istanbul where some people had serious injures from abondaned Co-60 source.

While Turkey believes that the storage and control of nuclear materials is a national responsibility, it is inevitable to have a robust international legal framework for combatting with nuclear smuggling. The need for international cooperation becomes evident particularly, in situations where the effectiviness of physical protection in one State depents on the taking by other states.

2. SITUATION OF ILLICIT TRAFFICKING INCIDENTS IN TURKEY

Since the collapse of the former Soviet Union, the number of illicit trafficking in nuclear materials and other radioactive sources has increased substantially. As a result, concern about nuclear "black market" has drawn international attention. Simultaneous developments have occured in Turkey with some remarkable differences. First, in some countries where illicit trafficking in nuclear and other radioactive sources incidents encountered were of proliferation concern in comparison with Turkey. Second, as previously mentioned, the offenders involved in smuggling cases were of amateurs or non-proffessionals acquiring materials without any accurate knowledge and market of them. An evidence of this assertion is the police reports stating that all sellers were arrested in operations when dealing with the police in 2000. In view of past illicit trafficking incidents taken place in Turkey, at least until now, contrary to some other countries, Turkey may not be evaluated as an nuclear "black market". Perhaps, it might only be considered as an transshipment route for illicit nuclear trafficking which is a questionable conclusion as well.

2.1. OVERVIEW OF REPORTED ILLICIT NUCLEAR TRAFFICKING INCIDENTS IN TURKEY

Nuclear materials confiscated in Turkey were in almost every instance taken to Çekmece Nuclear Research and Training Center in Istanbul for analysis. From the records of this center, we can draw the following preliminary conclusions:

Between 14.05.1993 and 23.03.2001, the number of materials taken to the center with a formal analysis request from Police Headquarters and from Public Prosecutors in various provinces is over 100. At the moment, there is one more additional request for a material with a suspicion of being Red Mercury.

Table I shows all the verified cases in Turkey between 1993–01 and 2001–04. For proliferation aspect, none of incidents involves significantly enriched amount of Uranium. In all cases, seized material is either natural or low enriched Uranium or depleted Uranium. Verified Plutonium included incident has not taken place until now. However, according to some open sources, Turkish Authorities supposedly seized several grams of Plutonium in Bursa, Turkey in 1998 which is not true.

In figure 1, annual occurences of illicit nuclear trafficking is illustrated. According to these data, the total number of reported incidents in Turkey has increased in a period from 1993 to 1997. It is worthwhile to notice that there is no reported incident in 2000 and in the first quarter of 2001 even this period is not depicted in the figure.

Regarding the distribution of nuclear and other radioactive sources seized in Turkey between 1993-01 and 2001-04, only those verified and included in IAEA database, is depicted in figure 2. As it could be seen from the figure the majority comprise nuclear material incidents. Furthermore, it can be concluded from Table I. that radiaoactive source involved incidents replace the nuclear materials ones in recent years.

In figure 3 distribution of seized nuclear material by incident frequency not by amount is given for the same period. The majority of the cases involve LEU (67%).

Table I. Verified Illicit Nuclear Trafficking Incidents in Turkey between 1993–01 and 2001–04

Incident Date	Type of Material	Location	Seized Material	Amount of Material/Activity
1993-10-05	N	İstanbul	U	2.49 kg Natural U
1994-07-19	N	İstanbul	U	12.38 kg Depleted U
1994-10-19	N	İstanbul	U	650 g Low Enriched U
1996-01-26	N	Yalova	U	1121.1 gr Low Enriched U
1996-05-03	N		U	U238 16250 Bq/g
1996-05-21	N	Kocaeli	U	15 gr Low Enriched U
1996-12-09	N	Kocaeli	U	15.4 g Low Enriched U
1997-02-14	N	Edirne	U	15.4 g Low Enriched U
1997-02-28	N	Edirne	U	508.2 gr Low Enriched U
1997-05-26	N	Bursa	U	841 gr Low Enriched U
1997-12-16	S	İstanbul	Alpha Source	Alpha Source
1998-07-01	S	Van	Mixed Source	Ca,Cu,Zn,Fe Rb, Zr,Ma,Sr
1998-09-10	N	İstanbul	U	4932 g Low (%4.6) Enriched U
1999-01-07	N	Edirne	U	0.1 g Natural U
1999-01-08	S	İstanbul	Co-60	88 Ci
1999-08-05	S	İstanbul	Cs-137	1739MBq, 44MBq

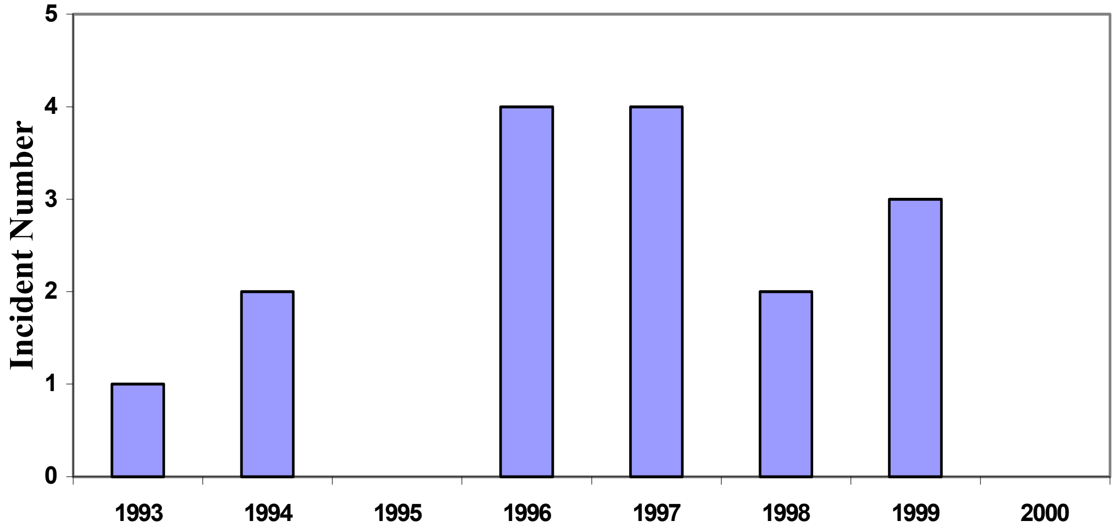

FIG. 1. Annual verified incidents of illicit nuclear trafficking in Turkey between (1993-01)-(2001-04)

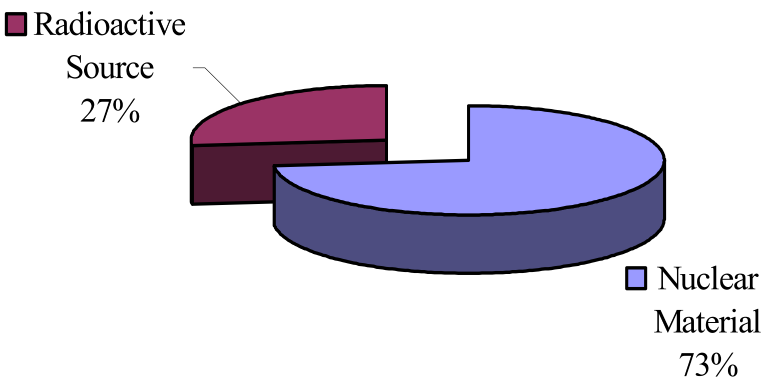

FIG. 2. Distribution of seized nuclear materials and radioactive sources between (1993-01)-(2001-04) in Turkey

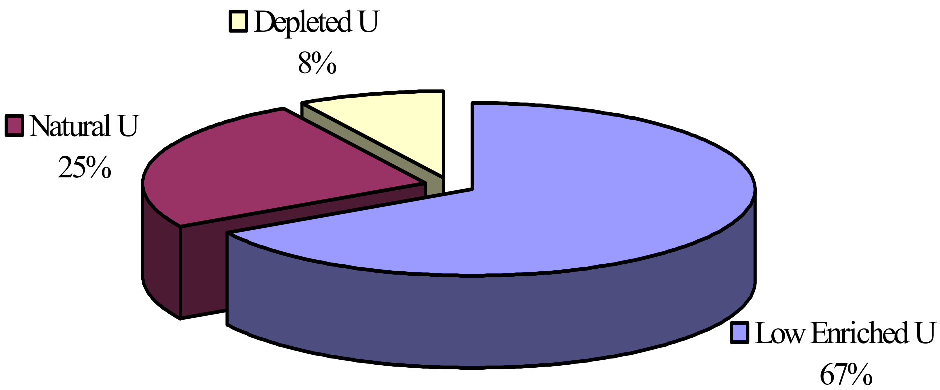

FIG. 3. Distribution of nuclear materials in the incidents between (1993-01)-(2001-04)

2.2. ORIGIN, ROUTES AND FINAL DESTINATION OF SEIZED MATERIALS

According to some reports of the Police which are outlining outcomes of inquiries conducted by the Police, the origin of the seized materials is newly independent states of the former Soviet Union, especially Kazakhstan. Police officers claim the existence of two main routes of illlicit trafficking of nuclear materials and radioactive routes between the period of 1993–1999: the material originating from Kazakhistan is brought to Turkey by sea from Romania and Bulgaria for transshipment, and from Northern Irak to Turkey. It was also mentioned in the reports of the Police that there were many cases in which the starting points of illicit trafficking were the Russian Federation, Georgia, Iran and Azerbaijan.

Figure 4 illustrates the number of verified incidents versus location of incidents between 1993-01 and 2001-04. The concentration of incidents in Istanbul can be interpreted as dealers/sellers may seek prospective buyers in the "international bazaar" of Istanbul. It is also interesting that all the cities except for Edirne which has border with Bulgaria aren't in the vicinity of international borders. This observation leads to conclusion that the shipments haven't been carried out across international borders. Furthermore, all the cities, except Edirne, are located at the industrial regions of Turkey and with great seaports. The concentration of incidents on these cities may also support the assertion that shipment of nuclear materials and other radioactive sources to Turkey is mostly by sea.

Then, the question arises "was it intended in these incidents that the materials seized would be forwarded to other ultimate destinations by sea?" Unfortunately, this question couldn't have been answered with confidence.

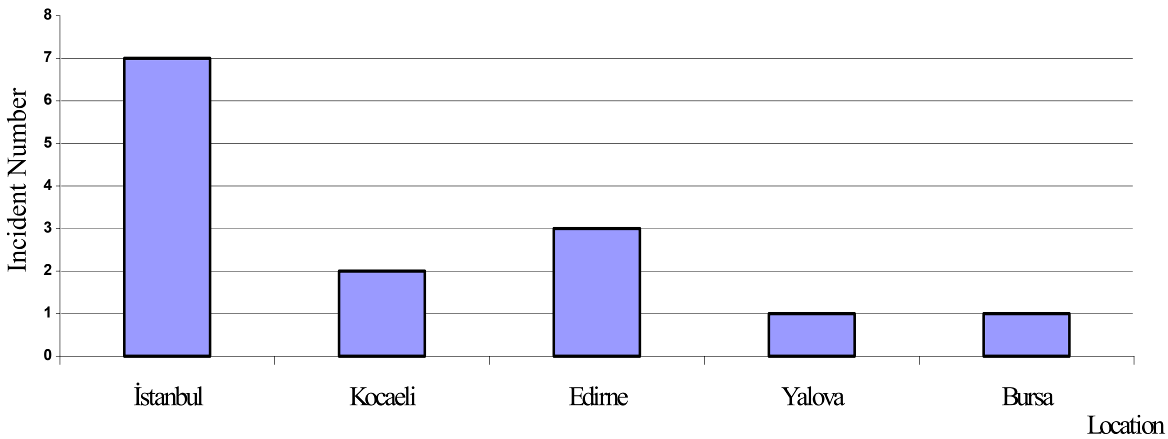

FIG. 4. Location of Verified Incidents in Turkey Between (1993-01)-(2001-04)

3. TURKEY'S SUPPORT TO NONPROLIFERATION REGIME

Turkey provides an active support to the non–proliferation efforts, because of its geographical location which is close to the regions where the potential of proliferation of weapons of mass destruction and their delivery means is extremely high.

Turkey became a state party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) by signing it on January 28, 1969, and ratifying it on March 29, 1979. After ratifying the NPT, Turkey concluded a "full-scope" Safeguards Agreement with the International Atomic Energy Agency (IAEA) in 1981. Besides NPT, Turkey signed the Convention on The Physical Protection of Nuclear Materials in 1983 and ratified it in 1984.

In accordance with its foreign and security policy, Turkey has also become a state party to international agreements and arrangements that seek to prevent the spread of all sorts of weapons of mass destruction such as Chemical Weapons Convention, Biological and Toxin Weapon Convention, Comprehensive Test Ban Treaty, Wassenaar Arrangements, Missile Technology Control Regime etc.

As a country that never sought to acquire weapons of mass destruction, Turkey has endorsed efforts to strengthen the nuclear nonproliferation regime and the verification mechanisms of the IAEA within the context of the "Programme 93+2". Within same context, Turkey signed the Additional Protocol on July 6, 2000.

Turkey believes that nuclear export control measures play an important role in preventing the proliferation of nuclear weapons. Therefore, Turkey expressed its eagerness to accede to the Nuclear Suppliers Group (NSG) and Zangger Committee (ZK) and to abide by their guidelines by passing the necessary export control laws. Turkey became membership of ZK on October 21, 1999 and NSG on 20 April, 2000.

3.1. COMPETENT AUTHORITY

The regulatory activities regarding nuclear materials and facilities including nuclear material accountancy and control, and physical protection activities under supervision of Turkish Atomic Energy Authority (TAEA) in Turkey.

TAEA was established by the Act No. 2690 of 9th July 1982 and replaced the Turkish Atomic Energy Commission created by the Act No. 6821 in 1956. TAEA's general objective is to promote the peaceful uses of nuclear energy under the energy development plans approved by the Turkish Government and the application of nuclear techniques.

TAEA has four technical departments. The Department of Nuclear Safety, which is one of the specialized technical departments, was established under TAEA in 1973, as the central organization to conduct the respective roles on licensing and safety of nuclear installations. Among its other activities this department is responsible for the accountancy and control and physical protection of nuclear materials. Regarding safety and security of radioactive sources, The Department of Radiation Safety of TAEA is authorized by the Act to give license for handling, using, importing, exporting, transporting, storing, trading in radioactive materials and equipments.

After signing the Safeguards Agreement with the IAEA, Nuclear Material Safety Division (NMSD) was established under the Nuclear Safety Deparment in 1981 and was given the responsibility for establishing and maintaining the Turkey's SSAC. In the same year, SSAC was designed based on IAEA document "Guidelines for SSAC, IAEA/SG/INF/2" to meet Turkey's obligations arising from Safeguards Agreement.

3.2. REGULATORY FRAMEWORK

TAEA Act reaffirms Turkey's attachment to the peaceful use of atomic energy in conformity with the NPT and authorizes TAEA to carry out the activities connected with the fulfilment of Turkey's obligations arising from international agreements in the field of safeguards and physical protection.

Since 1982, several decrees and regulations based on main safety goal have been issued under TAEA Act. Following legal documents are related to nuclear and radioactive material safety and security:

- Decree on Pertaining to Issue of Licences for Nuclear Facilities.
- Decree on Radiation Safety.
- Regulation on Accounting for and Control of Nuclear Materials.
- Regulation on Measures for Physical Protection of Special Nuclear Materials.
- Regulation on Safe Transport of Radioactive Materials.
- Regulation on Permission for the Export of Material and Equipment used in Nuclear Field and related Technology.
- Regulation on Radiation Safety.

4. COMBATING WITH ILLICIT TRAFFICKING

The new phonemenon of "illicit trafficking" in nuclear materials and radioactive sources has been arised in the 1990s. As a result of increase in the number of incidents, the international community realized that the immediate measures must have been taken and during the ninth General Conference of the IAEA, it was requested to take all necessary measures to prevent illicit trafficking in nuclear materials. At that conference, the resolution on "Measures Against Illicit Trafficking in Nuclear Materials" (GC(XXXVIII/RES/15) was adopted on 23 September 1994. This resolution accelareted the IAEA's activities that are described in the document "Measures Against Illicit Trafficking in Nuclear Materials and other Radioactive Sources" (GOV/2773, dated 24 November 1994).

Because of importance of this matter, Turkey has given full support to the IAEA Programme on Combatting Illicit Trafficking in Nuclear Materials and Radioactive Sources. In 1996, Turkey notified the IAEA that it accepted the Database on Illicit Trafficking in Nuclear Materials and other Radioactive Sources, and give the name of a person who could be contacted directly by the IAEA to obtain information concerning illicit trafficking incidents. In addition to the IAEA Database System, Turkey has established its own Database System to collect information regarding illicit trafficking incidents at the TAEA.

4.1. RESPONSE TO INCIDENTS AND REPORTING SCHEME

In case of illicit trafficking in nuclear materials, TAEA is informed by the police or customs. In order to determine the necessary precautions with respect to radiation safety, a preliminary evaluation of the information is made. Following the evaluation, if it is found necessary that TAEA's experts will be sent to incident location. In any case, arrangements for temporary storage and transport to final authorised laboratories of TAEA are made. Analysis of laboratories covers the following:

- Visual inspection.
- Radioactivity and contamination measurements.
- Physical examination.
- Sampling cutting, grinding chemical sample preparation if necessary.
- Enrichment analysis by Multichannel Gamma Analysis.

After performing above analysis, the result including elemental and isotopic composition, impurities, chemical form, radiation levels, etc. and possible origins of the materials and any information useful is being sent to TAEA. Another report for judicial purposes is also being prepared. Seized nuclear material is kept at research centers which is a temporary depository of the material. A final decision about the permanent location of the material is given by the court. If the material is nuclear then it is transferred to MBA for safeguard and physical protection purposes. So, it is open to IAEA inspections.

Information regarding each illicit trafficking incident is being recorded in National Database System and sent to IAEA through National Contact Point after filling out Incident Notification Form.

4.2. PREVENTION

The prevention of illicit trafficking in nuclear materials and other radioactive sources could be achieved through improvements and strengenthining of State's system of accounting for and control of nuclear materials (SSAC) and via adequate control mechanism in radiation safety infrastructure. Prevention also requires a strengenthened State system of physical protection of nuclear materials and facilities. Considering these facts, Turkey has been performing following activities:

- Turkey signed Additional Protocol which was intended for implementation of Part II of 93+2 Programme on 6 of July, 2000. The process is on the stage of approval by Grand National Assembly of Turkey. Revision studies on regulation on accounting for and control of nuclear materials, pertaining to certain additional obligations which were brought by he Additional Protocol, has been going on.
- The revision studies on Regulation on Measures for Physical Protection of Special Nuclear Materials in conformity with IAEA document "Physical Protection of Nuclear Materials and Facilities" (INFCIRC/225/Rev.4) has been going on.
- It is planned to upgrade physical protection system of research reactors. A project for upgrading was approved and funded by State Planning Organization. After the facilities prepare revised physical protection plans, they will be evaluated by TAEA for approval.
- Penalty articles, concerning giving deterrent penalties for the crimes committed with Nuclear and Radioactive Materials, were added to Turkish Criminal Code and presented to Grand National Assembly of Turkey for endorsement.
- "Regulation on Permission for the Export of Materials and Equipment Used in Nuclear Field and Related Technology" was prepared and put into force after publication on Official Gazette on 15 of January 2000. This regulation comprises the permission arrangements for the export of the nuclear materials and related technology for material, equipment and components used in nuclear field as well as nuclear related dual-use equipment and materials in the lists of Nuclear Suppliers Group and Zangger Committee.

4.3. DETECTION

In order to detect the smuggled nuclear materials and radioactive sources passing through customs gates, it is planned to establish proper equipment capable of detecting these substances. To determine the immediate necessities of customs gates, TAEA accelerated cooperative works with Customs Undersecretary. Additionally, US Government and Turkey entered into a cooperative arrangement in 2000 that would result in installation of radiation detection equipment at Turkish border points of entry. Under this programme which is funded by State Department's Non- Proliferation and Disarmament Fund (NDF), United States sent Department of Energy (DOE) personnel to Turkey to work together with Turkish officials in determining border points-of-entry suitable for the installation of radiation detection equipment. After this initial assesment, two border points-of-entry was chosen to install detection equipments as a donation from US. The installation is expected to be throughout 2001 and further installations is under consideration for more border point-of-entries.

4.4. TRAINING

The prevention of criminal activities involving nuclear or other radioactive materials requires broader competence and a thorough understanding of the related issues, and closer co-operation at the national and international level between nuclear regulatory authorities and law enforcement authorities (police, customs and intelligence). Since 1998, TAEA, as Competent Authority, has been arranging training courses periodically on combating nuclear smuggling relevant aspects such as prevention, detection and response to illicit trafficking incidents in nuclear and radioactive materials for the customs officers and police investigators.

Besides national training programme, Turkish officials from Atomic Energy Authority, customs administrations and police have participated to the training courses which were organised by IAEA, in co-operation with World Customs Organisation (WCO) and INTERPOL.

5. INTER-AGENCY AND INTER-EU CO-OPERATION

Turkey is a participant of the ongoing UAEA Project "Physical Protection and Security of Nuclear Materials" RER/9/060. In the meeting held in Vienna under this project, Turkey requested the assistance of IAEA in the fields of training, nuclear material detection devices at the custom gates, knowledge about control of illegal nuclear materials carried via ships. In the scope of this project, some staff of custom officers and police of Turkey attended aforementioned training course which was arranged by IAEA/WCO/INTERPOL.

Turkey has been attending the informal Open-Ended Experts Meetings to discuss whether there is a need to revise the Convention on the Physical Protection of Nuclear Material and advocating the idea that the content of the Convention is inadequate and needs to be broadened.

As a future member State to the European Union, Turkey attended the meeting on combatting illicit trafficking on nuclear materials which was held in Institute for Transuranium Elements, Karlsruhe, November 9-10,2000. In this context, PECO Project Agreement and Contract are being evaluated in terms of their conformity with Turkish Law.

Turkey participated in second interlaboratory comparison (Round Robin) exercise which were organized by Nuclear Smuggling International Technical Working Group (ITWG) created under the auspices of the P8. The objective of the test is to compare means and methods of forensic analysis on samples of seized nuclear material. At this stage, Uranium sample is planned to send Çekmece Nuclear Research and Training Center for forensic analysis.

6. CONCLUSION AND RECOMMENDATIONS

Turkey believes that;

- Illicit trafficking of nuclear materials has a transboundary dimension and the measures at the national levels cannot solve this important problem. The identification of the international aspects of the problem and their solution will become possible through the conclusion of an international legal instrument.
- All States with nuclear materials on its territory should adopt strict physical protection arrangements and adhere to the Convention on the Physical Protection of Nuclear Materials.
- Combating illicit trafficking is multi institutional problem (different institution and also international co-operation) and also manpower, technical capabilities, legal framework and co-operation are very important elements.
- All States having a Safeguards Agreement with IAEA should conclude the Additioanal Protocol in the near future.
- It is important to complete ongoing studies on Draft Convention on the Suppression of Acts of Nuclear Terrorism.
- One of the major measures of prevention of nuclear smuggling is a strengthened national accountancy and control system.
- The scope of Convention of Physical Protection of Nuclear Materials should be extented.
- Last but not least, it should be stated that enhancing co-operation and co-ordination with the States and international organizations with aim of preventing detecting and responding to the illegal use of nuclear and other radioactive materials is the most important key point of the subject.

REFERENCES

[1] Ministry of Interior, Turkish National Police, Department of Anti-Smuggling and Organized Crime, Report, Ankara, 1998.

[2] Ministry of Interior, Turkish National Police, Department of Anti-Smuggling and Organized Crime, Report, Ankara, 1999.

[3] Ministry of Interior, Turkish National Police, Department of Anti-Smuggling and Organized Crime, Report, Ankara, 2000.

[4] YÜCEL, F.A., Status of National System of Accounting for and Control of Nuclear Materials in Turkey, Symposium on International Safeguards, Vienna, 13–17 October 1997.

[5] Working Group of the International Open-Ended Expert Meeting Whether there is a Need to Revise the Convention on the Physical Protection of Nuclear Materials, Final Report of the Working Group, Vienna, 2001-02-02.

QUESTIONS AND ANSWERS

A. Gotsev (Bulgaria): Do you regulate the import as well as the export of radioactive material?

A. Yücel (Turkey): Yes, we have a decree on radiation safety, which regulates the licensing of radioactive material and includes rules for import, export, transport, handling, use and storage.

I. Maalmann (Estonia): Which organization is responsible for illicitlly trafficked material seized by the police and what measures are taken?

A. Yücel: Police or customs inform the Turkish Atomic Energy Authority (TAEA) any of illicit trafficking incident. The TAEA makes a preliminary evaluation of the information and, if necessary, sends its experts in radiation safety to the location. In any case, arrangements are made for temporary storage and transport to the TAEA's analysis laboratories. If the material is nuclear, it is transferred to the MBA and placed under safeguards. Illicit trafficking data is recorded on a national database and sent to the IAEA.

I. Badawy (Egypt): How should the scope of the CPPNM be extended?

A. Yücel: For example, it should cover NM material in domestic use, storage and transport.

S. Chetvergov (Kazakhstan): Can you comment on the assertion that NM is being transferred from Kazakhstan via Turkey to northern Iraq?

A. Yücel: I cannot give you a specific example, but — according to police reports — there are many cases of NM originating from Kazakhstan being brought to Turkey by sea from Romania and Bulgaria for transshipment.

NATIONAL INFRASTRUCTURE FOR DETECTING, CONTROLLING AND MONITORING RADIOACTIVE SOURCES

I. OTHMAN
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Abstract. The Atomic Energy Commission of Syria (AECS) is the sole responsible organization in the Syrian Arab Republic for radiation protection and nuclear safety. The Radiological and Nuclear Regulatory Office (RNRO) assures compliance with national radiation protection regulations and practices by registrants and licensees. AECS has established nine Monitoring Stations at entrances to the Syrian Arab Republic. Recently, a new radiation monitoring system was installed at four Monitoring Stations.

1. INTRODUCTION

Various types of sealed or unsealed radioactive sources are in use in the Syrian Arab Republic in the fields of medicine, agriculture, industry and researches. The regulatory and operational radiation protection measures are in conformity with the international standards. These measures control the unauthorized movement of nuclear materials and radioactive sources, which threat not only the non-proliferation regime, but also affect the public health. They include the relevant national legislation, physical protection, accounting for and control of nuclear materials and radioactive sources and operational health physics.

The Atomic Energy Commission of the Syrian Arab Republic (AECS) has a direct responsibility for the safe handling, accounting for and controlling of nuclear materials and radioactive sources. This is carried out by applying the system of prevention, inspection, training and exchanging of information.

2. PREVENTION

Prevention of any misuse of radioactive sources requests the strengthening of the national infrastructures in the areas of legislation, physical protection, accounting for and control of nuclear material, control and security of radioactive sources.

3. LEGAL FRAMEWORK

Act No. 12 of 1976 has authorized the Syrian Atomic Energy Commission as the sole responsible organization in the country for radiation protection and nuclear safety. In particular, paragraph 7 of article 2; stated that "AECS has full responsibility in carrying-out the proper and necessary measures for the protection of human and environment and remediation actions against radiation risks, and has been given the task to prepare regulations and code of practices on radiation protection and safety, also to issue authorization and instructions of using radiation sources, and assure their enforcement".

Based on the national law, AECS prepared ministerial decree for Radiation Safety which was issued by the Prime Minister (No. 6514 dated 8.12.1997). This decree empowers the Syrian Atomic Energy Commission to regulate and monitor radiation sources movements and practices. This fulfills the basic requirements of radiation protection and safety, and it enforces the rules and regulations.

The Radiological and Nuclear Regulatory Office (RNRO) has been established in AECS as an independent office from its technical Departments. RNRO reports to the Director General of the AECS directly.

The Radiological and Nuclear Regulatory Office (RNRO) is responsible for preparing all the drafts of the required regulations. In 1999 the Basic Standards for Radiation Protection was issued by the Director General of the AECS, under Decision no.112/99 dated 3.2.1999. It is based on IAEA's publication, mainly safety series No. 115 (1996), and adopted to meet the national requirements. The System of Notification, Registration and Licensing is fully applied in the country in order to prevent any theft or damage or any unauthorized or misuse of radioactive sources.

Independent verification by (RNRO), is to assure the compliance of practices with the requirements of the national regulations by registrants and licensees, whom are primary responsible for the safety of radioactive sources.

4. IAEA SAFEGUARDS

The basic international obligations for nuclear material in the Syrian Arab Republic are contained in the Treaty of the Non-Proliferation of Nuclear Weapons (NPT) which signed since 1969; and the Safeguards Agreements (INFCIRC/153), which signed with IAEA in 1992, for a "Miniature Neutron Source Reactor". The Agency is obliged to verify the presence of the nuclear material in the Syrian Arab Republic subject to safeguards under the agreement, and the Syrian Arab Republic is obliged, among other things, to report to the Agency if there is or may have been any loss or theft or abnormal conditions of nuclear material in its territories.

5. INSPECTION AND COMPLIANCE PROCEDURES

The Regulatory Authority under decision No.112/99 established an inspection and compliance system for manpower and facilities to carry out inspection in order to enforce compliance with the national radiation protection regulations.

Decision No. 814/2000 dated 10 August 2000 of regulatory authority specified qualifications and experiences required to be licensed as an inspectors. Candidate has to pass a written and a practical examinations.

AECS established nine Monitoring Stations at the controlled entrances to the Syrian Arab Republic, to monitor traffics of materials (import and export) which might be either contaminated or containing radioactive sources for illicit trafficking. They considered as a monitoring stations to prevent unauthorized movement of nuclear material and radioactive sources in and out of the country.

Each monitoring station is provided with the suitable instruments and detectors in order to fulfill their duties in an ideal way. They apply an approved procedures for the safe import, export and transit of radioactive sources. The Radiation Protection Officers (RPOs) provide authorization stamped on an entry approval document or approval for transit across their territory. This enables to track the legal movement of shipments to prevent theft, diversion or misuse of radioactive sources.

Recently a new radiation monitoring system were installed in four monitoring stations in which each of them has a radiological control for vehicle loads (Multi channel system) RCVL. This system allows the radiological control for vehicle loads at each access of the Syrian borders: Syrian-Lebanon, Syrian-Turkey and Syrian-Jordan borders. Each system is made up of:

1. 2 infrared detection sets (emitter/receiver) made up of:

- 2 inrared cells.
- 2 reflectors.
- 2 corner plates.

The infrared detection set is a detector by reflexion: it detects the presence of a vehicle by the cut of the infrared reflected beam. It is equiped with a heating optics to avoid hoar frost or condensation deposition.

2. 2 plastic scintillation detectors DSP 010 + screws for leads + reports

The detector is a plastic scintillation detector which is screened with flat lead. The scintillating plastic is coupled with a photomultiplier, connected to a chain of dynodes-amplifier — discriminator.

When the scintillating plastic is struck by gamma radiation, it emits a small flash or light, that is to say a scintillation. These scintillations are converted into electric pulses which can then be analyzed and counted electronically to give information concerning the incident radiation.

The amplifier-discriminator card is related by a flat cable to a power supply card which gives the tension needed by amplificator-discriminator circuits and the high power supply voltage. All these elements are enclosed in a watertight and lightproof aluminium case.

The Junction Box; mainly includes the remote control card, 2 operational amplifiers recopy the tensions of the 2 potentiometers which are used as references for the adjusting of the high voltage and the discriminator.

3. 12-channel interface box

It permits the power supply of the two detectors. It includes an insultion card for the pulses coming from the detectors. It transforms the electrical pulses, an insultation card for the input/output of the computer and a watchdog to check that the computer is in good running. A buzzeris fixed on the box to give the alarm if the alarm threshold is exceeded. Its power supply is provided by a power distribution box with supplies specific voltage.

1 computer PC (with 1 color monitor, 1 keyboard, and 1 mouse). Is equiped with the operating system WINDOWS NT 4.0 ARABIC and the centralization software SAPHYMO.

There are three channels to analyze the information coming from the detectors. Each of the two first ones is related to a detector and processes the information coming from it. The third one is a summing channel analyzing the whole information coming from the two detectors.

6. TRAINING

AECS carefully select the radiation protection officers to work at the monitoring stations. They must have good scientific background, and good English language for dealing with documents and for communication. The AECS arranged for them a regular national basic training courses which administered by the concerned section in AECS in the field of radiation protection, dosimetry, use of instruments, emergency procedures in case of radioactive incidents, in order to have a qualified trained staff members professionals in the control and monitoring systems.

7. INFORMATION EXCHANGE

Exchanging information is accomplished through national, regional and international meetings and conferences, where representatives from different States all over the World can exchange information in a way to facilitate and expand the coordination and cooperation among international organizations in the prevention, detection, and response to incidents involving illicit trafficking of nuclear materials and other radioactive sources.

ACKNOWLEDGEMENT

The Author would like to thank Ms. Maha Abdul-Rahim for her assistance in preparing this paper.

QUESTIONS AND ANSWERS

N. Kravchenko (Russian Federation): a) Which authority controls NM at the border and b) what is the judicial basis for financing border radiation control?

I. Othman (Syrian Arab Republic): a) More than nine authorities, including police, customs and security, are involved. The Atomic Energy Commission has a border office and surveys goods and vehicles for radioactive material. b) These costs are not covered by law. We treat them as labour costs.

L. Obiagwu (Nigeria): Does the Commission — which is vested with powers to enforce its regulations — prosecute cases of illicit trafficking directly or does it hand them over to the police?

I. Othman: When it comes to legal enforcement of our regulations, e.g. against an importer that does not adhere to them, we ask the police to take action.

STRATEGIES TO REDUCE ILLICIT USES OF RADIOACTIVE MATERIALS: THE ETHIOPIAN PERSPECTIVE

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Abstract. In Ethiopia, attempts/incidents of illegal use of radioactive sources have, so far, been limited. However, in Ethiopia's perspective, preventing and controlling illicit uses and trafficking of radioactive materials includes strengthening national systems of control and protection; achieving co-ordination between regulators, law enforcement bodies and customs; developing effective information systems; and training responsible parties in prevention, detection and response.

1. SYNOPSIS

The illicit uses of radioactive sources can impose a direct danger to public health and safety. A number of cases worldwide have resulted in ionizing radiation exposures to individuals.

Although the incident of illicit trafficking is greatly influenced by the national system of protection of radioactive materials at their use and storage location this alone may not ensure an absolute guarantee against such occurrence.

The challenges of preventing illicit uses of radioactive sources and activities is more complex in the face of more integrated global economic environment. The national system of control, the cross border involvement, multiplicity of participants in the supply to end-use chain, diversity of systems and instruments are factors contributing to this complexity.

Smooth interplay and overall systemic effectiveness of the national system of regulatory control, the strategic coordination of responsible parties and the systemic tie of such bodies, the efficiency of information flow and the pattern of know-how and training is what ensure the effectiveness of preventing, detecting and responding to any illicit activities and trafficking of radioactive sources.

In Ethiopia, the attempts/incidents of illegal use were so far limited. However, the possibility of such occurrence cannot be ruled out and due attention should be paid as the activity is complex and is global problem of general concern. Therefore, in addressing these issues the following strategies are believed appropriate in Ethiopia's perspective for preventing and controlling illicit uses and trafficking of radioactive materials.

- Strengthening the national system of control and protection including boarder controlling.
- Achieving effective coordination within and among regulators, law enforcement bodies and customs.
- Developing and maintaining effective system of information handling and flow.
- Training of principally responsible parties in the prevention, detection and response to illicit trafficking.

The details of the recommended strategies pertaining to the realities and conditions of Ethiopia are discussed in the following parts of the paper.

2. THE STATUS OF REGULATORY CONTROL IN ETHIOPIA

The main legislation governing the control of ionizing radiation and radioactive materials called "The Radiation Protection Proclamation No. 79/1993" was issued by the House of Representatives, Government of Ethiopia, on 22nd December 1993.

This law has established and empowered the National Radiation Protection Authority (NRPA) to, authorize and inspect regulated activities, issue guidelines and standards and enforce the legislation and regulations.

The law has also established that, the importation, exploration, manufacture, possession, sale, use, storage, transportation or disposal or radioactive materials or devices emitting ionizing radiation shall only be based on licenses issued by the Authority.

The NRPA is organized as an autonomous public authority and now strengthened and developed to a level of competence for effectively fulfilling its legislative mandate under the enabling provisions of the legislation. Its functions are also emerging and developing to cover all aspects of the regulatory control including the control of illicit uses of radioactive materials.

2.1. THE NATIONAL REGULATORY SYSTEM

The regulatory activities are designed in line with the main regulatory instruments, Notification, Authorization, Inspection and Enforcement.

In its effort to develop a systematic regulatory regime in a professional transparent and sustainable manner, NRPA has developed and tested in practice pertinent guidelines and procedural manuals.

a) notification:

The system of notification for effectively identifying and locating radiation sources subject to regulatory control is very well in place. Users of radiation sources and machines notify the NRPA through application for import and authorization for practice.

Arrangement is made with the Ethiopian Customs Authority and Investment Authority of Ethiopia, so that any importation of radiation sources and equipment is subject to the clearance and approval of the NRPA.

The NRPA has an organized inventory of sources and equipment and periodically update the source/equipment user and inventory status.

b) authorization:

NRPA has developed a system of authorizing practices by registration or license. A final set of procedural guide documents as well as application forms, safety assessment protocols, and practice specific guides are designed and currently put in practice.

c) inspection:

In the 1999/2000-budget year NRPA has established and activated inspection plan and priority listing, based on the degree of hazard associated with the practices and past inspection history.

Now all practice centers and sources are routinely inspected once in a year and the frequency can be increased based on the degree of hazards associated with practices.

Inspections are carried out following appropriate procedural and technical guidance documents and a system of monitoring are in place to ensure that inspection findings are communicated to the users in a timely and clear manner.

d) enforcement

NRPA has developed a coherent set of strategies to progress enforcement actions in a step-by-step incremental manner and by starting from the front-end (most recent) practices.

A new cooperative framework arrangement is made with Ministry of Health, Addis Ababa Regional Government Health Bureau and other Regional Governments to coordinate actions for the enforcement of the radiation protection proclamation.

An enforcement guide is now in use to maintain consistency and objectivity. Regularly improving the enforcement guide document is also a follow-up task for NRPA to ensure continual systemic improvement.

2.2. NATIONAL INVENTORY OF RADIATION SOURCES AND RADIOACTIVE MATERIALS

Registration of radiation sources and radioactive materials has started in 1996 by distributing questioners to different institutions and departments in the country and simultaneously issuing calls by public media. Since then the inventory has been regularly updated and an up to date inventory of about 95% of Radiation Sources and Radioactive materials in the country is accounted.

The NRPA has now fully implemented the Regulatory Authority Information System (RAIS), which provides a systemic integration and will be instrumental to enhance the effectiveness of the regulatory control system.

The Radioactive Sources inventory stands at 51 with the following breakdown:

- Nuclear Gauges 22
- NDT 2
- Research (sealed sources) 17
- Research (unsealed sources) 2
- Medical application 3
- Dosimetry laboratory 5
- Total 51

3. STRATEGIES TO REDUCE ILLICIT USES OF RADIOACTIVE MATERIALS

In Ethiopia, the attempts/incidents of illegal use were so far limited. However, the possibility of such occurrence cannot be ruled out and due attention should be paid as the activity is complex and is global problem of general concern. Therefore, in addressing this issues the following strategies are believed appropriate in Ethiopia's perspective for preventing and controlling illicit uses and trafficking of radioactive materials.

- Strengthening the national system of control and protection including boarder controlling.
- Achieving effective coordination within and among regulators, law enforcement bodies and customs.
- Developing and maintaining effective system of information handling and flow.
- Training of principally responsible parties in the prevention, detection and response to illicit trafficking.

The details of the recommended strategies pertaining to the realities and conditions of Ethiopia are discussed as follows.

3.1. STRENGTHENING THE NATIONAL SYSTEM OF CONTROL AND PROTECTION INCLUDING BOARDER CONTROLLING

The national system of control based on the main regulatory instruments of Notification, Authorization, inspection and enforcement.

Although the incident of illicit trafficking is greatly influenced by the National Systems protection of radioactive materials at their use and storage location, this alone may not ensure an absolute guarantee against such occurrence.

As well as keeping an up-to-date inventory of sources shall be strengthened as a main starting point.

Therefore, scope and out reach of the system of control shall also expand in order to effectively prevent and respond the illicit uses radioactive sources.

Mechanisms should be developed for gathering information to enable control and intervention on a proactive basis. By creating a coordinated working arrangement with border police and Customs Authority, control should also be exercised on critical border points and major port of entries.

3.2. ACHIEVING EFFECTIVE COORDINATION WITHIN AND AMONG REGULATORS, LAW ENFORCEMENT BODIES AND CUSTOMS

Ensuring the smooth interplay and overall systemic effectiveness of the national system of regulatory control, the strategic coordination of responsible parties and the systemic tie of such bodies is one of the major determinant factors enhancing the capability of the national instrument to prevent intercept and respond to illicit uses of Nuclear materials and radioactive sources.

To achieve this:

a) A multi organizational approach should be adopted and the control should be exercised in a manner that allow smooth interplay of these participants.

In the Ethiopian context, the Regulatory Authority NRPA, Transport Regulators, Crime Police, Customs Authority, Border Police and Regional Authorities are the major bodies of control fitting in this framework.

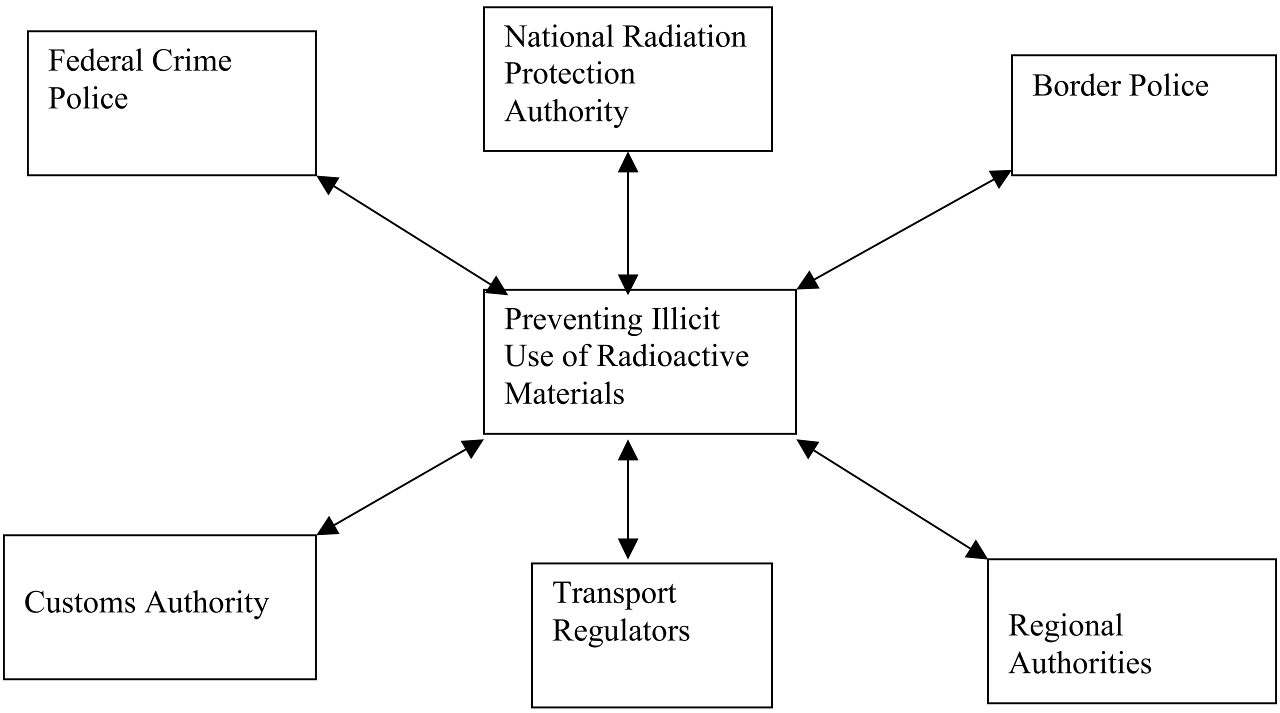

FIG. 1. A multi-organizational approach

b) A formal coordinating mechanism with an established responsibilities and shared objectives should be developed and maintained in order to achieve a strategic coordination and a systemic tie between and among such bodies.

3.3. DEVELOPING AND MAINTAINING EFFECTIVE SYSTEM OF INFORMATION HANDLING AND FLOW

The proactivity and the effectiveness of the coordinated measures to prevent, intercept and respond to illicit uses of radioactive materials greatly depend on the quality of information and the efficiency of the system of information gathering, handling and flow.

Therefore, an information system should be developed and maintained which is capable of providing integrated reports and generate and disseminate orderly flow of pertinent and timely information to relevant bodies.

The system should be capable of accepting a inputs from relevant sources and then processing this in to a meaningful information and ensure timely dissemination for the benefit of decision makers to trigger a timely action.

When this system of information is strategically created and then institutionalized throughout the cooperative mechanisms, its value is enhanced.

3.4. TRAINING OF PRINCIPALLY RESPONSIBLE PARTIES IN THE PREVENTION, DETECTION AND RESPONSE TO ILLICIT TRAFFICKING

Training is essential to the success of the national system of control. Training helps the participants to understand the system of control and the technicalities involved on carrying out the regular work, it greatly aids the process of change and can also achieve substantial improvement at the systemic level.

The training should be designed in order to address the varying needs of participants at various levels, from strategic to operating levels. The strategic and decision level should be trained to encourage participation, devolve responsibility and create new methods of work. The training should also address the operating level in exercising control on all relevant dimensions and equip the details of technicalities involved in exercising control.

The training should not be a one-time issue, rather should be continuous to revalidate the know-how and bring about current awareness on the contemporaneous issues.

QUESTIONS AND ANSWERS

S. Shakshooki (Libyan Arab Jamahiriya): I believe that training of customs and intelligence officials should be developed with the assistance of the IAEA in syllabus preparation and advice on procurement of instrumentation.

G. Gebeyehu Wolde (Ethiopia): Training should address the technical and operational needs of a multidisciplinary task team and should expand to address the strategic and changing nature of the work.

S. Banda (Zambia): What is the strategy for handling orphan sources and the five per cent of the radiation sources that are not within the control of Ethiopia’s regulatory framework?

G. Gebeyehu Wolde: The sources entered the country before regulatory control was established a few years ago, so they needed to be retroactively licensed and controlled. The strategy for controlling sources that are unaccounted for is to continue searching and monitoring. Orphan sources need safe interim storage until decisions about disposal are reached. In this connection we are co-operating with the IAEA.

LEGAL FRAMEWORK AND PRACTICE TO PREVENT AND DETECT ILLICIT TRAFFICKING OF NUCLEAR AND RADIOACTIVE MATERIALS

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Abstract. The regulation of nuclear energy utilization activities in Indonesia in under control of Indonesia Nuclear Energy Control Board. The control of any activities utilizing nuclear energy is implemented through regulation, licensing and inspection in order to ensure the the safety, security and peace of the people, and the health of public, worker and environmental protection. Prevention and detection of illicit trafficking in nuclear and radioactive material is based on the regulation and procedure set up to ensure the control of the nuclear and radioactive materials. The paper covers the national nuclear legislation and the implementation of control through making regulation, licensing and inspection.

1. INTRODUCTION

The Nuclear Energy Act No. 10 year 1997 is the legislative basis for the safety, including nuclear material accounting and control activities as well as security measures on the utilization of the nuclear and radioactive material in Indonesia. Government establishes Nuclear Energy Control Board (BAPETEN) as Regulatory Body having the task to control any activities using nuclear energy. The activities of control are implemented through regulation, licensing and inspection.

Illicit trafficking in nuclear and radioactive materials in the country and across country borders has become serious problem from both nuclear proliferation and radiological hazard point of view. Prevention and detection of illicit trafficking in nuclear and radioactive materials is based on the regulation and procedure set up to ensure the control of the nuclear and radioactive materials throughout their life. Practically, prevention and detection measures in ensuring that nuclear materials do not become the subject of unauthorized use leading to illicit trafficking constitute (1) accounting for and (2) control of nuclear and radioactive materials and (3) physical protection of such materials.

2. VISION AND MISSION

2.1. VISION

The vision of the BAPETEN is to be recognized as high class regulatory body committed to excellence.

2.2. MISSION

To provide safety and peaceful condition in any nuclear energy utilization to the user, wokers, and people, so that nuclear energy can be utilized widely in Indonesia for the welfare and prosperity of all people, without bringing any harm and damage to the environment. To support this mission, BAPETEN has three principal regulatory functions (1) establish regulation; (2) issue licenses and (3) inspect nuclear facilities.

3. NUCLEAR LEGISLATION

National nuclear legislation for nuclear safety, including physical protection and nuclear material control activities in Indonesia is provided essensially in the following level.

3.1. INTERNATIONAL LEVEL

3.1.1. NPT and Safeguards agreement

Indonesia is party to NPT. NPT was signed in 1970 and ratified in 1978 by the Act No. 8/78. Under this treaty, Indonesia negotiated and concluded a safeguards agreement with IAEA in 1980. According to the agreement, Indonesia has accepted IAEA safeguards on all nuclear material in all peaceful nuclear activities within its territory, and also agree to establish and maintain a SSAC of nuclear material subject to safeguards under this agreement. The two principal objective of SSAC are to accounting for and control of nuclear material and to contribute to the detection of possible loss or unauthorized use or removal of nuclear material.

3.1.2. Convention on Physical Protection of Nuclear Material

The Convention on physical protection on nuclear material and facility was signed by Government of Indonesia in 1986 and enacted by Presidential Decree No. 49/86. By signing the convention, Indonesia is responsibe for making arrangement to provide public safety by prevention of theft or sabotage of nuclear material and facility through appropriate measures.

3.2. NATIONAL LEVEL

3.2.1. Act

3.2.1.1. Nuclear Act No. 10/97

In the Nuclear Act No. 10/97 stipulated that the responsibe for the executing and regulatory functions in the field of nuclear energy is separated into two different institutions to avoid the overlapping activities on the promotion and the control in order to improve nuclear safety. The two institutions are under and directly responsible to the President

Pursuant to Article 3 of the Act No. 10/97, the Executing Body shall have task to conduct research and development, general surveys, explorations and explotations of nuclear ore, raw material production for manufacturing and fabrication of nuclear fuel, production of radioisotopes for research and development, and radioactive management.

Pursuant to Article 4 of the Act No. 10/97, the Regulatory Body shall have task to control any activities using nuclear energy through establishing regulation, conduct licensing and inspections. Acording to Article 20. (3) inpection to the facility can be conducted perodically and at any time.

3.2.2. Government Regulation and Pesidential Decree

GOVERNMENT REGULATION

(i) Government Regulation No. 63/2000 on Radiation Safety
This regulation set forth the safety requirement for the worker in using radioactive material and equipment emitting ionizing radiation.

(ii) Government Regulation No. 64/2000 on License for Nuclear Energy Utilization
This regulation set forth the requirement for issue of licenses for nuclear energy utilization. There are three type of licenses for nuclear energy utilization.

(a) license for radioactive material and equipment emitting ionizing radiation
- ♦ Having facility to utilize the radioactive material or radiation sources.
- ♦ Having qualified person to safely handle radiation equipment.
- ♦ Having technical and radiation safety equipment.

(b) License for fissile nuclear material utilization
The following is the license requirement for fissile nuclear material utilization:
- ♦ Having SSAC of nuclear material.
- ♦ Having PPS of nuclear material and facility.

(c) License for nuclear reactor or other nuclear installation
- ♦ Having safety analysis report.
- ♦ Having analysis on environmental impact.

3.2.2.1. Government Regulation No. 13/75 on Transportation of Radioactive Material

The regulation is based on the IAEA regulations for safe transport of radioactive material (S.S No. 6).

3.2.2.2. Pesidential decree No. 76/98 on the Nuclear Energy Control Board

The decree stipulates the main tasks, functions and organisational structure of Nuclear Energy Control Board (BAPETEN). One of the important task of BAPETEN is making rules relating to nuclear energy utilization.

3.2.3. Decree of BAPETEN's Chairman

(i) Decree of BAPETEN's Chairman No. 13/Ka-BAPETEN/VI-99 concerning SSAC
This decree based on the safeguards agreement between Indonesia and IAEA.

(ii) Decree of BAPETEN's Chairman No. 02-Pka-BAPETEN/VI-/99 concerning PPS
This decree based on the IAEA recommendation for physical protection of nuclear material (INFCIRC/225 Rev.1) In this decree stipulated that the establishing and controling responsibility rest on BAPETEN, but the implementation of physical protection of nuclear material is the BATAN’s responsibility.

4. DEVELOPMENT OF LEGISLATION

(a) Gemernment regulation on the safety of Transportation of radioactive material (Final draft).
(b) Gemernment regulation on Radioactive Waste Management (final draft).
(c) Guidance on implementation of physical protection of nuclear material and facility.

First component of regulatory function is establishing regulations, which define the capabilities that need to be satisfied by facility operators to protect against theft which in turn could lead to illicit trafficking. BAPETEN established the Decree on National System of

Accounting for and Control of Nuclear Material (SSAC) based on the Agreement between RI and IAEA on the Application of Safeguards in connection with NPT ratified in the Act No.8 year 1978. BAPETEN also established the Decree on the Guidance for Physical Protection of nuclear material under Chairman Decree of BAPETEN No. 02-P/1999 (adopted from IAEA document INFCIRC/225 Rev.1), as the implementation of the Convention on Physical Protection of nuclear material signed in 1986 and ratified by Presidential Decree No. 49/86.

4.1. LICENSING

The second component of the regulatory function is licensing. An organization or individual intending to utilized nuclear energy must obtain license from BAPETEN. Guidance for applicants is provided in the form of standard format, which contain license conditions. Any utilization of nuclear energy shall maintain physical protection program or security plans. When the applicants meet BAPETEN's criteria for physical protection of nuclear material and facility, a license is granted. By this licensing, BAPETEN is able to know where, by whom, and how the use of nuclear and radioactive materials is conducted.

4.2. INSPECTION

The third component of the regulatory function is inspection. To ensure that legal user's activities comply with BAPETEN regulation and the conditions of their licenses, BAPETEN periodically inspects BAPETEN-licensed facilities. Inspections can be announced or unannounced, and varies in scope and frequency according to the authorized activities. The finding of all inspection are documented in inspection reports. These reports are sent to the licensees to inform them of the BAPETEN findings. When inspections disclose violations of BAPETEN requirement, BAPETEN has a range of enforcement sanctions available. Recommendation stated in the inspection report requires the licensee to correct the problem, take steps to prevent a recurrence of the violation, and advise BAPETEN at the action it has taken. The result of inspection by Bapeten is published periodically and open for public. Some illicit trafficking of nuclear and radioactive materials can be detected during inspections. This detection must lead to prompt information of BAPETEN in order to take actions needed to reestablish control of lost material and to inform the public of any potential dangers.

The purpose of inspections is to nuclear facilities in order to verify whether the condition laid down in relevant regulation or other provition relating to nuclear energy utilization are coplied with. A programme of inspection is conducted prodically every year by BAPETEN and could be performed at any time if necessary.

CONDUCT ON SITE INSPECTION

On-site inspections consist of three stages:

a. Check of the sitability of equipment and its implementation

First, the inspectors must check that the equipment in use is suitable for its assigned function. For example, metal detector.

b. Examination of records

The second, the inspectors must confirm the existence and relevance of the various document:

- procedures and log sheets for equipment;

- priodic operating test, maintenance operations, alarm detected and incident;
- intervention instrucions.

c. Check of the actual performance: check and function test

The third, the inspectors must perform functional test of the equipment. For example, alarm function test.

4.3. CO-OPERATION

In the case of international transfer of nuclear and radioactive material, BAPETEN closely co-operate with Customs Directorate for solving the problem of illicit trafficking.

In international co-operation, Indonesia has taken all necessary measures to prevent illicit trafficking in nuclear and radioactive material. Indonesia has given full support to the IAEA program on combating illicit trafficking of nuclear material and other radioactive materials. In 1999, Indonesia notified IAEA that it accepted the Database on illicit trafficking on nuclear material and other radioactive material, and gave the name of a person who could be contacted directly by IAEA to obtain information concerning illicit trafficking incident. Indonesia also requested the IAEA IPPAS mission to support BAPETEN in reviewing for implementing effectively the existing physical protection systems at the authority and facilities level. IPPAS preparatory meeting has already held in Jakarta on 15 May 2000 and proposed date for the mission agreed on 5–16 February 2001.

QUESTIONS AND ANSWERS

S. Banda (Zambia): What is cobalt–60, the source detected being illicitly trafficked, used for in Indonesia?

D. Sembiring (Indonesia): It is used in radiography and gauging.

T. Kotze (South Africa): On the slide, all incidents of theft were dated 20 October 2000. Is this a typing error?

D. Sembiring: We received the information on that date: the thefts did not all occur on the same date.

MEASURES AGAINST ILLICIT TRAFFICKING OF NUCLEAR MATERIALS AND OTHER RADIOACTIVE SOURCES IN NIGERIA

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Abstract. The paper provides background information on the appropriate measures taken against illicit trafficking of nuclear materials and other radioactive sources in Nigeria. Organizational structure, manpower training and development, and the provision of adequate and necessary facilities and infrastructure for nationwide radiation monitoring programme are discussed in the paper. In conclusion, problem areas and areas where assistance are sort from the Agency were highlighted.

Introduction

The concern worldwide over the illicit trafficking of nuclear materials and other radioactive sources and the associated health hazard to the people and the environment is shared by the Federal Government and people of Nigeria. In order to protect its territories and minimise the danger unauthorized possession poses world-wide, the government in the second quarter of 1998 gave a directive that Nigeria should be registered as a participating nation in the Illicit Trafficking Database Programme being organised by the International Atomic Energy Agency (IAEA), Vienna, Austria.

In response to the government's directive, The Sheda Science and Technology Complex (SHESTCO), Abuja, took the initiative to call a meeting of the Chief Executive Officers of relevant government institutions and agencies. At the Inaugural meeting, a National Committee (NC) was established comprising of all relevant ministries and government agencies, particularly the ones involved in the control and use of radioactive materials such as the Federal Radiation Protection Service (FRPS), Nuclear Research Centres, Federal Environmental Protection Agency (FEPA), Energy Commission of Nigeria, the Nigerian Police Force, the Customs and the Ports Authority.

By August 1998, the committee got Nigeria duly registered with the IAEA as a participating nation and presented a proposal to the Federal Government on how to monitor the entire country particularly the ports of entry in order to participate effectively in the programme.

In order to check illicit trafficking of nuclear materials effectively and efficiently within and across the Nigerian borders, the National Committee gave priority to proper organizational structure, manpower training and development, and the provision of adequate and necessary facilities and infrastructure for nationwide radiation monitoring programme. In addition to the three priority areas, the Committee recommended that a nationwide inventory of nuclear materials, radioactive substances and radiation machines should be carried out and baseline radioactivity levels nationwide should be determined.

For a smooth take-off of the programme after the official registration of Nigeria as a participating nation in the IAEA organised illicit trafficking database programme and to ensure that Nigeria participates effectively, the committee limited its scope in the first phase to the three areas of high priority and decided to consider the other areas subsequently.

The National Committee, in order to ensure adequate supervision and regular review of the programme, decided to:

(i) Establish a Technical Committee to supervise the personnel involved in the monitoring of our territory and coordinate the database programme.

(ii) Hold regular quarterly meetings for the National Committee to review the programme in line with the quarterly review by the IAEA; and

(iii) Organise emergency preparedness programme in order to protect our citizens against radiation hazards during accident and incident situations, most especially the ones resulting from illicit trafficking.

Organizational Structure

The legal framework for the programme was provided by a Nuclear Safety and Radiation Protection Decree No. 19 of 1995 which established the Nuclear Regulatory Authority (NRA) and an Institute of Radiation Protection (IRP) [1]. The decree empowers the NRA to ensure that no project shall be embarked upon, no practice shall be adopted, introduced, conducted, discontinued or ceased and no source shall be mined, milled, processed, designed, manufactured, constructed, assembled, acquired, exported, imported, distributed, sold, loaned, hired, received, sited, located, commissioned, possessed, used, operated, maintained, repaired, transferred, decommissioned, disassembled, transported, stored or disposed of, except the NRA is notified and authorization given in accordance with the internationally accepted Basic Safety and Radiation Protection, in order to ensure radiation safety of the general public, radiation workers, properties and the environment [2].

Pending the time the NRA and IRP are brought to operational existence, the FRPS has been mandated to perform the role of the Regulatory Body while the existing three Energy Research Centres and the FRPS are jointly saddled with the responsibilities of the IRP. All these government agencies and the research centres play major roles in the National Committee on Illicit Trafficking and form the core of the Technical Committee of the National Committee.

Six institutions which are strategically positioned have been selected as Illicit Trafficking Data Collection Centres taking into consideration competence and ability to handle the monitoring tasks. The institutions are the Centre for Energy Research and Training (CERT), Ahmadu Bello University, Zaria; Centre for Energy Research and Development (CERD), Obafemi Awolowo University, Ile-Ife; Federal Radiation Protection Service, University of Ibadan, Ibadan; Sheda Science and Technology Complex, Abuja; Petroleum Training Institute, Warri; and the University of Nigeria Teaching Hospital, Enugu. The selected institutions have Radiation Physicists who can competently handle the nation-wide radiation monitoring and participate effectively in the programme. The Sheda Science and Technology Complex, Abuja is the coordinating centre and Point of Contact pending the time the NRA is properly constituted and becomes fully functional. Reports on illicit trafficking in Nigeria from the Data Collection Centres as well as reports from the Illicit Trafficking Database at the IAEA are sent to the Point of Contact in Abuja.

Manpower Training and Development

The Technical Committee (TC) is to provide adequate supervision for the programme, guide the personnel involved in the monitoring of our territories at the seaports, airports, border posts and hinterland, and develop a sound training programme for all the participants. In addition, members of the TC are to pay regular visits to the monitoring centres particularly at the ports. During each visit, Seminars/Lectures are to be organised for the personnel of FEPA, Police, Customs, Immigration and the Ports Authority in order to increase awareness at the ports of entry and to update functionaries responsible for radiation monitoring at the ports. The responsibility of the TC also includes presentation of progress report and the IAEA reports to the National Committee at its quarterly meetings.

In the first instance, seventy five personnel are proposed to undergo training in Nuclear Safety and Radiation Protection with emphasis on radiation monitoring. Fifteen ports have been identified and in each port, one personnel each from the FEPA, the Customs, the Ports Authority, the Immigrations and the Police would be trained. The three training centres at FRPS, CERT and CERT are expected to handle twenty five trainees each. Since FEPA and the Intelligence Services Department have been working together at the ports of entry in tracking illegal importation of hazardous chemicals and other products that can have adverse effect on the environment, they have been made part of the training team in order to share experience with the trainees.

Provision of Adequate and Necessary Facilities and Infrastructure

In order to establish the necessary infrastructure, 6 seaports, 4 international airports and 5 land border posts selected as monitoring stations are to be equipped with radiation monitoring equipment. They are the seaports at Apapa, Tin Can Island, Warri, Port Harcourt, Calabar and Onne in the River State. The airports selected are Murtala Mohammed International Airport, Lagos; Aminu Kano International Airport, Kano; Nnamdi Azikwe International Airport, Abuja; and Port Harcourt International Airport, Port Harcourt. The land border posts comprises one in each geographical zone namely north east, north west, north central, south west, south east and south-south. More attention is to be paid to busy border posts, such as, Lake Chad border in the north east, Ilela in the north west, Idi-Iroko in the south west and so on.

The six data collection centres are to be upgraded with all necessary modern radiation monitoring facilities. Presently, three of the centres have facilities to detect and determine the type of radionuclides, type and quantity of radiation and provide further testing of any radioactive materials intercepted from unauthorized persons.

Conclusion: Problems and Areas of Need

There is a good organizational structure in place despite the absence of a national nuclear regulatory authority. In fact, the Nuclear Regulatory Authority, when properly constituted and becomes fully functional, should work with the relevant ministries and government agencies that constitute the present National Committee. We have well trained and qualified personnel that can properly manage the programme.

Our problems include

(i) Lack of radiation monitoring equipment at our seaports, international airports and the border posts for quick check for radioactive materials carried into and out of our territories. Consequently, it has been very difficult to successfully track the illicit traffickers; and
(ii) the National Committee does not have enough fund to carry out the committee's programme. This has inhibited the committee from expanding its scope of work.

Assistance is required from the IAEA to enhance efficiency and effectiveness by:

(i) providing radiation monitoring equipment for use at the ports of entry; and
(ii) personnel training, particularly, the Police, Customs and State Security Service in the tracking of illicit traffickers of nuclear materials and other radioactive sources.

REFERENCES

[1] FEDERAL GOVERNMENT OF NIGERIA, Nuclear Safety and Radiation Protection Decree No. 19 (1995).

[2] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, International Basic Safety Standards for Protection against Ionising Radiation and for the Safety of Radiation Source, Safety Series No. 115, IAEA, Vienna.(1996).

QUESTIONS AND ANSWERS

L. Himelsbach (USA): There are six major seaports in Nigeria with radiological monitoring. What challenges does this present to the effectiveness of your programme?

C. Adesanmi (Nigeria): These seaports have yet to acquire monitors, for which we need assistance from the IAEA and its Member States. This lack seriously affects our ability to track down illicit traffickers there.

DEVELOPMENT OF MEASURES TO DEAL WITH ILLICIT TRAFFICKING OF NUCLEAR MATERIALS IN GHANA

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Abstract. Ghana is extending its regulatory framework to cover the control of illicit trafficking of nuclear materials and other radioactive materials. This has become necessary due to global trends in illicit trafficking of nuclear material and other radioactive materials, which have no regard for national boundaries. The measures to be adopted include: a national system for the accountability, control and security of nuclear materials, technical measures to detect illicit trafficking of nuclear materials and other radioactive materials and response to illicit trafficking; legislation and regulation; training; collaboration and co-operation with all stakeholders; and international collaboration with neighbours to ensure cross border control. The objective of the IAEA Code of Conduct on the Safety and Security of Radioactive materials will be pursued to achieve and maintain a high level of safety and security of radioactive sources through the development, harmonisation, and enforcement of national policies, laws, regulations and through the fostering of international co-operation. Appropriate assistance will be sought from International Atomic Energy Agency to make the programme consistent with the requirements of the IAEA Illicit Database programme.

1. INTRODUCTION

The world has now become a global village as such no country can isolate itself from global trends. Reported cases of illicit trafficking in nuclear materials have focused international attention on ways to combat an emerging phenomenon of the 1990s. Of the 324 confirmed cases of illicit trafficking nearly 130 involved individuals trying to illegally sell radioactive materials used in medicine or industry whose unauthorized use or movement poses a danger to public health. Some other cases have involved samples of weapon-grade materials confiscated from individuals [1]. These incidents have raised public and governmental concerns. This has prompted stronger efforts to prevent illicit nuclear trafficking by state authorities, including collaboration and co-operation with international organisation such as the IAEA [2].

IAEA has established the Illicit Trafficking Database Programme and is encouraging all Member States to participate and to report all incidents of illicit trafficking in nuclear materials and other radioactive sources that come to their notice [3].

From the data available from the Regulatory Authority Information System (RAIS) in Ghana, there are 344 highly enriched uranium fuel elements (998.2g) in use in the 30kW Research Reactor, (GHARR-1) and 80 radioactive materials in use in medicine, industry, research and teaching. The reactor has been subjected to safety and security inspections by the radiation Protection Board and safeguards inspections by IAEA annually since it became operational in 1995. On the average there are nine authorised imports of radioactive sources into the country over the past seven years. Summary of category 1and 2 Radiation Sources [4] in Ghana is shown in Table I.

Table I. Category 1 and 2 Radiation Sources

Category	Radionuclide	Quantity	Total Activity(Bq)	Practice
1	Co-60 Cs-137 Ir-192	1 1 1 5 3	1850 E +12 185 E +12 18.2 E +12 26.6 E +12 7.03 E+12	Teletherapy Irradiator Irradiator Brachytherapy Industrial Radiography
2	Cs-137 Sr-90	30 17	1.56 E +11 1.11E + 10	Nuclear Gauging Thickness Gauging

Unlawful use of nuclear materials, through criminal or terrorist activities, may pose a proliferation threat, while unlawful use of radiation sources could impose a radiation risk to the public.

Ghana has therefore decided to establish an effective counter measures against illicit trafficking in nuclear and other radioactive materials, which might pose both proliferation threat as well as radiological risk to the public and the environment.

This envisaged programme will be implemented in phases taking into account governmental developmental priorities and resources to be committed by approving authorities.

2. MEASURES TO DEAL WITH ILLICIT TRAFFICKING

2.1. LEGISLATION AND REGULATION

Ghana seeks to build upon legal framework established to control ionising radiation and radiation sources [5, 6, 7] and expand it to cover combating of illicit trafficking of nuclear materials and other radioactive materials of socio-economic importance. The existing legislation and regulations will be upgraded to provided the legal basis for prevent, intercept and control illicit trafficking

2.2. MEASURES

2.2.1. Technical

The prevention strategy will involve developing a national system for the accountability, control and security of nuclear materials.

Technical measures to detect illicit trafficking of nuclear materials and other radioactive materials and response to illicit trafficking will be developed. The programme will include requesting IAEA assistance to provide detection equipment for nuclear materials screening of vehicles and individuals at borders to detect, locate, measure and characterise smuggling of nuclear and other radioactive materials.

2.2.2. Response to illicit trafficking

Anti-trafficking task force will be established which will include responsible authorities such as Customs, Civil Aviation Authority, Police, Radiation Protection Board. Intelligence and Defence Agencies, and District Assemblies co-ordinating and collaborating to combat illicit trafficking.

3. INTERNATIONAL CO-OPERATION AND COLLABORATION

Appropriate technical assistance will be sought from the IAEA to develop the Technical capabilities to detect, prevent and control illicit trafficking. Training opportunities provided by IAEA will be fully utilised.

Ghana is a country with a population of 18.5 million with 284 000 km^2 area. It has three official bounders points, two harbours and one international airport surrounded by three countries, Togo on the east, Cote d.'Ivoire on the west and Burkina Faso on the north. Tema Port services as a sub-regional shipment point for the West African Region.

It is envisaged therefore to establish regional collaboration with our near neighbours, Togo, Coted'Ivoire and Burkina Faso to ensure cross border control.

4. WORK PLAN

Table 2 gives the short-term work plan for the measures to deal with illicit trafficking of nuclear materials and other radioactive materials. The plan has taken into account the anticipated level of governmental support.

Table II. Work Plan to deal with illicit trafficking of nuclear materials

Activity	Action by whom	Period	Agency Input
1. Upgrading of Legislation and Regulations 2. National stakeholders seminar on illicit trafficking of nuclear materials	Radiation Protection Board Radiation Protection Board	By ending of 2nd quarter 2001 By ending of 3rd quarter 2001	Legislative assistance and review IAEA Provision of relevant materials on subject matter One expert to assist
3.Training of designated staff	Selection of personnel by GAEC	By ending of 2nd quarter 2001	To provide training fellowship/Scientific Visit
4. Development of technical measures	Radiation Protection Board, GAEC Customs Authorities, EPA, Civil Aviation, Military Authority, Police, Ministry of Interior	By 4th quarter 2001	Agency to provide appropriates equipment for detection of illicit materials.
5.Developmenmt of regional Collaborative agreement	Ministry of foreign Affairs of Member states	By 1 quarter 2002	Expert advice

5. CONCLUSION

Ghana is seeking to develop appropriate infrastructure for security of nuclear and other radioactive materials to prevent, protect against, and ensure the timely detection of, the theft, loss or unauthorised use or transfer of these materials within or across its borders in the sub-region.

The objective of the IAEA Code of conduct on the Safety and Security of Radioactive sources [8] will be pursued to achieve and maintain a high level of safety and security of radioactive sources through the development, harmonisation, and enforcement of national policies, laws, regulations and through the fostering of international co-operation.

Appropriate assistance will be sought from International Atomic Energy Agency to make the programme compatible with the requirements of the IAEA illicit Database programme and Code of Conduct on the Safety and Security of Radioactive sources.

REFERENCES

[1] THORSTENSEN, S Safeguards and Illicit Nuclear Trafficking towards more Effective Control IAEA bulletin 38/4 (2000).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY General Conference Resolution, GC (43)/RES/18 on Measures against Illicit Trafficking in Nuclear Materials and Other Radioactive Materials (1999).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY Illicit Trafficking Database Programme.

[4] INTERNATIONAL ATOMIC ENERGY AGENCY Categorisation of Radiation sources IAEA-TECDOC 1091,Vienna, Austria (2000).

[5] Atomic Energy Law, Act 204 of 1963.

[6] Atomic Energy Amendment Law, PNDC Law 308 of 1993.

[7] Radiation Protection Regulations, Legislative Instrument LI 1559 of 1993.

[8] INTERNATIONAL ATOMIC ENERGY AGENCY. Code of Conduct on the Safety and Security of Radioactive Sources.

QUESTIONS AND ANSWERS

C. Adesanmi (Nigeria): Why was caesium–137 listed as both category 1 and 2?

C. Schandorf (Ghana): The caesium–137 listed under category 1 is a single source activity of $18.2x10^{11}$ whereas that listed under category 2 represents the average activity for 30 nuclear gauges.

G. Bunn (USA): Have you considered an IPPAS expert visit while you are undertaking all these activities to improve PP of nuclear and other radioactive material?

C. Schandorf: This assistance may be considered if a full assessment is made of the present and future use of nuclear material in Ghana. There are interested groups considering the nuclear power option for energy needs and a higher power research reactor for radioisotope production and other research needs.

SAFETY AND SECURITY OF RADIOACTIVE MATERIALS: THE INDIAN SCENARIO

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Abstract. Radiation sources are being extensively used for various applications in India. A large number of sources are used in different fields. Despite strict control measures, accidents/incidents do occur. As a result of these accidents/incidents some of the sources have been lost and could not be recovered. Accidents which have occurred in India during the period 1986–1999 have been compiled and their probable causes analysed in this paper. Lessons learned from incidents have been taken into account to upgrade the safety measures. More emphasis is given on training and awareness programmes. System of source registry has also been strengthened.

1. INTRODUCTION

There has been a phenomenal increase in the use of radiation sources in diverse fields such as medicine, industry, agriculture, research and teaching, in India and elsewhere. Though the radiation safety record in these applications has been good, there have been a few incidents/accidents during transport/use of radioactive materials. Current status and various aspects of regulatory control to ensure safety and security of radioactive material including incidents of missing/orphan sources in India, are discussed in this paper.

2. REGULATORY INFRASTRUCTURE

Government of India enacted the Atomic Energy Act in 1962 to provide a regulatory infrastructure for control and use of radioactive materials and radiation sources. Radiation Protection Rules, 1971, were promulgated under this Act and Chairman, Atomic Energy Regulatory Board (AERB) was appointed as the Competent Authority to enforce these rules. Radiological Physics & Advisory Division (RP&AD) of Bhabha Atomic Research Centre provides technical and executive support to AERB in the implementation of the regulations in the non-nuclear applications of radiation. Under the Rules, the Competent Authority has issued regulatory surveillance procedures for different applications.

Various codes and guides on regulatory procedures relating to specific applications of radioactive material have also been issued by the Competent Authority. As per the procedures, each practice and source requires specific authorisation. The pre-requisites for the procurement of radioactive material for various applications are: (a) Approved source and equipment, (b) Approved installation, (c) Provision of an exclusive safe and secure storage facility for radioactive material when not in use or pending installation, (d) Trained manpower duly approved by the Competent Authority, (e) Radiation monitoring devices(area and personnel), (f) Emergency preparedness and (g) Commitment from the licensee for safe disposal of disused/decayed sources.

When the applicant complies with all the prerequisites for source procurement, the authorisation is issued with specific terms and conditions. Each source replacement, sale, transfer, transport and disposal requires a specific authorisation.

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* Present Address: Atomic Energy Regulatory Board, Niyamak Bhavan, Anushaktinagar, Mumbai-400 094.
**Retired.

In India, sources for all applications, are allowed to be imported only after obtaining prior permission from the regulatory authority.

The user is required to submit a safety status report with respect to the use of all radiation sources including physical inventory of the sources, at regular intervals to the Competent Authority as well as to RP & AD, BARC. As for the spent/disused sources, the user is required to make sure that the sources are sent back to the original supplier and an undertaking to this effect is to be submitted to the Competent Authority, before the authorisation/licence is issued. Complete computerised inventory of all radiation sources possessed by various users is maintained by AERB and RP&AD and updated regularly. Current data on number of sealed sources in various applications is shown in Table I.

Table I. Number of sealed sources presently in use

Application	Number of sealed sources/units
Industrial Radiography	1100
Nucleonic gauges	6500
Well logging sources	500
Brachytherapy units	102
Teletherapy sources	215

3. INCIDENTS OF MISSING/ORPHAN SOURCES IN VARIOUS APPLICATIONS OF RADIATION SOURCES

In spite of strict regulatory procedures and inventory control in force, there have been a few cases of accidents/incidents involving missing/lost sources which might have ended up as orphan sources. The probable causes of these incidents are (a) unsecured temporary storage pending installation, (b) temporary suspension of the use of sources, (c) unsecured storage after decommissioning, (d) poor quality of labelling and marking on packages during their transport, (e) improper packages used for their transport, (f) improper temporary storage prior to disposal of sources, (g) illicit procurement of imported sources and (h) mobile/portable industrial radiography devices left unattended. The incidents which occurred during 1986–1999 in various applications of radioactive sources are summarised in the following sections.

3.1. INDUSTRIAL RADIOGRAPHY

In India, there are about 400 institutions spread among private and government undertakings engaged in industrial gamma radiography throughout the country. Remote operated equipment, imported as well as those indigenously fabricated, form the major support base for the use of ^{192}Ir and ^{60}Co sources. There are nearly 1100 radiography sources including 75 ^{60}Co units. These sources are used in about 500 radiography sites in India. About 800 radiography devices are annually transported for source replacement and movement from one radiography site to another by different modes, such as air and road. There have been 43 radiation accidents in this field including loss of sources during use, storage and transport. Eighteen incidents relate to de-coupling or source getting stuck up in the guide tube of exposure device. Although most of them were of minor nature, a few of them resulted in radiation exposure to the exposed individuals. Analysis of these incidents reveals that there were 25 cases of missing radiography sources/equipment during 1986–99 out of which 28% (7 cases) relate to loss of sources due to improper transport, 20% (5 cases) relate to negligence of the operator during use and 52% (13 cases) relate to theft from the storage facility at the radiography sites. However, 13 sources could not be traced. In all the cases where the source could not be traced, extensive search and interrogations of the concerned staff and public were conducted before abandoning search operations so as to ensure that the source would not reach the hands of members of the public. In these cases, the chances of tracing the source are low mainly due to the delay in noticing/reporting the loss. From the above analysis, it is very clear that improper storage or transport coupled with carelessness on the part of radiography personnel are the main reasons for the source loss. Among the possible incidents/accidents, loss of radiography source needs to be viewed seriously because the source can readily get into the hands of members of public who may be totally ignorant of the hazards associated with radiation sources. The lost source, if not traced quickly, can lead to serious consequences. Analysis of these incidents is shown in Table II.

Table II. Incidents/Accidents in Industrial Radiography

Nature of Incident/Accident	Number of cases
Source de-linked from drive cable during equipment operation	18
Loss of source during transport	7
Loss of source due to negligence of the operator during use	5
Theft of the source from its storage place	13

3.2. NUCLEONIC GAUGES/WELL LOGGING DEVICES

There are 6500 nucleonic control systems used in about 1100 institutions. ^{60} Co and ^{137}Cs sources are widely used in nucleonic gauges for process control purpose, ^{241} Am is used in thickness gauges and smoke detectors. Neutron sources such as ^{241} Am-Be and gamma sources such as ^{137}Cs are widely used for well logging. There are more than 500 devices using Neutron & gamma sources for well logging at present.

A total of sixteen incidents have taken place during the period involving the well logging devices. Of these, in 50% of the cases the sources were successfully recovered and the remaining sources (five^{137} Cs and three ^{241}Am-Be) were abandoned since these could not be fished out of the well. These wells, with abandoned sources, were plugged with appropriate thickness of concrete.

Sixteen incidents involving nucleonic gauge sources were reported including 12 lost sources, out of which 3 sources were recovered. The recovered sources included three well logging sources stolen from the storage room and these were finally recovered from a river into which they were thrown. This was a deliberate act of sabotage. In three incidents, the sources were involved in fire. Incidents in the process control industry using nucleonic gauges including well logging sources are shown in Table III.

Table III. Incidents involving Nucleonic Gauging Devices

Nature of Incident/Accident	Number of cases
Theft of sources	1
Fire incidents	3
Loss of source in storage and transport	12
Loss of well logging sources in the wells	16**

** 8 sources were fished out of 16.

3.3. MEDICAL RADIOTHERAPY SOURCES

Radiotherapy includes brachytherapy and teletherapy. There are 102 brachytherapy units operating in India. There have been 9 incidents of lost sources out of which 5 sources could not be recovered. After 1990 no incident/accident was reported as majority of the centres have switched over to remote/manual afterloading techniques where source security is effectively ensured. The causes of these incidents are mainly improper handling and violation of safety norms. No accident was reported in teletherapy centres during last 15 years.

4. SAFETY AND SECURITY OF RADIOACTIVE MATERIALS

Instances of theft of radioactive sources and equipment and illicit trafficking of radioactive materials have been brought to the notice of concerned authorities in India and other countries. This problem has been addressed internationally in meetings and conferences which were organised to highlight the seriousness of the problem and evolve preventive measures. In India, a two-day workshop was organised during April 14–15, 1999 at BARC with participants from various organisations representing the central and state governments such as Airport Authorities, Port Trusts, Intelligence Bureau, Excise and Customs, Border Security Force, Coast Guard and Civil Defence College.

As a follow-up of this workshop, a two day training programme has been planned for personnel drawn from the above mentioned organisations, in order to familiarise them with radiation protection procedures, identification of radioactive package, detection of radiation using appropriate radiation measuring instruments, detectors etc. Three such training programmes have been organised in Mumbai and New Delhi specifically for the customs officials. More such courses for above agencies are planned at their training centres throughout India.

5. CONCLUSION

A well-established regulatory infrastructure coupled with regular surveillance procedures and inventory of all the sources in use and disuse will minimise the incidents of orphan sources. Such an inventory should be updated constantly. Procedures should be devised for maintaining strict control in respect to safe and secure storage of radioactive material, specially when the sources are used in public domain e.g. industrial radiography. Regular training/awareness programmes for users, maintenance staff/administrators; periodic surveillance of practices and a regulatory procedure to obtain a periodic inventory and radiation safety status from the user, say, once in 6/12 months, will go a long way in ensuring safety and security of the sources and in minimising chances of their loss.

QUESTIONS AND ANSWERS

S. Fernandez Moreno (Argentina): a) What measures are you adopting to keep track of disused sources? b) Was the theft of radioactive sources in the 13 reported cases committed with malice aforethought?

A. Kumar (India): a) All disused sources are disposed of at BARC and those imported after 1995 are to be sent back to the country of origin. b) The theft in all 13 cases was possible because of improper storage at the radiography site. Sometimes it was taken along with other material from the storage room.

S. Banda (Zambia): Are any measures taken to prevent the well-logging sources that are not fished out of the wells from landing in the wrong hands or being put to clandestine or non-targeted use?

A. Kumar: Attempts are made to recover the logging sources. Otherwise, they are buried in the well, which is then covered with concrete and not used for further drilling. Hence, there is no chance of diversion.

N. Kravchenko (Russian Federation): a) Are customs or border police responsible for checking NM at the border? b) What equipment is used?

A. Kumar: a) On land borders paramilitary security forces and customs personnel and at airports and seaports customs personnel control movements of radioactive material.

REGULATORY CONTROL OF RADIATION SOURCES IN BANGLADESH

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Abstract. Nuclear and radiological practices are doing immense benefits to society but like all other practices nuclear and radiological practices also have risks. Necessary laws and regulatory bodies exist in many countries for a long time to control and keep the risks within acceptable limits. Bangladesh, though late, also enacted laws and initiated to implement the law. In this paper are presented the regulatory aspects of the radiation sources safety in Bangladesh, based on the Nuclear Safety and Radiation Control Act and Rules. The radiation protection infrastructures and procedures are described as well as their functioning for the implementation of relevant activities such as licensing, regular inspection and enforcement. The issue of the security of radiation sources is dealt in close relation with the preparation and use of the inventory of all radiation sources in the country. This paper outlines the methodology of regulatory control exercised by the BAEC for safe use of the radioactive materials and the radiation generating equipment in the country.

1. INTRODUCTION

In Bangladesh, ionizing radiation has been used extensively in various economic activities and in research and education. Bangladesh have been firmly committed to the beneficial and peaceful applications of ionizing radiation in medicine, industry, agriculture and research since its emergence in 1971. Different radioactive sources, such as Co-60, Cs-137, Sr-90, C-14, H-3, Kr-85, I-131, Ir-192, Tc-99m, Am-241, Am-Be neutron sources and others with different activities are imported annually and used in different applications. The country now has a 3 MW research reactor, three irradiators, two medial linear accelerators, neutron generators, van de Graaff accelerator and modest use of ionizing radiation sources in health service, industry, construction, mineral exploration, agriculture, research and education and in other economic activities. The country is also considering building a nuclear power plant. The misuse and/or uncontrolled use of nuclear and radiological practices, however, will put the professionals, patients, occupational workers, public and the environment at risk. Consequently, any country using ionizing radiation and radioactive material must ensure that they are used safely. In order to achieve this goal a country must establish appropriate national infrastructure related to radiation protection and safety. This requires appropriate regulatory mechanism together with enforcement ability. The national infrastructure adopted in a country will depend on the actual needs of the country, the size and the complexity of the regulated practices and sources, as well as on the regulatory tradition in the country. Necessary laws and regulatory bodies exist in many countries for a long time to control and keep the risks within acceptable limits. Bangladesh, though late, also enacted laws and established regulatory system to control the practices. With the promulgation of Nuclear Safety and Radiation Control (NSRC) Act and Regulations, the overall activities pertinent to nuclear safety and radiation protection have considerably increased in the country. Bangladesh Atomic Energy Commission (BAEC) is legally responsible for developing and strengthening the necessary radiation protection infrastructure in the country through the effective enforcement and implementation of regulatory requirements, criterion, obligations, guiding codes, etc. in order to save man and the related environment from the deleterious effects of ionizing radiation. The paper focuses on the country’s regulatory status on the safety and protection of the practices.

2. LEGISLATION

The first step in achieving adequate control of safe uses of ionizing radiation and radioactive material in Bangladesh is establishing appropriate national legislation, which provides a foundation for a regulatory program. The legislation bases on general principles of radiation protection of people and safety of radiation sources.

2.1. The Bangladesh Atomic Energy Commission (BAEC): The Bangladesh Atomic Energy Commission, a statutory body, was formed by the Presidential Order no. 15 of 1973. This order provides only promotional power to the BAEC.

2.2. Nuclear Safety and Radiation Control Act: After long and concerted efforts, the Nuclear Safety and Radiation Control (NSRC) Act-93 (No. 21 of 1993) was promulgated on July 23, 1993 "to provide for ensuring nuclear safety and radiation control" in the country [1]. The Act confers all necessary powers to the BAEC to regulate the uses of atomic energy, radiological practices and the management of radioactive wastes.

2.3. Nuclear Safety and Radiation Control Rules: Pursuant to section 16 (1) of the NSRC Act, the BAEC formulated draft rules in February 1995. The NSRC Rules, after the review by the concerned ministries/establishments and the vetting of the ministry of Law, Justice and Parliamentary Affairs, were finally notified in the Bangladesh Gazette on September 18, 1997 [2]. The rules essentially incorporated all the important requirements of the IAEA Basic Safety Standards (IAEA BSS No.115, 1996) [3].

3. REGULATORY AUTHORITY

The national legislation (NSRC Act) nominates a national Regulatory Authority, which is given responsibility for regulating any practices involving sources of radiation. The Bangladesh Atomic Energy commission (BAEC), vide Section 3 of the Act, is the Competent Authority to implement the regulatory control in the country. This provision has been further illustrated in the Rules. In order to implement the NSRC Act and NSRC Rules, BAEC has created a division named Nuclear Safety and Radiation Control Division. This division is headed by a Director who reports to the Commission through a member of the Commission.

The Nuclear Safety and Radiation Control Division (NSRCD) vide Rule 4, is responsible to the BAEC for facilitating the implementation of the provision of Rules. The NSRCD is still in its early formative stage. Necessary manpower has still to be recruited and adequately trained manpower to meet the growing demand of regulatory responsibilities in the field of radiation safety.

4. REGULATORY CONTROL

The main elements required for control of radioactive and radiation sources in Bangladesh include authorization for receipt, possession, use, transport, import, export and disposal of radioactive materials.

- Authorization to possess radioactive and radiation sources.
- Authorization to transport of radioactive sources.
- Authorization to import and export of radioactive sources.
- Authorization to dispose and storage of radioactive materials.
- Periodic checks of physical security of radioactive sources.

- Periodic checks of accountability of sources and record.
- Periodic checks of inventories of radioactive sources.
- Occupational exposure limits.
- Assessment of public exposure.
- Health surveillance of radiation workers.
- Emergency response and preparedness, etc.

Based on NSRC Act and Regulations, a program of licensing and inspection is prepared. For the licensing purposes the legal person declares through a special application form all necessary information to regulatory authority. This information contains the characteristics of the radiation sources, the purposes of the uses, the aggregate form of the source, the countermeasures in the cases of an accident etc. A detailed information needed also for the person responsible for the safety, like his/her qualification and working experience. Only after a careful examination of the data and inspection in situ, the BAEC decides to issue or not the license. The license is valid for a limited period of time. Concerning inspection, the regulations give the rights to inspectors for exerting the duties and enforcement, which comes from the legislation. Inspectors are in charge to inspect and to control in details the performed activity, to control all documents and registers, to take samples and to suspend the activity when exist sufficient data for radiological hazards toward workers, public or environment. Based on inspector's reports, BAEC can suspend or revoke the issued licenses toward different radiation activities with real or potential hazard.

Notification and inspection of all radiation users of the country have just been completed. Licensing of the facilities as per the law and rules have also been initiated and processing. The frequency of inspections (six months to five-yearly) and renewals of license (one yearly to five yearly) for each type of the practices will be decided based on the specific risks involved and availability of manpower and resources.

5. INVENTORY OF RADIOLOGICAL PRACTICES

Accounting and safety assessment of all sources is the primary task and, essential for an effective regulatory program. But as late as April 1999, BAEC had information on the important or critical practice like-radiotherapy, nuclear medicine, industrial radiography etc. constituting only 10% of the estimated sources. In order to have comprehensive data based assessment of all radiological practices in the country, a nation wide survey/inspection program was initiated on May 15, 1999[4]. The surveys have been completed on March 15, 2001. Inventory of radiological practices is shown in Table I. The information received so far from the survey and inspections are quite revealing. There is hardly any facility, in the strict sense of the Rules, can be declared as fully satisfactory. The personnel monitoring program dose not exist in most of the radiation facilities [5–7]. The concept of the Quality Assurance (QA) program is a new word to most of the license holders. Findings of the survey have been communicated to the inspected facilities as well as the concerned ministries and Establishments.

6. IMPLEMENTATION OF THE RULES

The rules (NSRC Rules-97) have been notified and put to force on September 18, 1997. It took considerable time to shake off the initial inertia and motivate people towards licensing and compliance of the safety and regulatory requirements. The licensing activities have been geared up from the middle of 1999 and are gradually gaining momentum, as may be seen in figure 1. The NSRCD, till 31st March 2001 has received 194 license applications and of these 156 licenses have been issued.

Inspection is one of the major aspects that strongly affect safety and security of radioactive materials. The personnel authorized by the Regulatory Authority carries out periodic announced and unannounced inspection of radiation facilities based on the standard checklists available for each radiation practice. In case of non-compliance with stipulated regulatory provisions, appropriate regulatory actions are enforced according the nature of violations and severity of the hazards.

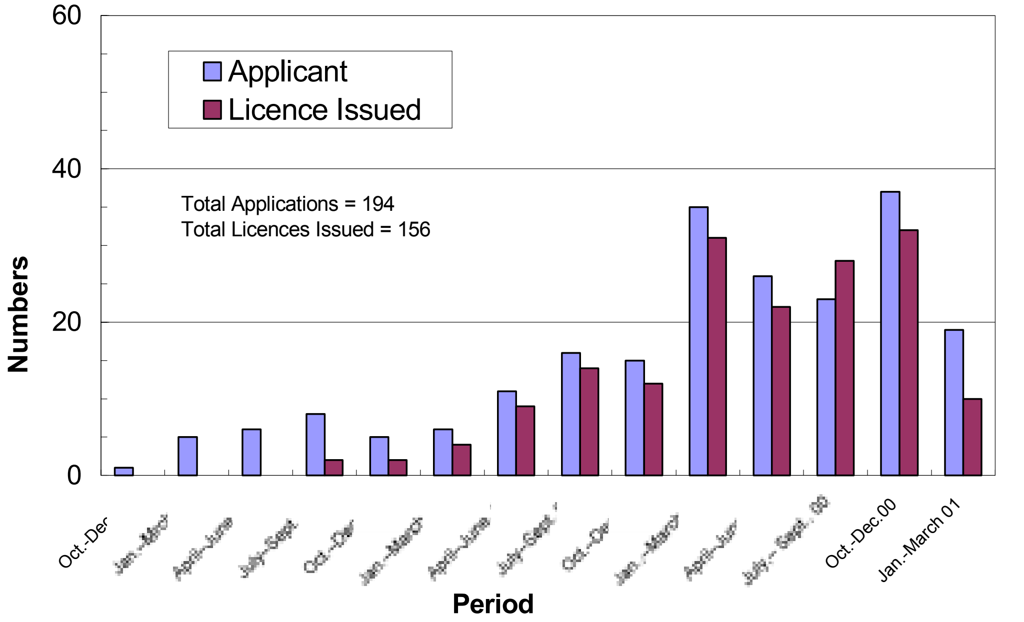

FIG. 1. Status of license applications received and number of licenses issued for the period of October 1997-March 2001

7. SECURITY OF RADIOACTIVE MATERIALS

The security of radioactive materials is the main prerequisite to provide a good practice with radiation sources. The licensee has the primary responsibility for the safe use, control and security of the licensed radioactive materials. It is his responsibility to prepare and maintain a detailed accountability system that includes complete records for all the licensed sources. The record should include description of each source or radioactive material for which he is responsible, such as its activity, quantity and form, its use location and movement and all measures that have undertaken to ensure security of the source. The licensees are obliged that radiation sources are adequately marked to indicate radioactive material and to provide their storage in a secure location such that people in the vicinity are not inadvertently exposed and that it is unlikely unauthorized persons could remove the sources. The security of the radiation sources is provided by their periodic control performed by the regulatory authority.

8. CONCLUSION

In Bangladesh, an adequate regulatory infrastructure is in existence to ensure radiation safety in various applications. The principle objective of the regulatory infrastructure is to achieve the desired level of safety of radiation sources and the protection against ionizing radiation, so that the risks to radiation workers, public and environment are well within the internationally acceptable limits. Country wants to achieve the safety standards compatible with the BSS requirements. But to accomplish this goal, adequate financial and administrative supports to train and motivate the concerned persons, and to create necessary infrastructure and facilities will be needed. Nevertheless, regulatory program is constantly reviewed taking into account experience, newer national/international standards etc. and every effort is made to make the program more effective.

Table I. Summary of the status of radiological practices in Bangladesh (as of March 2001)

Practices	Device/source	Total No. of facilities	Total No. Facilities Inspected	Total No. of Facilities Licensed
Radiodiagnostic (Radiography, mammography, CT, etc.)	X ray generator	2150	2150	100
Radiotherapy (Brach (Brachytherapy, teletherapy, megavoltage therapy)	Deep therapy X ray machines (<300 kV), Co-60, Cs-137, Ir-192	9	9	6
	Liner accelerator (6 MV and 10 MV)	2	1	-
Non-destructive testing (NDT)	X ray generator, Ir-192, Cs-137, Co-60	13	13	8
Nuclear Medicine	I-131, I-125, Tc-99m, Sr-90, Co-57, Tl-201	16	16	13
Industrial irradiator	Co-60	3	3	1
Gauge and Well logging	Cs-137, Co-60, Am-Be, Sr-90, Kr-85, C-14	17	17	8
Isotope Production	I-131, Tc-99m, Sc-46, Ir-192	1	1	1
Calibration	Cs-137, Am-241, Ra-226, Co-60, X ray generator	1	1	-
Waste storage facility	Radioactive wastes (solid and liquid), spent sources, etc.	2	2	-
Research, Training and Education	3 MW research reactor	1	1	-
	3 MeV van de Graaff accelerator	1	1	-
	14 MeV Neutron generator	1	1	-
	Cs-137, Co-60, Sr-90, C-14, H-3, Cf-252, Pu-239, Ni-63, Am-Be neutron sources, etc.	12	12	5
Analytical services (XRF)	X ray generator, Cd-109	1	1	-
Diffraction	X ray generator	2	-	-
Agriculture	P-32, Zn-65, Am-Be neutron source	1	1	-
Luggage scanning	X ray generator	2	-	-
Smoke detectors	Am-241	1	1	-
Gas mantle	Thorium nitrate	3	3	-
Misc. (trade, import, etc.)		14	14	14

REFERENCES

[1] NSRC Act No. 21 o 1993, Bangladesh Gazette Extraordinary, dated 22nd July 1993.
[2] NSRC Rules-97 (SRO NO205-Law/97), Bangladesh Gazette Extraordinary, dated 18th September 1997.
[3] International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, IAEA SS No. 115, IAEA, 1996.
[4] Regulatory surveys/inspections of the ionizing radiation sources in Bangladesh, NSRC/RS/MR/BD/2001, Volume 1 (2001).
[5] A.S. Mollah, "Status of radiation protection and quality assurance in radiodiagnostic facilities in Bangladesh", Proc. of the IAEA/BAEC National workshop on radiation protection and quality assurance in radiodiagnostic, Dhaka, April 18–21, 2000.
[6] A.S. Mollah, "Status of radiation protection and quality assurance in radiotherapy practices in Bangladesh", Proc. of the IAEA/BAEC National workshop on radiation protection and quality assurance in radiotherapy, Dhaka, July 7–12, 2000.
[7] A. S. Mollah, "Status of radiation protection and quality assurance in Nuclear Medicine in Bangladesh", Proc. of the IAEA/BAEC National workshop on radiation protection and quality assurance in Nuclear Medicine, Dhaka, August 21–26, 2000.

QUESTIONS AND ANSWERS

C. Himmelsbach (USA): Has your country experienced any illicit trafficking?

A. Mollah (Bangladesh): No.

LESSIONS LEARNED AND FUTURE NEEDS
(Session 10)

Chairperson

L. VAN DASSEN
Sweden

Keynote Address

LESSONS AND RECOMMENDATIONS FOR NATIONAL EFFORTS AND INTERNATIONAL COOPERATION IN THE FIELD OF COMBATING ILLICIT TRAFFICKING OF NUCLEAR AND RADIOACTIVE MATERIALS

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Introduction

A couple of weeks ago I was asked by the organizers whether I would be willing to deliver the final presentation for this conference. I was proud to receive this question and did not hesitate to answer "yes". The issues in the field of combating illicit trafficking have been with me for some time, and together with Mr. Paul Ek and associates of the Swedish Nuclear Non-Proliferation Programme- both in Sweden and abroad- I had the privilege to discuss many of the aspirations and topics for this conference. By then we all lived in the expectation and hope that Paul would complete this conference and that would have been a tribute to his long career and commitment to nuclear non- proliferation.[1] It is against this background that I want to underline that I stand humble before the task of drawing a number of conclusions from the work that has been presented over the past five days. But even if I speak in place of Paul, my objectives are no less ambitious than his would have been.

To my mind, it has been a very rich and successful conference. It is impossible for me to summarize of synthesize the essence across all the issues, problems, perspectives and solutions presented during the conference. However, I think it is remarkable how the presentations have at the same time been very diverse and encompassing while also carving out a large piece of common understanding. In this respect, states on all continents have addressed the illicit trafficking issue and have struggled and continue to struggle against it. But not only states are active. International organizations are also putting large resources into creating networks of cooperating and collecting and disseminating information among each other and Member States.

The need for aspirations

In spite of the wide and encompassing area that has been covered I think there is a large amount of agreement among the persons, agencies, state representatives and international organizations present here today. This may of course be misleading considering the nature of the problem. Combating illicit trafficking is fighting an enemy that is hard to define, hard to detect, often remains invisible and whose ambitions remain uncertain and always incomprehensive to us. Uncertainty makes us bewildered and also inclined to go separate

[1] The present text and words are (as stated) hardly mine alone. Mr. Paul Ek had intense discussions and deliberations with many people active in the field of non-proliferation and illicit trafficking of nuclear materials. Prior to this conference, Sweden launched a study on illicit trafficking that included experts from Sweden, (Mr. Paul Ek and Dr. Göran Steen), Latvia (Mr. Andrejs Salmins) and Norway (Mr. Sverre Hornkjöl)**: Report on Combating Illicit Trafficking, SKI Report 00:3, January 2000**. Based on experiences regarding the applicability of these recommendations, two documents (one by Dr. Göran Steen and another by Mr. Paul Ek and Mr. Lars Wredberg) were written to serve as background information for the intended keynote address by Mr. Ek. For the current keynote address I have been inspired by these texts, leaving room for suggestions and inspirations from the presentations and developments of the conference. For the content and the presentation only I am responsible.

roads. However, in this case there is hope that the uncertainty can make us choose to develop common means and measures to alleviate this insecurity and threat posed by illicit trafficking.

If it is correct that this conference has created a larger field of common understanding, then I think it would be an error of potentially historical dimensions. If we did not try to use the atmosphere, knowledge and skills gathered here today to look ahead in order to improve things outside the boundaries of this conference room. There is nothing that tells us that illicit trafficking of nuclear and radioactive substances is a problem that will and must remain with us for all times. With the appropriate efforts and improvements the currently malevolent or ignorant persons or groups who for whatever reason try to acquire nuclear or radioactive materials may find out that it is unprofitable, unhealthy, dangerous and unnecessary to smuggle and acquire these goods. Even if the road to this destination where there is no longer a threat posed by illicit trafficking — seems long and troublesome — that is nevertheless the road we have to lay the foundations for. And only if we have high aspirations can there be a high outcome. Too modest ambitions, on the other hand, will be self-defeating and maybe even make things worse due to the pessimism that can be the immediate consequence.

In the following I will deal with a number of possible improvements. I can say that they fall in two broad but related categories. The first refers to changes and improvements in the work of international organizations and primarily the IAEA. The second refers to changes needed at domestic levels in terms of the legal and regulatory frameworks. Having said this, it should, nevertheless, be pointed out that the domestic and international domains cannot be understood in isolation. Rather it is necessary to point out that it is bridges between Member States and the IAEA that should be improved. I will return to this point toward the end.

The limitation of existing frameworks

For all the problems that the illicit trafficking of nuclear and radiological materials has lead to over the last decade, there is one quality in the matter that we can choose to appreciate. Illicit trafficking is an issue that touches upon a number of the existing mechanisms used to control the application, and uses of nuclear technologies. It is to some extent possible to say that if these measures had universal coverage and were complete in terms of their constructions — then that would eliminate the possibility for there being a phenomenon like illicit trafficking. Let me shortly address these four mainstays or mechanisms of control where there is a presence or use of nuclear technologies. That may make my point clear at a later stage.

I will start with ***physical protection,*** as it is probably the measure that is given most credence in the struggle against illicit trafficking. If all materials were kept under surveillance and control in a manner where there can be no theft of deviations then we may assume that there will be no room for illicit trafficking. However, the Convention on Physical Protection of Nuclear Materials only covers materials in international transport. Materials in national transport, use or storage are not covered. For the remainder, the non-binding document INFCIRC/225 and advice from IPPAS is of support to those states who *choose* to use this opportunity to secure their nuclear materials.

A second measure of great importance is safeguards. If all materials are counted registered and files in terms of their quantities, location and relocations, then there should be no room for dislocations and deviations. However, this overlooks the fact that IAEA safeguards only apply to Non-Nuclear Weapon States and signatories of the NPT, or, that adhere to the older INFCIRC/66 safeguards agreement. The Nuclear Weapon States fall outside the obligations and so do others who have not signed the NPT and accepted the implementation of safeguard arrangements. In spite of the broad coverage of IAEA safeguards, it pertains to fissile materials and thus many radioactive materials of a lower proliferation-prone dignity fall outside this coverage.

Thirdly, ***nuclear safety*** also plays a role but certainly a less significant one than physical protection and safeguards. It is relevant to mention nuclear safety in the sense that the safe operation of nuclear installations provides stability and order, whereas unsafe operation threatens routines and procedures and this increases the risk of deviating activities and materials. In this field, the IAEA has extensive competencies to address the safety situation levels.

Fourth, it is important to point to export controls as a measure against illicit trafficking. A rigorous export control system keeps track of exporters and recipients and if embedded in an international export control framework, the information exchange may be able to restrict the access to strategic goods for actors with the malevolent intentions. With export controls in place, states generally have a better understanding of the technological capabilities of companies on their territories just like they can estimate the potential attraction that this offers abroad. In this export control field the IAEA plays a minor role, as the important forum for multinational export control systems is the Nuclear Suppliers Guidelines.

Pulling the strings to tie a stronger knot

With respect to the issues and insufficiencies pointed out above, it would be longish and counterproductive to wait for the treaties and agreements underlying activities in physical protection, safeguards, nuclear safety and export controls to become fool-proof so to speak. The illicit trafficking issue is here and with us now and the question is rather whether there is a way by which the mentioned weaknesses can be turned into strengths instead. Illicit trafficking is an issue that cuts across many of the areas of competence in the IAEA. That makes the efforts to reduce and eliminate illicit trafficking a complex undertaking.

What this calls for is body within the IAEA that can draw on the means available in safeguards, nuclear safety, export controls and physical protection in order to take concrete steps against illicit trafficking. This body which one tentatively could call illicit trafficking advisory group, or "ITAG" could provide and guidance to states on a broad range of issues.

First of all, "ITAG" would be served well by a database that covers more information on more illicit trafficking cases. On the basis of this information and in cooperation with other organizations that also operates illicit trafficking databases. It would be possible to *analyze new trends and developments.*

Secondly, the "ITAG" could compare and draw lessons from the laws, regulations and procedures produced in various states in order to *define successful standards for legal frameworks* as well as estimating what is required for ensuring the effective implementation of laws and regulations.

Third, the coordinating body within the IAEA could play a major role with respect to the assistance given from donor countries to recipient states in the field of illicit trafficking. This would alleviate some of the current problems where some efforts are duplicated while others are neglected.

Existing analyses of the procedures, laws and implementation aiming at combating illicit trafficking at state levels make it obvious that there are wide differences, in spite of ambitions to accomplish the same objective. The illicit trafficking problems are many, facetted and therefore also need broad responses. Yet, at the same time, as pointed out by Mr. Reynolds in his presentation, it is necessary to make estimates of the risk. These risk assessments may come to different conclusions as time passes and it would be necessary to make states and national agencies aware of changes and new trends.

In the field of international cooperation, states are always slow in granting competence to common institutions. However, an abundant amount of examples show that states little by little can accept international advice, guidance and even prerogatives to demand certain things of state activity. Within the International Civil Aviation Organization, ICAO, the slow realization of the dangers arising from too many standards for aviation safety have made states pass competencies to ICAO. From an initial advisory role in some fields, ICAO may today demand states to take certain steps and follow norms. This is a major prerequisite for the aviation safety that exists today.

In the field of illicit trafficking it is both possible and desirable to strive for a similar development. If the suggested ITAG in an initial stage had advisory functions, then its success and challenges would determine whether and when there would be room for a decisive role.

In all this I will conclude by underlining one point I made in the beginning. It is neither the IAEA, a body within the IAEA or the Member States that can be singled out as the key word in my suggestion: Instead, it is the bridges between international institutions and states that are the keywords. The improvement of international organizations and the strengthening and aligning of state regulations and practices are in fact phenomena that take place every day all over the world. However, the circle and process has to start somewhere and for this a push is sometimes needed. Such a push can be made by this audience; if we dare to realize that we cannot do sufficiently well separately can be achieved in cooperation and by means of an international forum.

POSTER SESSION

ITRAP — INTERNATIONAL LABORATORY AND FIELD TEST SITE EXERCISE FOR RADIATION DETECTION INSTRUMENTS AND MONITORING SYSTEMS AT BORDER CROSSINGS

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Abstract. Illicit trafficking in nuclear materials (nuclear criminality) has become more and more a problem, due to the circulation of a high number of radioactive sources and the big amount of nuclear material. The International Atomic Energy Agency (IAEA) has reacted on this actual problem by setting up a new program to fight against nuclear criminality and has suggested a pilot study for the practical test of border monitoring systems. Co-ordinated by the Federal Ministry of Economic Affairs and Labour, the Austrian Government financed the pilot study ITRAP carried out by the Austrian Research Centers Seibersdorf (ARCS). Aim of the study was to work out the technical requirements and the practicability of an useful monitoring system at border crossings. The results of the study will be offered by the IAEA to the Member States as international recommendations for border monitoring systems. The results of the study will be offered by the IAEA to the Member States as international recommendations for border monitoring systems. First results of the ITRAP study were given at the IAEA Conference On the Safety of Radiation Sources and the Security of Radioactive Materials, Dijon, France, in September 1998 [1]. This paper describes the final results of the ITRAP study in detail and discusses conclusions.

1. INTRODUCTION

Illicit trafficking (IT) in nuclear materials has become more and more a problem, due to the circulation of the high number of radioactive sources and the big amount of nuclear material. The IAEA data base counts at present more than 300 verified cases concerning IT [2]. The endangering cased thereby ranges from possible health defect for the publication to terrorists activities and production of nuclear weapons. In addition to the primary criminal reasons the illegal deposal of radioactive sources as salvage, scrap and others show a further problem, which has lead to severe accidents and lethal effects in the past (e.g. Goiana, Mexiko, Spain). Some countries have already under taken countermeasures (e.g. Monitoring at the Finnish-Russian and German-Polish border, border monitoring in Italy). The International Atomic Energy Agency (IAEA) has reacted on this actual problem by setting up a new program to fight against nuclear criminality and has suggested a pilot study for the practical test of border monitoring systems. Co-ordinated by the Federal Ministry of Economy and Labour the Austrian Government financed the pilot study ITRAP (Illicit Trafficking Radiation Detection Assessment Program) carried out by the Austrian Research Centers Seibersdorf (ARCS). Aim of the study was to work out the technical requirements and the practicability of an useful monitoring system at border crossings. The results of the study will be offered by the IAEA to the Member States as international recommendations for border monitoring systems.

Radiation monitoring systems for contaminated scrap metals have been successfully applied in steel plants and scrap yards since several years. Using sophisticated software and dynamic scanning techniques such systems allow to detect a 10% increase in radiation level, even if the natural background is substantially suppressed by the vehicle entering the monitor.

However, measurement conditions at borders are essentially different from that in plants. Large traffic limits the time for detection to a few seconds and multiple checks are impractical. Shielded radioactive sources - even of high activity — which are deeply buried in scrap, can not be detected without unloading the vehicle, which is generally ruled out at borders. Highly sensitive monitoring systems cause frequent false alarms or nuisance alarms due to innocent radioactive materials such as NORM or medical radioisotopes administered to patients. In support of the IAEA program to combat illicit trafficking [2] and to derive practical performance requirements for border monitoring instrumentation a large pilot study (ITRAP) have been conducted in co-operation between the Austrian Government, the IAEA and the Austrian Research Centre Seibersdorf (ARCS), with participation of 23 manufacturers from 9 countries. The final report of the ITRAP study was presented and discussed in detail at the International ITRAP Conference at Vienna, on October 31, 2000 [3].

2. THE ITRAP STUDY

The ITRAP study were organised as an international laboratory and field test site exercise for gamma and neutron radiation detection instruments and monitoring systems at border crossings. The ITRAP study did not work as an inter-comparison test. Participating companies were invited to exchange experience and worked together within working groups on requirements for appropriate equipment for border monitoring. A team of international experts of IAEA and other Research Institutions observed and advised the ITRAP study. Further more the Illicit trafficking program was supported by World Customs Organization (WCO), International Police (INTERPOL) and the Hungarian Government. International suppliers and manufacturers of nine different countries as Austria, Belarus, Canada, France, Germany, Russia, Sweden, UK, USA participated the ITRAP study.

The ITRAP study was carried out from September 1997 to September 2000. After a pre-selection of equipment and comprehensive lab tests at the Austrian Research Centers Seibersdorf the selected systems were installed at the border site Nickelsdorf and at the Vienna Airport. The practical tests of the instruments showed, that the border monitoring of nuclear and other radioactive material, is possible with acceptable expense, according the worked out minimum requirements for such systems. Each system was online remote linked with ARCS and were continuously checked. Border guards have been acquaint with the instruments by recurrent and appropriate training. The permanent call-stand-by of ARCS assured that even in unforeseen cases sufficient expert support was available. In addition to the practical tests of the instruments by the users the workout of a standardised course of the inspection procedure was an important result.

2.1. DESIGN OF THE STUDY

Together with IAEA experts the definition of equipment and performance requirements have been worked out. For further investigations and tests the following categories of instruments have been defined:

- Fix-installed monitoring instruments.
- Pocket type instruments.
- Hand held instruments.
- Searching instruments.
- Dose rate survey meters.
- Isotope identification instruments.

The fix-installed monitoring systems should detect nuclear material emitting gamma as well as neutrons radiation. Pocket type instruments have not to be sensitive for neutrons. Hand held instruments are desirable with the capability of neutron detection but not necessarily in one unit. A hand held instrument has not to have all mentioned properties in one unit. To qualify the instruments for further practical field tests at border crossing lab-test scenarios have been worked out and agreed by all experts: An outside, controlled area at ARCS has been modified to a radiation test facility (ITRAP lab test facility). The control units of the fix-installed monitoring systems were placed inside a building. For the ITRAP field test site the Austrian-Hungarian border and the Vienna Airport have been selected. Reason for the Austrian-Hungarian border was due to the high frequency of border crossing by different types of vehicles: "truck, car, bus". The Vienna Airport has been selected because of the very high number of passengers.

2.2. PRE-SELECTION

In November 1997 manufacturers and suppliers were invited to present the available instruments concerning monitoring of radioactive material in truck, car, bus and passenger traffic. An official invitation to participate the ITRAP study have been sent to all IAEA Member States. The pre-selection of equipment, based on supplier's product information, a standardised equipment data sheet and information by the literature was carried out end of February 1998.

2.3. LABORATORY TESTS

An outside, controlled area at ARCS have been modified to a radiation test facility for gamma and neutron radiation (see figures 1 & 2). The control units of the fix-installed monitoring systems were located in a dry area (see figure 3). The ITRAP lab tests were designed to work as a very strict benchmark to qualify border monitoring systems with low false alarm rates for further field tests at the border sites. The minimum sensitivity to give an alarm are given for fix-installed systems, pocket type and hand held instruments.

2.3.1. IAEA Minimum Requirements for Fixed-installed Monitoring Systems at Border Crossings

Alarm level for gamma radiation:

Increase of the dose rate at the reference point of the detector from a background level of 0.2μS/h by a dose rate of 0.1μSv/h for a duration of 1 second. This requirement has to be fulfilled in a continuous, incident gamma energy range from 60keV to 1.5 MeV (tested with ^{241}Am, ^{137}Cs and ^{60}Co). Reference point: Most sensitive location at the detector system.

Alarm level for neutron radiation:

A neutron flux density of 20,000 n/s emitted from weapons Plutonium for a duration of 10 seconds at 2m distance from the reference point of the detector, gamma radiation shielded to less than 1%, should trigger alarm. (Tested with a modified, gamma shielded Cf-252 source).

Search region:

Geometrical region in which the minimum requirements for alarm level are fulfilled:

- Pedestrian monitor: vertical: 0 to 1.8m, horizontal: up to 1.5m.
- Vehicle monitor: vertical: 0 to 3m; horizontal: up to 4m.
- Train monitor: details to be defined.

Pre-selected Systems and Instruments

Instrument Type	Instrument Name	Manufacturer/Supplier	Country
Fix-installed	Yantar-1U	ASPECT	Russia
Fix-installed	Yantar-2U	ASPECT	Russia
Fix-installed	APM Automobile & Personnel Monitor	BICRON-NE	USA
Fix-installed	BPM Border Monitor	BICRON-NE	USA
Fix-installed	RGM	BITT	Austria
Fix-installed	FHT 1388	ESM - Eberline	Germany
Fix-installed	SYREN 510 N	EURISYS MESURES	France
Fix-installed	GR-526/4400 (Gammascan 300)	EXPLORANIUM	Canada
Fix-installed	GR-606/1100 (Gammascan 200)	EXPLORANIUM	Canada
Fix-installed	CGV	MGP instruments	France
Fix-installed	PUMA-TM (Neutron Glass)	NUCSAFE	USA
Fix-installed	PM5000 (VM-250 GN)	POLIMASTER/TSA	Belarus/USA
Fix-installed	CDM-001	SAPHYMO	France
Fix-installed	TSA 700	TSA	USA
Fix-installed	TSA 702	TSA	USA
Hand Held	N92 Neutron Scanning Instrument	AEA Technology	UK
Hand Held	Neutron Survey Meter LB 6414	Berthold	Germany
Hand Held	MicroSievert	BICRON-NE	
Hand Held	FH 40 G-L Radiameter System with gamma and neutron probes (FHZ 502 P+FHT752SH)	ESM — Eberline	Germany
Hand Held	Syrena	EURISYS MESURES	France
Hand Held	Neutron Rem Counter	NE Technology	England
Hand Held	DG5A	Novelec	France
Hand Held	PM1402+BD01+BD04+BD02	POLIMASTER	Belarus
Hand Held	PM1710	POLIMASTER	Belarus
Hand Held	RNI 10/SR+Biconsonde	RNI AB	Sweden
Hand Held	6150 AD Ratemeter	SAPHYMO	France
Hand Held	PRM-470P	TSA	USA
Hand Held/Isotope Identification	Universal Radiometer-Spectrometer MKS-A02	ASPECT	Russia
Hand Held/Isotope Identification	FieldSPEC	Bicron	Germany
Hand Held/Isotope Identification	MiniSPEC	EXPLORANIUM	Canada
Hand Held/Isotope Identification	MCA 166	GBS Elektronik	Germany
Hand Held/Isotope Identification	Nanospec 2	OXFORD-INSTR.	USA
Hand Held/Isotope Identification	Ranger/Ranger — Plus	QUANTRAD SENSOR	USA
Pocket	RIC-11	Constellation	USA
Pocket	PM 1401	POLIMASTER	Belarus
Pocket	PM 1703	POLIMASTER	Belarus
Pocket	Radiation Pager	Sensor Technology	USA

Detection probability:

Probability to detect radioactive material causing the dose rate specified under alarm level: 99.9% i.e. 1 failure in 1000. (Test: Not more than 10 failures in at least 10 000 tests).

False alarm rate:

Rate of alarms which are not caused by a radioactive source:
1 false alarm in 10 000. (Test: Not more than 4 false alarms in at least 40 000 tests).

Operational availability:

99%, i.e. less than 4 days out of operation per year.

Background level:

All tests are performed at a background level of at least 0.2µSv/h.

2.3.2. Lab tests of fix-installed systems

14 fix-installed systems have been installed outside, in a circular geometry to measure all instruments at the same time. In the centre the test source was located in an distance of 3 m to the reference point of the detector (figure 1). For monitoring systems using two pillars, each single pillar has to fulfil the IAEA minimum requirements.

The systems were installed in a fenced, outside area, unprotected against temperature changes, humidity, etc. installed (figure 2). The control units were located in a building, close to the detectors (figure 3).

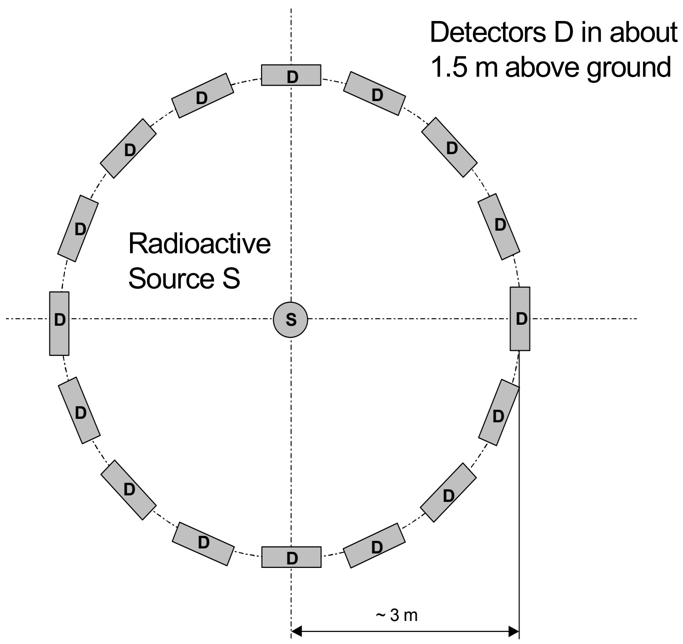

FIG. 1. All detector systems have been tested at the same time at a circular arrangement. The radius is 3 meters with the radioactive source in the centre.

FIG. 2. View of several monitoring systems at the ITRAP lab test facility and the gamma test source

FIG. 3.View of the control units of the detector systems and the ITRAP lab test control system

For the sensitivity tests in the alarm case, a gamma source (^{137}Cs, ^{241}Am, ^{60}Co) as well as a neutron source (^{252}Cf) have been used to exposure the systems for time period of 1s, in the case of a gamma and 10 s, in the case of a neutron source, according the IAEA minimum requirements for these instruments. The increase of the dose equivalent rate is 0.1 µSv/h above a background of 0.2µSv/h for all gamma tests. After the exposure the source stayed for a minute behind the shielding and the next test cycle starts (figure 4). The facility is able to operate continuously for several weeks. The natural background is increased by an additional radiation source (^{137}Cs) in the centre according to the IAEA test requirements.

For the neutron tests a special prepared Californium source (^{252}Cf) was used to simulate weapons plutonium according the IAEA minimum requirements. The source is shielded against gamma radiation, use a moderator and emits a neutron rate of 20 000 n/s.

To test the false alarm rate (rate of false positive) the same test facility, under the same background conditions, was used but without a radioactive test source.

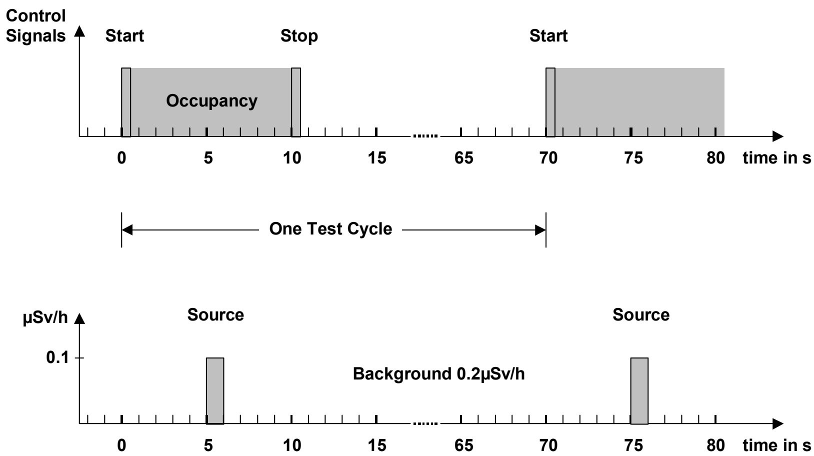

FIG. 4. Test cycle for the gamma alarm test for fix-installed monitors. The ITRAP control system provides all monitoring systems and instruments a start and a stop signal to simulate the "occupancy" situation of a vehicle or pedestrian. The status of all systems was checked every 0.5 ms by the ITRAP control system. During the waiting period the systems had time to recalibrate.

Summary of alarm and false alarm tests

Tables I and Table II show all lab tests with fix-installed and transportable systems (pocket type and hand held instruments). In summary we have done some 190 000 tests with fix-installed systems and 40 000 tests with transportable systems. The high number of tests guaranties a high statistical probability to qualify the systems concerning false alarms.

Table I. Number of lab tests with fix-installed systems

Test with	Number of Tests
gamma sources: ^{241}Am, ^{137}Cs, ^{60}Co	50.000
modified neutron source Cf-252	51.000
false alarm tests	86.000
SUMME	**187.000**

Table II. Number of lab tests with transportable systems

Test with	Number of Tests
gamma sources: ^{241}Am, ^{137}Cs, ^{60}Co	10.000
modified neutron source Cf-252	10.000
false alarm tests	20.000
SUMME	**40.000**

2.3.3. Tests for Pocket sized and Hand Held instruments

According the IAEA lab test requirements for transportable systems (pocket type and hand held instruments) had to pass the following tests:

1. Battery life test under alarm and no-alarm conditions.
2. Test of the dose rate display for systems which give the display in dose unity (e.g. see figure 5).
3. Test of the sensitivity, alarm- and false alarm test.
4. Isotope - identification test (e.g. see figure 6).
5. Environmental test for a specified temperature and humidity range.
6. Trop test (only for pocket type instruments).

2.3.4. IAEA ITRAP Test Requirements for Pocket Type and Hand Held Instruments

1. Pocket type instruments

Sensitivity Test: Dose rate of 1.0 µSv/h (^{137}Cs) at the detector reference point, for a duration of 2 seconds should trigger alarm. This requirement has to be fulfilled in a continuous, incident gamma energy range from 60keV to 1.5 MeV (tested with ^{241}Am, ^{137}Cs and ^{60}Co). Reference point: Most sensitive location at the detector system).
[Test setup: ITRAP circular exposure system. Background 0.2µS/h Cs-137].

Alarm Threshold: check validity of specified threshold level (one low and one high threshold only). [Test setup: Dosimetry lab, Circular exposure system with Cs-137].

Dose Rate Indication: check validity of indicated dose rate (one low and one high value only). [Test setup: Dosimetry lab, Circular exposure system with Cs-137 (± 30% uncertainty)].

Detection probability: Probability to detect radioactive material causing the dose rate specified under alarm level: 99% i.e. 1 failure in 100. (Test: Not more than 100 failures in at least 10 000 tests). [Test setup: ITRAP circular exposure system. Background 0.2µS/h Cs-137, alarm output line required].

False Alarm Rate: Rate of alarms which are not caused by a radioactive source: not more than 1 false alarm in 12 hours of operation. (Test: Not more than 10 false alarms in at least 120 hours). [Test setup: ITRAP circular exposure system. Background 0.2µS/h Cs-137, alarm output line required].

2. Environmental Tests

Operate in temperature range: -15°C to + 45°C. [Test Setup: climatic chamber, instrument tested with source to give alarm at low and high temperature]

Operate at high humidity >95% rel. [Test Setup: instrument wrapped in plastics bag with moist tissue for 30 min, then tested with source Cs-137].

Battery life: > 800 hours for non rechargeable, > 12 hours for rechargeable units under no alarm conditions. More than 3h under alarm condition. [Test setup: under no alarm condition, current drawn from battery measured].

Drop Test: meet specification after 0.7 m drop on concrete (at the risk of the manufacturer!), three times in three different directions.

2.3.5. Hand held instruments

Gamma sensitivity test: Dose rate increase of 0.2 µSv/h (^{137}Cs) at a background of 0.2 µSv/h at the detector, for a duration of 3 seconds should trigger alarm. This requirements has to be fulfilled in a continuous, incident gamma energy range from 60keV to 1.5 MeV (tested with ^{241}Am, ^{137}Cs and ^{60}Co). Reference point: Most sensitive location at the detector system.

Neutron sensitivity test: ITRAP test source (modified Cf-252 source) in 0.25 m distance for 10 seconds should trigger alarm.

Detection probability: Probability to detect radioactive material causing the dose rate specified under alarm level: 99% i.e. 1 failure in 100. (Test: Not more than 100 failures in at least 10,000 tests). [Test setup: ITRAP circular exposure system. Background 0.2µS/h Cs-137, alarm output line required].

False Alarm Rate: test only applicable if instrument provide alarm feature. At background level of 0.2 µSv/h and threshold above background: Requirement: not more than 1 false alarm per minute (Test: Not more than 100 failures in at least 100 minutes). [Test setup: ITRAP circular exposure system. Background 0.2µS/h Cs-137, alarm output line required].

Dose Rate Indication: check validity of indicated dose rate (one low and one high value only). [Test setup: Dosimetry lab, with Cs-137 (± 30% uncertainty)].

Isotope Identification: After calibration the following isotopes should be identified behind 3mm and 5mm steel shielding, dose rate at detector without shielding 0.5 µSv/h above background, duration of identification less than 3 min:
Unshielded: (less than 1 min) In-111, Tc-99M, Tl-201, Ga-67, Pd-103, Xe-133, I-125, I-131, Am-241.
Shielded behind a 3 mm steel shielding: U-235, U-238, U-233, Co-57, Ba-133.
Shielded behind a 5 mm steel shielding: Pu-239, K-40, Ra-226, Th-232, Cs-137, Co-60.

Environmental Tests:

Operate in temperature range: -15°C to + 45°C. [Test Setup: climatic chamber, instrument tested with source to give alarm at low and high temperature].

Operate at high humidity >95% rel. [Test Setup: instrument wrapped in plastics bag with moist tissue for 30 min, then tested with source Cs-137].

Battery life: > 12 hours under no alarm conditions, > 3h under alarm conditions. [Test setup: current drawn from battery measured].

Searching Capability: to be tested during field tests on border. Time required to find source in a vehicle should be as short as possible.

Figure 5 shows a hand held instrument at the primary standard gamma calibration facility at ARCS. Figure 6 demonstrate an identification test with fertiliser.

FIG. 5: ITRAP Test at the ARCS gamma calibration facility

FIG. 6: Isotope identification test with fertiliser

2.3.6. ITRAP lab test conclusions

1. Fix-installed Monitoring Systems

The ITRAP lab tests for the fix-installed systems started at May 1998 and first results were given in September 1998. Only 2 of 14 fix-installed monitoring systems could fulfil the minimum requirement concerning neutron detection. The IAEA expert team decided to allow the suppliers improvements of their fix-installed systems during a time period of 6 months. ARCS supported these activities with a development workshop. Suppliers could use the ITRAP test facility for improvements of their instruments. In May 1999 7 of 14 fix-installed monitoring systems (50%) passed the ITRAP lab test. Together with the suppliers and IAEA experts it was decided, that the qualified fix-installed monitoring systems are ready for the installation at the ITRAP field test sites Nickelsdorf and Vienna airport.

2. Pocket Type and Hand Held and Instruments

Concerning the tests of the transportable units 13 of 24 instruments or instrument combinations have passed the ITRAP lab tests for pocket type and hand held instruments. 7 systems clearly failed the tests and 4 systems could not be tested according the minimum requirements due to technical problems of the instruments. Concerning the isotope identification no instrument has fulfilled the minimum requirements. The systems showed wrong identification at different isotopes and different shielding conditions.

2.4. FIELD EXERCISE AT BORDER TEST SITES

The field exercise at border test sites at two different Austrian borders was the second part of the ITRAP study. It took into account the diverse situation concerning road traffic and airport. Particularly in this phase of the study the co-operation with the concerning resorts, customs and border guard officers was a very important part.

The tests have been done at:

1. Austrian–Hungarian Border Nickelsdorf

- three fix-installed monitors at three car lanes (figure 7);
- two fix-installed monitors at one bus lane;
- two fix-installed monitors at one truck lane;
- pocket sized systems and hand held instruments at each location;
- standardised response procedure carried out by the border guards.

2. Vienna Airport

- Two monitors at custom check point at green channel (figure 8) and blue channel;
- “quiet alarm” — no response procedure.

FIG. 7. Installation of fix-installed monitors at the car lane at the ITRAP field test site Nickelsdorf

FIG. 8. Installation of fix-installed monitors at the ITRAP field test site Vienna airport

The installation of the fix-installed monitors at the border site Nickelsdorf was done in June 1999. In June 1999 a special ITRAP training program for border guards, concerning basics in radiation protection, usage and searching of radioactive material and operation of the instruments was carried out. Due to the unexpected delay of the official allowances for the tests at the border crossing Nickelsdorf the start was shifted from June 1999 to November

1999. Further training for the border guards were organised for several days in early spring 2000. Border guards were also trained on a standardised response procedure in the case of an alarm at all fix-installed monitoring systems.

The official allowance for the tests at the airport was given beginning of the year 2000, so that the tests could start in March 2000. At the airport no response procedure by the border guards was carried out.

All devices were checked weekly concerning the proper operation and were tested with a test source by ARCS experts. The fix-installed monitoring systems were remote linked to ARCS to provide data access and control at any time. In addition a permanent call standby hotline to ARCS experts was established.

3. RESULTS OF THE BORDER TESTS

The official ITRAP field exercise tests at the Austrian–Hungarian border Nickelsdorf lasted from mid of November 1999 to end of June 2000. The control procedure by the border guards in the case of an alarm at Nickelsdorf was:

- Alarm at the fix-installed monitoring system.
- Verification of the alarm with a hand held equipment by the border guard.
- Recording of the event in the ITRAP journal book.
- Carrying out of the appropriate responds.

The fix-installed systems alarmed at approximately 15% background increasing at each monitoring location.

Figure 9 shows an alarm event distribution at the truck lane during a start period of about one month (mid of November to mid of December 1999). The alarm level is given in multiple of natural background at the monitoring location. Even during a one moth period of observation (17. Nov. 1999 to 13. Dec. 1999) a wide range of different goods could be observed, ringing an alarm at the truck lane (see table in figure 9).

The border guards have been trained on the instruments in June 1999 during the installation of the equipment at the border site. Due to the delay of the official allowances for the tests at the border crossing Nickelsdorf the start was shifted from June 1999 to November 1999. During this 6 month period a change of the border guard officers has taken place. I shows very instructively the effects of the training with border guard officers: The percentage of recorded alarms by the border guards during the test period April 2000 was almost 100% for the truck and the bus location, 57% at the car lane, in the case after a detail training in March 2000. Compared with the start period November/December 1999 the half of the recorded alarms by the border guards were observed.

An overview of a 6 months test period (January–June 2000) shows table II. The rate of alarms per day ranges from about 13 alarms per day at the truck lane, to 8 alarms per day at the airport and one alarm in 2 days at the car and bus lanes. The observed false alarm rate of the fix-installed instruments was quite low (< 0.01%) which demonstrates the effect of the strict qualification at ITRAP lab test. No neutron alarms were detected at the truck lane. The neutron alarms at the bus and car location have been either not recorded in the journal book or could not be verified by a further test with a hand held instrument. There are also strong indications, that some old, gas driven cars produced electronic interference which also could lead to a neutron alarm at the car or bus lane. Further analyses would be necessary to explain effects in greater detail. We observed also neutron alarms at the airport for which we have no verification by the officers up to now. Possible explanations for the observed neutron alarms could come from nuclear material, statistical false positive alarms, unknown electromagnetic interference or interactions with neutron contribution from solar events. This explanation are very speculative and a further inspection procedure for such alarms by border officers is strongly recommended. During the continuously test alarm checks each monitor has detected the test sources. The maximum background increase have been observed at the truck lane with about 60, 15 at the bus lane, 3 at the car lane and 11 at the airport monitoring location. It has been analysed that 50 % of all observed alarms are coming from a radiation increase compared to the natural background of some 20% to 40% (see table II).

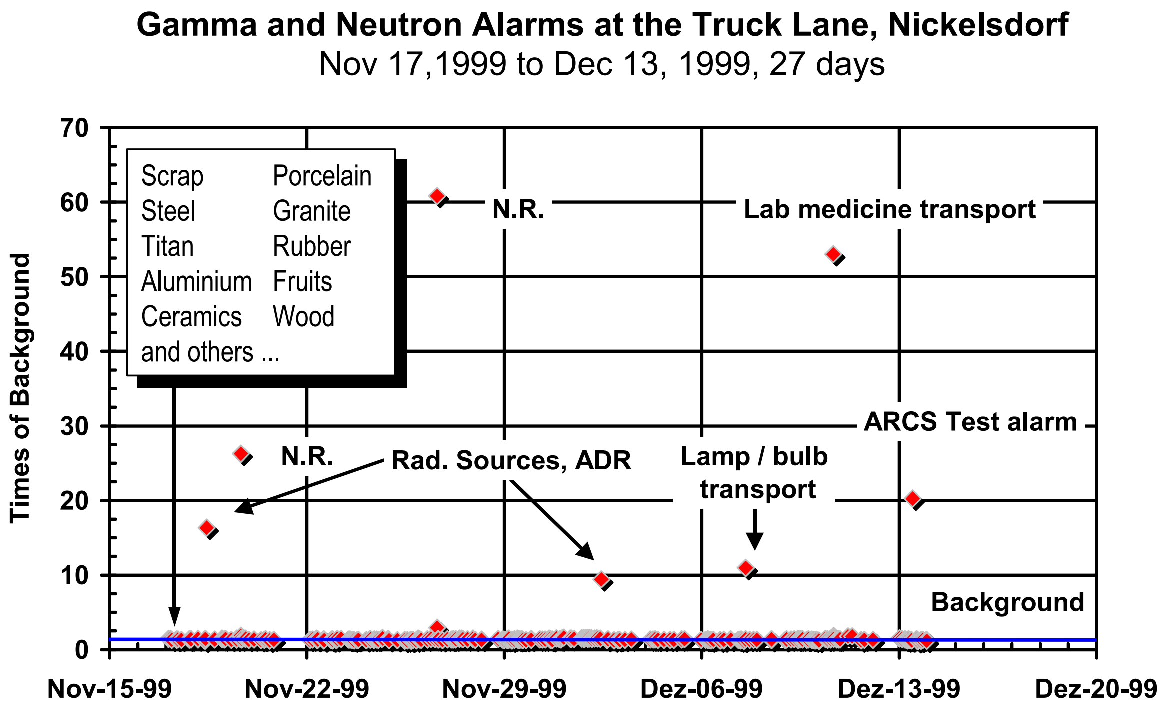

FIG. 9. Alarm event distribution at the truck lane during a start period of approximately one month: mid of November to mid of December 1999. The indication N.R.. means that no record in the ITRAP journal book was made by the border guard.

Table I. Comparison during the start period of the field tests and after detailed training

	TRUCK		BUS		CAR-3	
Nov/Dez 1999						
Number of Passages	25,338		729		98,000	
Number of Alarms	286	1%	3	0.4%	22	0.0%
Alarms per day	11		0.1		0.8	
Recordes Alarms	160	**56%**	2	**67%**	6	**27%**
April 2000						
Number of Passages	26,448		902		127,941	
Number of Alarms	465	2%	3	0%	7	0%
Alarms per day	15.5		0.1		0.2	
Recordes Alarms	430	**92%**	3	**100%**	4	**57%**

Table II. Overview of the results in a test period of 6 month (January to June 2000) at the ITRAP field exercise test site Nickelsdorf

	Truck	Bus	Car-1	Car-2	Car-3	Airport
Days	181	181	181	181	181	106
Number of Passages	162958	5400	360000	300000	236690	260490
Number of Passages per day	900	30	1989	1657	1308	2457
False - Alarms	<0,01%	<0,01%	<0,01%	<0,01%	<0,01%	<0,01%
Gamma Alarms	2256	66	65	76	48	837
Neutron Alarms	0	5	11	12	11	5
Alarms per day (G + N)	12.5	0.4	0.4	0.5	0.3	7.9
Not detected Test Alarms	0	0	0	0	0	0
Max. BGR	68	15	3	3	3	11
50% of the Alarme from BGR	> 1,4	> 1,2	> 1,3	> 1,3	> 1,4	> 1,3

No industrial radioactive source or smuggled nuclear material were founded during an observation period of November 1999–June 2000. It is also very unlikely to find a smuggled radioactive source or nuclear material during such a study because the study was already internationally announced and very public. A smuggler would take an other route or an other border than Nickelsdorf. Nevertheless, it is important to mention, that one alarm per week was due to an iron, scarp or metal transport (see table III). It should be mentioned that at the border site Nickelsdorf there is no facility to unload or dump e.g. scrap. Such a facility would be necessary to check a contaminated scarp loading on a truck in detail. One alarm per week in average was observed from agricultural products. Some of this events were analysed by the customs concerning radiation limits in food. Table III shows a summary of four different defined categories which caused an alarm at the truck lane in Nickelsdorf during the test observation period. In the last row of table III the maximum radiation increase is given in multiple of natural background which were found in the concerning category, including the recorded remarks by the border guard. An increase of 60 is the maximum value what the instrument can show. Above this level the instrument gives an overload.

Table III. Categories of goods which have been found during the alarm observation period of 6 months at the truck lane Nickelsdorf

Alarms	Reason	Max. observed multiple of background with examples
10 per day	**Industrial Products and Raw Material** e.g. ceramics, fertiliser, lamps, TV, etc	60 at some events with e.g. ceramics
1 per week	**Agricultural Products** e.g. fruits, vegetable, wood, etc.	60 at one transport with a chicken
1 per week	**Iron and Metal Transports** e.g. Scrap, etc.	60 at metal plates
1 per week	**Legal (ADR) radioactive Transports** e.g. radio pharmaceutical transports and industrial sources, etc.	60 at almost all transports

4. CONCLUSIONS OF THE ITRAP STUDY

First results of the ITRAP lab test have shown that initially almost all (85%) tested, fix-installed monitoring systems could not fulfil the IAEA minimum requirements concerning neutron detection! And more than 70% did not fulfil the requirements concerning gamma - and false alarms requirements. After instrument improvements 50% of all tested equipment passed the ITRAP lab and field tests according the IAEA minimum requirements. The ITRAP lab tests concerning isotope identification systems have shown that no instrument could fulfil all IAEA minimum requirements concerning isotope identification, particularly the requirements concerning identification of shielded isotopes. Further improvements of isotope identification systems (hard- and software) and advanced requirements for field tests are strongly recommended [4].

All ITRAP qualified systems showed good performance concerning false alarms and reliability at the border exercise field tests. The ITRAP field tests have also shown, that improvements of fix-installed systems concerning the neutron detection and further advanced minimum requirements for neutrons are recommended for future developments. During the field tests at the Vienna airport neutron alarms were observed. A procedure of further verification and check by customs and border officers is strongly recommended.

The maintenance and servicing of mature instruments is after a start period absolutely possible. Concerning the practicability of fix-installed monitoring systems further improvements should be done of the display and output to give a clear and permanent visible indication to the user of the maximum observed increase of radiation during the measurement procedure (e.g. increase of back ground in cps or in multiple of back ground or several alarm levels). It has been also observed that several of the tested hand held equipment were to complicated for the practical usage by border guards. Instruments which needs a continuous training are not recommended for the usage at the border. A “three button mode” (soft- or hardware solution) is recommended: Searching mode, dose rate mode and isotope identification. During the practical tests with the hand held instruments it has been observed, that detailed searching measurements with hand held instruments at large vehicles, particularly trucks are not practicable. For detailed measurements of huge vehicles a sophisticated fix-installed system with identification capabilities (one per border crossing) is suggested. This system should be placed at an appropriate location for detailed checks.

Four different categories of transported goods which cause alarms have been identified with a certain alarm rate per day and week: About 10 alarms per day are coming from industrial products and raw material. Contaminated iron, metal or scarp as well as alarms from agricultural products have been observed once in a week. Legal transports lead to one alarm per week. It has been observed and practically tested, that at a standard truck loading of about 10 metric tons the used monitoring system are easily able to work as an entrance check on food products concerning radioactive contamination. For instance at a loading of blackberries 30% of the maximum limits of radioactive contamination for food were detected. This is particularly important in cases of an radioactive accident.

The ITRAP lab and field test showed that instrument standards and harmonised regulations concerning border monitoring and control procedures are urgently required!

Training of border guard officers concerning radioactive material at borders is strongly required (e.g. including into the basic training of officers).
The protection of the public and guards at border crossings can be ensured by fix-installed monitoring systems.

It can be concluded, due to the installation of fix-installed monitoring systems at border crossings and using hand held instruments, after an appropriate training of the border guards, the protection against illegal transports of nuclear and other radioactive or contaminated material is highly increased.

ACKNOWLEDGMENTS

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REFERENCES

[1] Beck P., Duftschmid K.E., *ITRAP — The illicit trafficking radiation assessment program,* Proc. IAEA Conf. On the Safety of Radiation Sources and the Security of Radioactive Materials, Dijon France, Sept. 1998, IAEA TECDOC-1045, 265 (1998).

[2] Duftschmid K.E., et. al., *Technical Consideration for Detection and Response to illicit Trafficking in Radioactive Materials*, Proceedings of the International Conference on Security of Material, Stockholm, May 2001, IAEA-86-29.

[3] Beck P., ITRAP, *Illicit Trafficking Radiation Detection Assessment Program*, Final Report, OEFZS-G -- 0005, Oktober 2000.

[4] Arlt R., Beck P., Duftschmid K.E., Kovar A., Swoboda M., *Improvements of Equipment needed for the detection and characterization of nuclear material and radioactive sources at borders,* Proceedings of the International Conferenceon Security of Material, May 2001,IAEA-86.

A BUSTLING ACADEMIC REACTOR CREATES CHALLENGES AND OPPORTUNITIES IN THE AREA OF PHYSICAL PROTECTION

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Abstract. The 250 kW TRIGA research reactor is located at the Atominstitut Vienna, Austria, only a few subway stations from the city centre of Vienna. Its main purpose is the training of university students in the field of nuclear engineering and radiation protection as well as in radiochemistry and neutron- and solid-state physics. The existing facility is visited during a normal academic year by about 300 persons per day falling into seven different categories including fully employed staff, students occasionally visiting a seminar, and IAEA personnel from all over the world. These different groups have to be accounted for daily and are separated into different categories in view of security and physical protection. The primary challenges with respect to physical protection have to do with changing requirements of an ageing TRIGA reactor. Such a university training facility has to make a compromise between strict security rules as is usual in nuclear facilities and easy access to academic premises. Too stringent restrictions would keep away the students, too easy access cannot be allowed due to the amount of nuclear material stored at the facility. Further, when the facility was established between 1959 and 1962, the security standards for physical protection were far below the requirements applied nowadays. It is especially difficult to upgrade existing buildings to today's standards while the normal academic life continues. Another problem is the fact that different building requirements contradict each other. For example, physical protection contradicts in some cases the fire protection standards and the requirement for emergency exists in large auditoriums. Therefore, very cautious implementations have to be performed to balance between the various requirements. During the past 39 years a number of physical, administrative and organisational procedures have been implemented to upgrade the physical protection of the institute. In the late seventies all entrance doors to the reactor hall and radioisotope laboratories were replaced by self-locking, fire-proof doors. The main access to the institute was strictly controlled and the room of the entrance guard was hardened. A closed TV system was installed to survey sensitive areas. In the reactor hall US and IR sensors were installed which are connected together with micro- switches in the access doors to a central security system. The system is activated during nights and week-ends with a direct connection to the nearest police station. Emergency units were established and emergency drills are carried out on a regular basis. Fire and smoke detectors were installed with an automatic alarm to the nearest fire brigade. All cable penetrations in the laboratories and the reactor hall were replaced by fire-proof penetrations. A sensitive radiation detector was installed at the main exit of the institute to monitor any illicit movement of radioactive sources in or out the institute in view of the high number of students moving in or out every day.

Total 16 radiation detectors are distributed in

- the reactor hall;
- the primary and secondary coolant system;
- the ventilation system; and
- near the main entrance.

The system is connected to a central radiation monitoring system with documents the radiation values both on hard copy and on a diskette .

The institute however is not only upgrading physical and radiation protection at its premises, one task is also to develop new or to improve existing systems for physical security and safeguards. An example of such a program is given below:

A busy reactor facility, such as the Atominstitut, is also an opportunity to demonstrate new techniques in physical protection. One technique being studied uses simulation in automated evaluation of physical protection data. The research goal is to create a simulation of a protection system where the data can be compared directly with that of a laboratory referent.

In the first phase of study, agreement between simulation and referent data is analysed in the context of decision criteria used to make the evaluation using rigorous statistical methods. The referent, under construction at the Atominstitut, is comprised of digital cameras and neutron detectors. Preliminary results suggest that routine and anomalous events in a nuclear facility could be discriminated using a system based on simulation data.

Research is underway where the objective is to design and validate quantitatively a physical protection system (PPS) and its simulation. The work is novel because the simulation is also used as the basis for automated evaluation of PPS data. Preliminary results indicate that routine and anomalous events in a nuclear facility can be distinguished in video and radiation data using this approach. Application of the technique promises that an investment in a simulation supports directly the physical protection objective. Consequently, it is also easier to realise other benefits associated with simulation-based acquisition, in addition to having a quantitative method for validation.

A modern PPS may include video cameras, radiation detectors, and electronic seals. Moreover, there is a trend to network electronic monitoring devices and to make their data remotely accessible to authorised clients. For the most part, analysis of PPS data is done manually and, when done so, can be expensive and prone to error. To help alleviate this problem, a technique for validating a simulation and using it to automatically evaluate PPS data is being developed. It is being demonstrated using a real and simulated PPS. Both rely on video cameras and radiation detectors to positively identify items and their movements. Each datum from the real and simulated devices is compared directly and the quantitative result is called *fidelity*. When the fidelity exceeds a threshold, defined in the objective function, items in the real data are identified automatically according to those in the simulation. The objective function succeeds when the threshold is met and fails when it doesn't. Applying statistical methods to many such outcomes result in a single quantitative parameter termed the validity or *fitness*, which defines the quality of the simulation.

The real PPS, or referent, for this research operates inside the reactor hall of the Atominstitut. It is the source of real data and reproduces the essential elements of most busy nuclear facilities with respect to the operation of a PPS. There are continuous activities involving radioactive sources, frequent use of a crane, electrical noise and, of course, personnel moving about. Plutonium-Beryllium sources are used to approximate the radioactivity of cans containing plutonium. A dedicated acquisition computer posts the PPS data to the Internet at regular intervals. The PPS simulation, which generates images and neutron streams like the referent, runs asynchronously on two networked computers off campus. The simulation under development is a modification of a game, which incorporates three-dimensional modelling, basic mechanical laws, and human forms with rudimentary behaviour. Basic radiation transport is being written into the code. Complex transport calculations will be possible by making calls from within the simulator to MCNP. The analysis client continuously downloads data from the referent via the Internet and the simulator via a local network. It performs automated evaluation of the real laboratory data and validates the simulation in quasi-real-time. The system will be tested via a series of nominal and diversion scenarios carried-out in the laboratory and the simulation.

It can be concluded that, even with the moderate financial resources of a university institute, adequate physical protection can be maintained in view of the amount and type of radioactive and special nuclear material stored at the facility.

RADIATION MONITORS OF NEW GENERATION — NEW METHODOLOGY OF DETECTION OF NUCLEAR AND RADIOACTIVE MATERIALS

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In recent few years the world community has faced a problem which was considered before as an almost theoretical one — a possibility of illicit trafficking of nuclear and radioactive materials due to their partially controlled or even completely uncontrolled proliferation.

Organization of the first conference entitled "Safety of Radiation Sources and Security of Radioactive Materials", Dijon, France, 14-18 September 1998, is particularly a witness of the world community’s concern about these issues. The conference was held under the aegis of the IAEA, European Commission, INTERPOL and World Customs Organization. The conference covered the whole range of problems concerned with both the elaboration of legal regulations of radiation control, development of equipment and training of personnel.

Since 1997 till 2000 the international ITRAP program (Illicit Trafficking Radiation Detection Assessment Program) was held under the aegis of the IAEA, WCO and INTERPOL. The task of the program was to work out the common requirements to the equipment, to test the equipment against the program requirements and to elaborate recommendations for the IAEA member-countries.

In the course of this program realization the modern devices of the world leading manufacturers of the equipment for radiation control at state borders had been tested. The equipment to be tested is designed to fulfil the following main tasks [1]: alarming about the presence of radioactive source in the controlled area; detection and location of the source, as well as its identification, personnel radiation protection being necessarily provided.

To fulfil each of the above tasks essentially different specialized instruments are used: from large fixed installed systems to portable instruments, “pager” type pocket search instruments and personal dosimeters. Consequently numerous different instruments have to be used during the radiation control at borders. It creates considerable difficulties for border guard (customs) officers, who as a rule are not experts in the field of radiation control and radiation protection. Therefore, an urgent task for the present is to develop simple, reliable and inexpensive instruments that would allow several of the mentioned tasks to be simultaneously fulfilled. For the last years instruments of a new generation such as the PM1703 and the PM1710 [2, 3] that combine functions of different class devices have been developed.

The main distinguishing and favorable features and advantages of these devices are as follows.

- These devices having small weight and dimensions permit not only effective detection of radioactive sources, but also their location.
- Special algorithm gives an opportunity to find sources not only with decreasing background as compared to the natural background value due to its shielding (e.g. by scrap), but also with
- increasing background due to other source (location of one source in the field of the other one).

- The devices have a non-volatile memory for the history accumulation and storage: time and date of the device switch on/off, source detection cases, etc. The history of operation may be transmitted to the PC for its further storage and processing.
- The devices have two LCD display modes: in the count rate units (the sources being detected and located in this mode) and in the dose rate units, which allows the evaluation of a danger of the detected and located source to a person.

The above-mentioned features of the described devices give an opportunity to develop **a new methodology** of detection of sources.

- Owing to small weight and dimensions and a low power consumption the user may hold these devices in a pocket (on a belt) during the entire working shift without switching them off.
- The user may fulfil his usual professional duties not related to the radiation control and even may not be concerned about the device and its operation — the device functions in the automatic mode and all the information about its operation is accumulated and stored in the non-volatile memory and, if necessary, may be consequently transmitted to the PC for analysis.
- When the source is detected (alarm triggers), the device may be hold in hand and used for location of the detected source.
- After the source is located one may evaluate its danger to a person just by switching the LCD indication to the dose rate units. It helps the user who may not be an expert in radiation protection to choose at once a proper way of actions in response to the detected and located source.
- It should be emphasized that these devices combine functions of fixed installed monitors (being in fact "fixed installed monitor in pocket"), portable devices and dosimeters. They are the only possible type of monitors that may be used for searching sources in such not easily accessible places as railroad cars, the interior of ships, etc.

Thus, these devices are examples of the new generation devices. They were developed using the available experience and up-to-date achievements in microelectronics especially for fulfillment of tasks in the field of control of trafficking of radioactive sources through the state borders. These devices provide an opportunity to develop new versions of methodology of their operation considerably simplifying and facilitating the user's work.

REFERENCES

[1] ANTONOVSKI, A., KAGAN, L., STAVROV, A., "Equipment of high sensitivity to detect smuggled radioactive materials transported across the "East-West" border", Safety of radiation sources and security of radioactive materials (Contributed papers, Conference held in Dijon, France, 14-18 September 1998). IAEA-TECDOC-1045 (IAEA-CN-70/42). IAEA. P. 287–290.

[2] "Pocket Alarming Ratemeter PM1703", ITRAP Report, Austrian Research Centers Siebersdorf, October 2000, OEFZS-G-0005, p. 34.

[3] "Hand held Alarming Ratemeter PM 1710", ibid, p. 35.

A NEW GENERATION HAND HELD IDENTIFIER FOR CUSTOMS APPLICATIONS

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In recent years increasing attention has been paid to control of illicit transportation of radioactive materials. Various methods (pagers/ portals etc.) are used in an increasing number of locations to identify the presence of radioactive material. Unfortunately many of the "detections" are caused by NORM material or Medical treatment remnants which may be considered acceptable, as opposed to illicit transportation. The on-site Customs personnel need some method of readily assessing these radioactive "detections" to segregate them into different groups to permit the appropriate response.

Current instrumentation for these applications have been extensively tested at the recent ITRAP [1] test program in Austria and these results showed that no currently available instrument is capable of meeting the complex demands of the Customs user. However, the tests provided an valuable input to a definition of the specifications that are required for such instrumentation as outlined in a recent IAEA TECDOC [2].

A prime requirement is a hand-held, very portable unit that can accurately measure Gamma-Ray and Neutron radiation to permit sources to be accurately located and then the same instrument used to qualify the isotope involved. Qualification is of crucial interest to the users as different isotopes require significantly different response (e.g. a Medical isotope "inside" a person may be acceptable but a Neutron emission would require a very different response.

A new instrument, THE IDENTIFIER (GR-135), has been developed specifically to overcome the system weaknesses identified during the ITRAP testing. The primary requirements as defined by IAEA, INTERPOL, and WCO are :

- Ease-of-use for non-technical users.
- Gamma analysis capability in a Search mode.
- Neutron detection capability.
- Reliable Nuclide Identification for shielded and unshielded gamma sources.
- Small and reliable.
- Reasonable (low) price.

The GR-135 has been developed to meet these requirements and field testing shows excellent system performance. The unit incorporates 4 separate detectors in an integrated package that is easily handled by non-technical personnel because the complex features are performed automatically without requiring user intervention.

The EASE-OF-USE is a primary requirement as the expected users have no technical background in radiation, so the instrument must be able to perform all it's "clever" functions completely automatically. The GR-135 has been designed with two user selectable modes of operation - BASIC and ADVANCED mode. The BASIC mode is very easy to use and user inputs and selections are restricted to a minimum. This is made possible by a combination of artificial intelligence and carefully designed displays and functions that give maximum information with minimum user input. Professionals can operate the same instrument in ADVANCED mode enabling all standard spectrometer functions. Such user adjustable functions such as Display contrast and system Gain stabilization are essentially fully automatic.

The GAMMA analysis requirement for a SEARCH capability requires the use of a Sodium-Iodide (NaI(Tl)) detector for high sensitivity operation so the GR-135 incorporates a large volume detector — 66cm^3.

Pressurized proportional counters with ^{3}He are widely used neutron detectors. For this application, however, a Lithium-glass based scintillation detection system was developed. This solution has the advantage that no high pressure tubes are required and therefore has absolutely no restrictions for passenger aircraft travel. By carefully selecting the Li material a very high Gamma rejection has been achieved and the technology surpasses the ITRAP specification of reliable detection of 300g of Weapons Grade Plutonium at 0.25m in less than 10 seconds, yet is very small and compact and adds very little to the instrument weight.

The NUCLIDE ID requirement was to perform highly accurate ID in a complex field (mixed sources) combined with various amount of shielding material between the source and the instrument. This requirement is further complicated by restrictions on analysis time and instrument price.

Table I

Detector Material	Typical energy resolution [FWHM] @ 662 keV	Sensitivity	Price	Portability
NaI(Tl)	7%	High	Low	High
CZT (commercial grade)	2.5%	Low	High	High
CZT (research detector)	1%	Low	Very high	High
HPGe	0.2%	Medium	Medium	Lo

Table I lists detector materials in common use for qualification and quantification of gamma radiation. The ultimate detector from a qualification point of view would be based on HPGE technology due to the superior energy resolution. The requirement for liquid nitrogen coolant, however, makes it impractical for the specific application. CZT-detectors offers energy resolutions somewhere between that of HPGE and NaI(Tl) detectors, making it a reasonable compromise between resolution an portability. The price for large size CZT detectors or research grade detectors are still considered to high for the application and for this reason it was decided to develop the GR-135 instrument around a hybrid combination of a NaI(Tl) detector AND a CZT detector. The instrument will automatically select the optimal detector based on the radiation field and the combination of these two detector technologies ensures the best possible analysis capability. The limitation of the energy resolution of NaI(Tl) has been addressed by combining a highly sophisticated peak analysis algorithm with a complex nuclide library and spectral modeling. This makes the nuclide analysis superior and much more consistent enabling only isotopes that do not contradict with the measured spectrum to be identified.

The GR-135 offers users the benefits of the maximum in current detector technology yet functions as a very “simple” unit for the unskilled operator. Such a capability permits a semiskilled user to achieve a high level of on-site analysis capability yet also provides a data output capability for technical involvement of a higher technical support level at an off-site facility.

REFERENCES

[1] ITRAP (Illicit Trafficking Radiation Detection Assessment Program) — sponsored by IAEA and WCO.

[2] IAEA, 2000. Detection of Radioactive materials at borders, International Atomic Energy Agency, Vienna (in press).

DEVELOPMENT AND IMPLEMENTATION OF METHODS FOR DETERMINATION OF THE ORIGIN OF NUCLEAR MATERIALS

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Abstract. The determination of the origin of seized nuclear material is important for authorities in the context of the criminal investigation, in order to return the material to its last legal owner and to help preventing any further diversion of material from this source. Origin determination is based on a complex pattern of parameters obtained through analytical measurements. The information required to determine the origin of nuclear materials may be divided into two categories: endogenous information (e.g. age or mode of production of the material) which is self-explanatory; whereas exogenous information (e.g. dimensions, surface roughness, impurities) requires a database to which the parameters can be compared [1]. The Institute for Transuranium Elements has developed methods to determine characteristic parameters like impurities, surface roughness, or microstructural information. Furthermore, a database was set up containing relevant information on reactor fuels [2]. Age determination of plutonium has been demonstrated successfully for both bulk and particle samples. It is based on several parent-daughter relations ($^{238}Pu/^{234}U$, $^{239}Pu/^{235}U$, $^{240}Pu/^{236}U$ and $^{241}Pu/^{241}Am$). These parent-daughter ratios are preferably determined by thermal ionisation mass spectrometry for bulk samples and by secondary ion mass spectrometry for particle samples [3,4]. The age determination of enriched ^{235}U fuel through the $^{234}U/^{230}Th$ ratio is being developed. The mode of Pu production can be identified by isotope correlation technique using accurately measured isotope ratios as input data [5]. Using data on surface roughness of fuel pellets proved to be useful to distinguish between production facilities applying different fabrication methods (e.g. grinding) [6]. The determination of the geographical origin of uranium fuel can be supported by geolocation techniques. These techniques are based on natural isotopic variations of certain elements. The variation in isotope ratios correlates with geographical location. A method based on $^{18}O/^{16}O$ variations has been investigated [7]. Currently investigations are going on to study isotope ratios of particular impurities for geolocation purposes in uranium materials. Results obtained by the different methods will be presented and discussed in view of the applicability for nuclear forensic science.

REFERENCES

[1] Koch, L., "Identification of nuclear material of unknown origin", Proceedings of the 17th Annual ESARDA Symposium on Safeguards and Nuclear Material Management, 9-11 May 1995, Aachen, Germany, 195-198.
[2] Dolgov, Yu., Bibilashvili, Yu., Chorokhov, N., Koch, L., Schenkel, R., Schubert, A., "Case studies with a relational database system for identification of nuclear material of unknown origin", Proceedings of the Russian International Conference on Nuclear Material Protection, Obninsk, Russia, 9-14 March 1997, 116-120.
[3] Wallenius, M., Mayer, K., "Age determination of plutonium material in nuclear forensics by thermal ionisation mass spectrometry", Fresenius' J. Anal. Chem. Vol. 366, No. 3, 2000, 234-238.
[4] Wallenius, M., Tamborini, G., Koch, L., "The age of plutonium particles", Radiochim. Acta, in press.
[5] Wallenius, M., Peerani, P., Koch, L., "Origin determination of plutonium material in nuclear forensics", J. Radioanal. Nucl. Chem., Vol. 246, No. 2, 2000, 317-321.
[6] Pajo, L., Schubert, A., Aldave de las Heras, L., Koch, L., "Identification of unknown fuel by impurities and physical parameters", submitted to J. Radioanal. Nucl. Chem.
[7] Pajo, L., Tamborini, G., Mayer, K., Koch, L., "Application of thermal ionisation mass spectrometry for oxygen isotope ratio measurements in uranium oxide", 6th Finnish–Russian Radiochemistry Symposium, 6-7 November 2000, Helsinki, Finland, Proceedings to be published.

THE IRES ELECTRONIC SEAL

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In the framework of the French Support Program for the IAEA Safeguards, the “Institut de Protection et de Sureté Nucléaire” (IPSN), developed an electronic seal called Integrated and Reusable Electronic Seal (IRES) that enables independent verification by different inspectorates (IAEA, Euratom, and National Inspectorate).

Furthermore, a bilateral co-ordination between Euratom and French domestic safeguards takes place in some French facilities regarding a common approach concerning the seals especially in case of crisis situation.

The seal can be remotely interrogated by radio frequency and integrated to other Containment/surveillance systems by serial line RS 485. Data are authenticated and the IRESMAG software manages in the seal reader all functionalities of the seal and records inspection data compatible with the IAEA’s Seal Database.

I — THE MAIN FEATURES OF IRES

The main features of the IRES seal are the following

- Interrogation by different inspectorate, allowing independent conclusions.
- Recording of events including tampering in a non-volatile memory.
- Authentication of data.
- Remote interrogation by an inspector or/and automatic for unattended systems or remote monitoring.
- Data encryption in case of remote monitoring.
- Reusable.

In the light of the results of the feasibility study, prototypes, developed by the SAPHYMO Company, have been demonstrated, in France, between July and September 1999, with data remote transmission to Vienna.

FIG. 1. IRES Prototype

II — SEAL TECHNICAL DESCRIPTION

The seal is manufactured as far as possible with existing industrial components, as following:

Seal enclosure, contains all components of the seal except the seal wire. The size of commercially available aluminum enclosure is 64*58*34 mm.

Sensor element “Sealing wire” : enables to fit through the containment parts for sealing and also to attach to the seal case and electronics. It is a special electrical cable containing a sensitive element able to detect any unauthorized attempt of tampering. This cable was selected to be easy to fit and resistant, with a diameter of 3 mm.

A dedicated watertight connector embedded into the seal enclosure performs the attachment to the electronics. This connector allows easy connection with gloves.

Continuous measurement of the resistivity corrected by the temperature insures the tamper indication to detect any unauthorized attempt.

Electronics, records any change in the status of the sealing wire connected and other tampering events and produces an internal data base containing a list of date and time stamped events which can be retrieved upon request (by the inspector during inspection or automated in remote monitoring applications). The database includes also state of health messages confirming the proper performance of the seal components (self-diagnostics).

The main micro controller manages all the seal functions. It is designed to minimize the power consumption.

The authentication micro controller hosts the authentication software DSA elliptic and the private key. The length of the key is 192 bits.

The EPROM has a capacity of 128 KO that is sufficient to record more than 1800 events and parameters. Furthermore, the memory stores parameters such as ID and specific code introduced at the factory and at a maintenance site of the inspectorate.

The Communication link, enables the data transfer between seal and seal reader. This is performed by radio frequency communication with a frequency of 470 MHz. It utilizes a standard protocol. The power consumption is some mA in communication and less than 1 μA in sleeping mode. The information transferred to the interrogating device is always authenticated between the seal and the seal reader and additionally encrypted in the case of remote monitoring. The access control utilizes the authentication technique, private/public key system. The advantage of this communication mode is to permit the verification of a seal placed into a glove box.

The serial line is RS 485 standards and the connector hosts the external power supply as well. The connector is watertight and easy to connect even with gloves.

The temperature sensor detects any sudden variation of temperature and records those variations. In addition it corrects automatically the measure of the cable resistivity. It is located close to the enclosure. Also the detection of abnormal variation of the temperature will be recorded before that the other components should be affected.

Batteries, are 3 R6 lithium type, in case of stand-alone mode. Batteries are exchangeable only during the maintenance of the seal. An additional back up battery ensures recording of events in case of main batteries failure.

The seal reader enables the inspector to attach detach and collect the seal authenticated data (status and performance) by remote data acquisition. The seal reader consists of a commercial portable computer notebook running a standard operating system Windows NT 4 and a specialized custom made interface device to establish the radio communication link to the seal.

The management software, is located in the seal reader. Seal data are stored, authenticated, evaluated by the management software, displayed on the screen with a possibility to print out tables for on-site inspections. The management software enables to produce inspection reports directly compatible with the IAEA seal database. The transmission to the remote monitoring station can be achieved directly from the seal by mean of authenticated serial line RS 485.

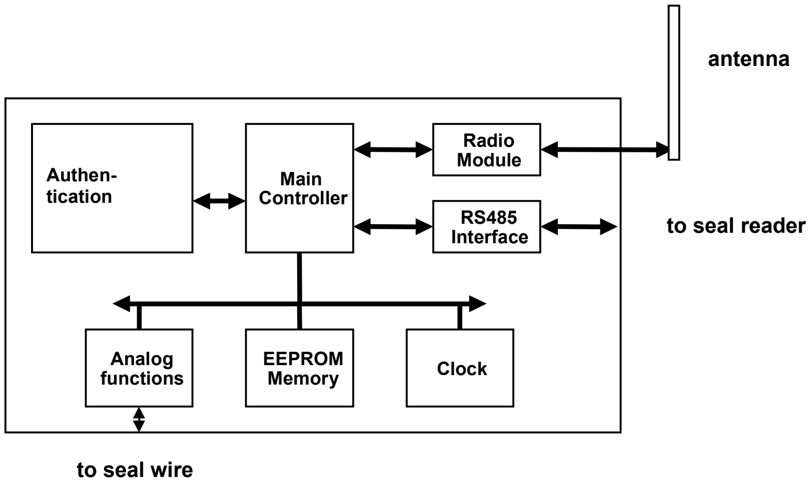

FIG. 2. Synoptic of electronics board.

EXPERIENCES FROM EXERCISES ASSOCIATED WITH NUCLEAR EMERGENCY RESPONSE IN GERMANY

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Responsibilities Regarding Emergency Response in Germany

In the Federal Republic of Germany, the 16 federal state Ministries of the Interior are responsible for emergency response (threat through weapons, explosives, etc.). In the case of threats due to radioactive material experts of the competent federal state radiological protection authorities are consulted. The Federal Office for Radiation Protection assists in serious cases of defence against nuclear hazards (nuclear fuels, criticallity, risk of dispersion).

Currently, exercises are being performed in all 16 federal states to co-ordinate the ways of behaviour, action and thinking of the various necessary organisational units, like police, deactivators, prosecution officials, radiological protection experts and fire brigade. The joint exercises serve the purpose to practise the total chain of necessary measures like: notification chain, organisation at the place of action, co-ordination of appropriate search strategy, investigation of who was responsible, analysis (X ray pictures, radiological analysis), activity determination, assessment of possible effects due to deactivation measures, determination of dispersion conditions, recommendation of measures for the protection of responders and the general population and measures to limit the consequences.

Given Exercise Scenario

Via the emergency emergency call a situation is transmitted that urgently demands joint and co-ordinated action of prosecution authority, emergency response and radiation protection authority, to be able to master the situation successfully. As a rule this means that one deals with an IED (Improvised Explosive Device) secured by a booby trap with added radioactive substances.

Organisation at the Place of Action

Experience shows that as a rule the patrol police and the local fire brigade will be the first to arrive at the place of action, already after a few minutes. Gradually, the other experts arrive. Depending on distance and traffic conditions, the radiological protection experts and the deactivators arrive only after hours. Problems of forming the operations management, finding office space for the operations management, parking space for the large fleet of cars, marking of organisational units, media work, etc. are described.

Search of the Depot of Radioactive Substances

Depending on the terrain detailed maps and a larger number of similar gamma and neutron measuring devices is required for the search for the radioactive material. A larger team must be used that can not necessarily be recruited, however, from radiation protection experts. Possibly, if the risk deems to be too great, even the adaptation of the measuring devices to remote-controlled manipulator vehicles is required. Necessary equipment, training and action are explained.

Analysis of the IED

The analysis in the given scenario urgently requires the joint efforts of deactivators and radiation protection experts. Otherwise, the deactivator can possibly not begin his work because of the radiation risk and the radiation protection expert because of the possible risk of explosion.

As a rule the deactivator will X ray the IED, the radiation protection expert will carry out a nuclide analysis, determine the activity content, to determine then the possible danger at the place of action and to the population. The delaboration with simultaneous minimisation of a possible dispersion of the radioactive substances requires a joint evaluation of the X ray by the deactivator and the radiation protection expert.

Investigation of Who Was Responsible

The exercises carried out so far have shown that not enough attention has been paid to the investigation of who was responsible. Frequently one deals with first offers of nuclear material, so that it would be very important to prosecute immediately possible persons behind, who could have in store even larger amounts of the material.

Also regarding the possibility to improve weak points of the facilities from which the material was stolen, successful prosecution work can be preventive.

Delaboration of the IED

The delaboration of an IED is a standard task for a deactivator team. If there have been added radioactive substances to the IED, however, as is the case of the given situation, every effort must be made to prevent a dispersion of these substances into the air. This requires a joint evaluation of the X rays of the IED by the deactivator and the radiation protection expert, to be able to fire the shot perfectly into the target. Furthermore, a concept has been developed by the Federal Office for Radiation Protection which by the help of foam avoids a dispersion of the radioactive substances into the air.

Decontamination of the Place of Action

Even if the IED does not explode the delaboration may result in a contamination of the foam and, thus, of small parts of the terrain. The German fire brigades are capable to capture and manage the contaminated foam without problems. In general, the exercises carried out until now have shown that the fire brigades are urgently required since they are best capable to provide the necessary infrastructure at the place of action, like e.g. ladders, water, foam, tools, energy supply, lighting, mobile offices and much more, within very short time.

Summary

Due to the exercises performed, all aforementioned points are analysed and proposals are made for a future problem situation.

SEARCHING PLUTONIUM FROM A TRAVELLING VEHICLE BY NEUTRON MEASUREMENTS

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For the search and detection of concealed nuclear material and neutron sources we have equipped a conventional car with a neutron measurement system. It consists of six neutron slab counters on each side. Each slab counter has a size of approx. 25 × 50 × 9 cm^3 and contains 6 He-3 tubes embedded in polyethylene covered by stainless steel. The active length of the tubes is 33 cm and the diameter 2.54 cm. The efficiency of all six slab counters on each side is 0.66 % for the detection of Cf-252 fission neutrons emitted from a point source in a distance of 100 cm from the center of the detectors. The complete system is mounted in a square steel rod assembly so that it can be fixed in most vehicles easily. Between the racks for the detectors we have fastened a voltage converter and the electronics. A view of this system installed into a car is shown in figure 1.

The pulses of the six modules on each side are summed passively and each side is analyzed separately. The results can be displayed on a handheld PC in the front of the car or in case of a covered search the data can be stored in a non-volatile memory in the electronics. For a clear location these data will be synchronized with a GPS signal.

FIG. 1. Car with neutron slab counters and accessory electronics.

A measurement performed with a car equipped with this neutron detection system is shown in figure 2. We placed a small neutron source (Cf-252) two meters away from the driving way of the car. The neutron intensity corresponds to less than 10 g reactor plutonium with a burn up of 30 GWd/t. The results show a very clear signal on the right side whereas the signal from the left row of the detector modules is only slightly above background.

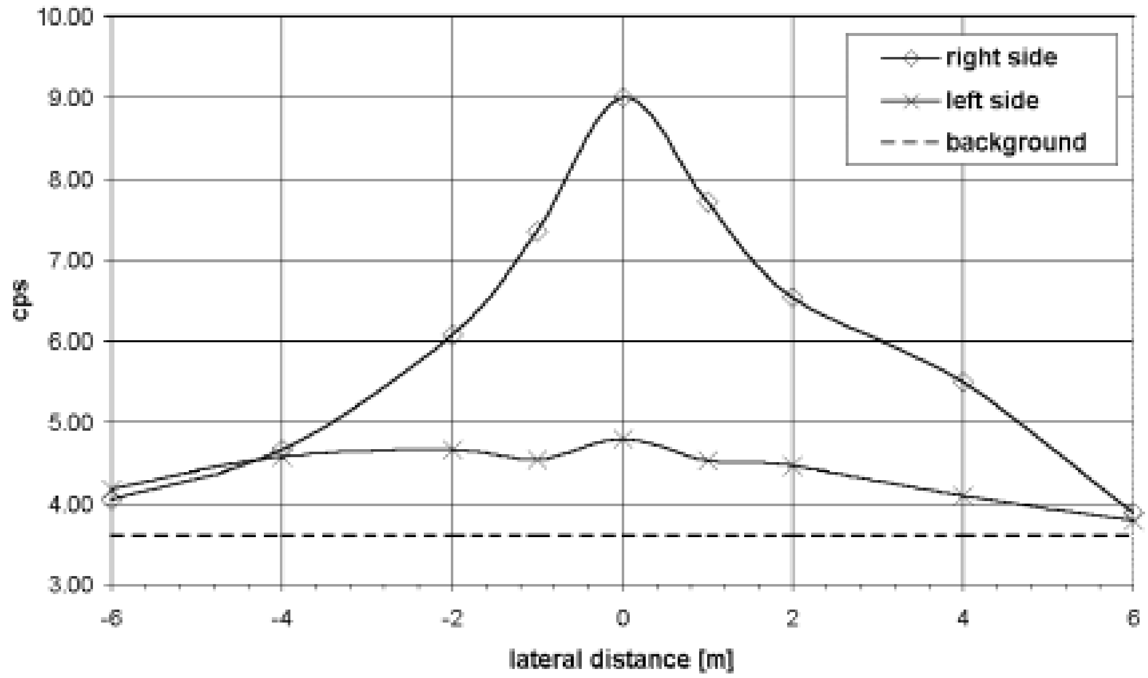

FIG. 2. Count rates from a Cf-252 source (activity 25.9 kBq), 2 m away from the right side of the car.

In addition we have performed measurements in practical operation. The typical neutron background was 10 cps on the test site. A neutron source (Cf-252) was hidden inside a house in the ground floor approx. 1 m above the floor. The neutron intensity of this source was 1.86 10^5 n/s (in 4π). This corresponds to about 530 g reactor plutonium (burn up of 30 GWd/t) or even less for higher burn up. In case of weapon grade plutonium this neutron intensity corresponds to a quantity of 3.5 kg. When driving slowly (velocity approx. 10 km/h) past the house in a distance of about 5 m a significant rise in count rate of up to 130 cps was monitored in the module row faced toward the house. Passing on the street in a distance of 10 m still a rise in count rate was monitored for velocities up to 10 km/h: we measured 25–30 cps.

For strong sources neutron coincidences may be measured in addition. If coincidences are recorded this is a clear evidence for fissionable material. The measurements show that such fissionable material can be detected clearly and easily from a car. This system may be used to discover illicit trafficking of nuclear material and to prohibit nuclear proliferation.

INTELLIGENT SOFTWARE SOLUTION FOR RELIABLE HIGH EFFICIENCY/LOW FALSE ALARM BORDER MONITORING

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ESM Eberline Instruments GmbH, Erlangen, Germany

Radioactivity Monitoring at border stations requires detection systems that are reliably operating under special conditions such as:

- different types and shapes of vehicles;
- different velocities;
- stop and go traffic.

ESM has developed a solution that achieves under all such conditions the lowest possible detection limit and avoids false alarms generated by naturally occurring radioactive material (NORM).

NBR (Natural Background Reduction) data evaluation

One of the main reasons for the success of the ESM gate monitors is the unique and proprietary NBR-technology of instantaneous discrimination of artificial and natural gamma radiation using large area plastic scintillators.

Thus the FHT 1388 gate monitors show 2 unique features:

- Possible setting of different alarm levels for NORM and artificial gamma sources.
- Self adjusting compensation of the background shielding of the truck in respect to the detection of artificial sources.

Both properties are a preposition for the highly sensitive detection of artificial gamma sources. While at scrap yards and steel mills usually all radioactivity (including NORM) must be detected, the main object of interest in respect to the measuring task at border stations, airports or harbours is clearly the detection of even very small signals of artificial radioactivity. The reliable rejection of the influence of natural radioactivity is of special importance in the case of detection of illicit trafficking, since construction material, fertilisers or soil often lead to much higher detector signals than the alarming levels for dangerous sources of interest.

Beside the varying content of natural radioactivity in the load of a truck, different loads and trucks show different influence on the reduction of the ambient radiation due to the passing vehicle. Thus software approaches assuming a specific reduction of the background countrate (regarding relative magnitude and shape) must fail when trucks of different shape and load pass through the gate. This is especially relevant for trucks with attached trailer, since the increase of background radiation between truck and trailer shows a very similar behaviour as a hidden radioactive source. In respect to the detection of artificial radiation, the NBR-technique allows a clear discrimination between these two scenarios, since the reduction of the natural background radiation does not alter the energy distribution which is in clear difference to the influence of any artificial radioactivity in the truck load.

The German customs have applied this technology to their detection systems installed at Hamburg because the original false alarm rate was absolutely unaccepted. Since installation of a system with NBR the station is operating nearly false alarms free with even better sensitivity that before.

Evidence for the necessity of rejection of alarms caused by natural background material is also described by IAEA in [2]. IAEA have carried out excessive field tests at the Hungarian/Austrian border and found that even at very high alarm rates (~ 2 × background) an unacceptable rate of false alarms has occurred which have mainly been caused by transportation of naturally occurring radioactive material.

The main and unique feature of the NBR technique is that a clear alarm can be generated well below the background level of the total count rate without any assumptions concerning the shape and shielding of the vehicle (and the load!).

Self adaption algorithms for different vehicle velocities, unknown source locations and variable ambient background radiation

The problem of optimising the measuring time which is dependant on an unknown angular velocity of the contamination/source (as described in [1]) has lead to the development of a self adapting evaluation algorithm. Due to the proprietary Advanced Digital Filter (ADF), no special adaptation is required for different distances and/or speed parameters of the source!

A self adaptation to the ambient background during the measurement is performed in respect to a symmetry consideration of opposite detectors for all radioactivity and in respect to the energy distribution (NBR analysis) for artificial radiation.

While no vehicle is present between the detectors, the background is updated with a ratemeter algorithm with adjustable time constant.

REFERENCES

[1] M.Iwatschenko-Borho M., Fritz J., Gagel A., Rieck W., Schapat W. “Illegal Transports of Radioactive Materials — a Challenge in the Field of Radiation Protection”, Austrian-Italian-Hungarian Radiation Protection Symposium, Obergurgl, Austria (1993).

[2] Beck, P., “ITRAP Illicit Trafficking Radiation Detection Assessment Program”.

REGIME OF PREVENTING, DETECTING AND RESPONDING TO UNAUTHORIZED ACTIONS IN MECKLENBURG-VORPOMMERN

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[1] Internal Ministry
[2] Environment Ministry

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In Germany the ensuring of safety for the population is at first the task of the countries. It also imposes to minimize the radiation risk to the public. Mecklenburg-Vorpommern is a country in North-East of Germany with coast length of 1470 km and 78 km boundary of European Community. MECKLENBURG-VORPOMMERN is a sparesly populated area with nearly 2 Million people in 23 500 km^2.

Concurrent with law ordinances and regulations by the Federal Government in MECKLENBURG-VORPOMMERN a system for preventing, detecting and responding to unauthorized actions with radioactive materials is prescribed by ordinance. This regime of preventing, detecting and responding to unlawful uses of radioactive material exists independent of the national system for the accountability, control and security of the materials.

1. RESPONSIBILITY

The authorities of defence — police and fire service — have to secure the place where the radioactive material is found or laid down together with a bomb. The authorities for atomic supervision are responsible for the clearing and elimination of the radioactive material, to combat illicit situation.

2. TO BE REACHABLE

In cases of finding, recognize or blackmailing of/ in connection with radioactive material the information arrives on civil way the police centre in the Internal Ministry. There upon is mobilized the working staff of defence and the staff of atomic supervision/measurement group being on standby duty on call.

3. EQUIPMENT

The policemen and firemen have dosimeter for self-safety.

The measurement group of the atomic supervision uses instruments and analyser for all different radiation situations. In this kind also there is worth mentioning the connection with remote handling systems of the defuser of munitions. Last kind can be important in cases of blackmailing.

4. WHEREABOUTS UNAUTHORIZED MATERIAL

Unauthorized radioactive material with unknown owners must be storied under separate conditions. Confiscated material, which isn't nuclear material, can be storied in a country own storage for radioactive materials, are wastes out of the nuclear industry.

Confiscated nuclear material must be send to the Institute for Transuranium of the European Community, Karlsruhe.

5. SOLVE THE CRIME PROBLEM

Because unauthorized radioactive material exists out of the law, a criminal offence must be prosecuted and solved. Consequently the public persecutors are present at the point of finding or confiscating the radioactive material.

In our land are discovered some pieces of radioactive materials occasionally on military areas of earlier sovjetunion army.

In all situations, when the system with radioactive material is not identified exactly by his appearance, the specialists of defuser of munitions have to proof the system.

Often there came loads of contaminated scrap-metal from east European countries on the border. This problem must be cleared under aspects of radiation protection.

An examination of this regime we try to practise in 2001.

QUANTITATIVE NON-DESTRUCTIVE ASSAY AND IDENTIFYING THE MATRIX OF UNKNOWN NUCLEAR MATERIAL

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A gamma-spectrometric method for determining the total nuclear material content of homogeneous nuclear-material pellets or powder of unknown origin with a total uncertainty of less than 2% is presented. From these results the matrix of the samples is identified for certain uranium compounds (U_3O_8, UO_2, uranium-nitrate and uranil-acetate).

The total nuclear material mass, *M*, is found form the count rate *C* at the 1001keV line of ^{234m}Pa (daughter of ^{238}U). Since the samples of interest are not infinitely thick for the assay energy, one can write,

$$M = K\frac{C}{F} \ ,$$

where *F* is the self-attenuation correction factor of the sample while *K* is a calibration constant which is determined by using a series of standard U_3O_8 sources (EC Nuclear Reference Material Set 171). The assay geometry of interest is the situation in which a cylindrical detector views a cylindrical sample, the two cylinders having a common axis of symmetry. If the radii of both the detector and the sample are much smaller than the source-to-detector distance, then the deviation of the gamma rays from the direction parallel to the system axis is negligible. In this case the set-up can be approximated with a one-dimensional model. Then the self-attenuation correction factor can be approximated as

$$F = \frac{s^2}{L}\int_0^L \frac{e^{-\mu x}}{(s+x)^2}dx \ ,$$

where *L* is the length of the sample, *s* is the distance from the sample to the detector, *x* is the distance a gamma-ray travels within the sample and μ is the linear attenuation coefficient of the examined material.

The count rate *C* was measured for five standard samples of U_3O_8 powder and a calibration constant was determined for 10cm, 20cm, 30cm, and 60cm source-to-detector distance. It was established that in our set-up 20cm is the minimum distance at which the one-dimensional model is correct. The linear attenuation coefficient of the unknown samples is determined by placing a standard europium source behind the examined material. For the measurements we used a coaxial high purity germanium detector with an active volume of 46cm^3. Pellets arranged into a hexagonal lattice or powder of the unknown samples are placed into a same type of container as the container of the standard samples. From the intensity of the 1001keV line the mass of ^{238}U can be calculated using the calibration. The ^{235}U enrichment values for the unknown samples were calculated by using the Multi-Group Analysis code for Uranium (MGAU). If the ^{235}U enrichment is known the total uranium content can be calculated.

By the usage of standard sources the results of the measurements are independent of the detector efficiency and of the branching ratio of the assay energy so the uncertainties which are usually involved in determining these quantities are avoided. The convenient geometrical set-up makes possible the simple measurement of the linear attenuation coefficient μ and the exact calculation of the factor F. Furthermore, a small error in the value of μ (and therefore in F) induces an even smaller error in the value of M. This way a total relative uncertainty of less than 2% could be achieved for the measured value of the total uranium content of the samples. On the other hand, this precision makes possible the determination of the matrix on the basis of the total uranium content. Namely, dividing the uranium mass by the total mass of the sample, which is determined by weighing the examined samples, the relative uranium content is obtained. Its value uniquely characterises the matrix of the unknown material, provided that the material is not a mixture and that the measurements are sufficiently precise, as the figure bellow shows.

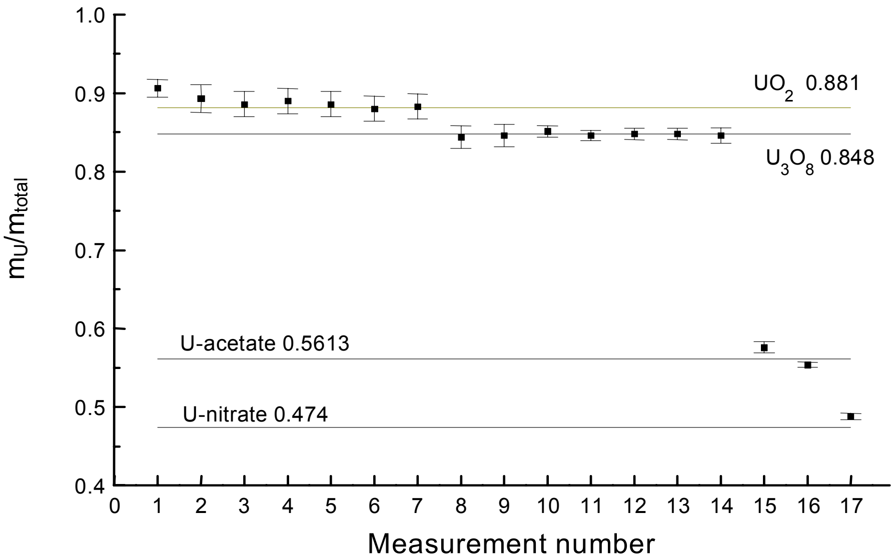

FIG. 1. Relative uranium content measured for homogeneous samples of different uranium compounds. The horizontal lines indicate the theoretical values.

REFERENCES

[1] T.E. Sampson and J.L. Parker, Applications of gamma-ray spectroscopy in quantitative non-destructive assay of special nuclear materials, *Nucl. Inst. Meth. Phys. Res. A*, 229, (1990), 327-334.

[2] D. Reilly, N. Ensslin and H. Smith, Jr., eds., *Passive Nondestructive Assay of Nuclear Materials* (Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, 1991).

MEASURES TO PREVENT ILLICIT USERS OF RADIOACTIVE SOURCES AND NUCLEAR MATERIAL IN LITHUANIA

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The government of every county, depending on it's economic recourses, attaches a great important to the radiation protection and safety of population. And one of the instruments, that helps in realization of this problem is to create a system in the country, that prevents possibility to illicit use sources of ionizing radiation.

It was very important task to create such system, after Lithuania gets back the independence in 1991. Because of geographic location the Lithuania becomes a transit country of illicit transport of radioactive materials from Russia, Ukraine and other former Soviet states in to western countries. At the same time it was very important to ensure the safety of the sources (that means to ensure from steal, plunder, loose, etc.) because the former system disintegrates, companies become bankrupt.

It was developed the System to solve such problem. Under the requirements of legal acts there were prescribed (delegated) functions of State institutions in order of competence in solving the problems to ensure Radiation Protection.

Under the requirements of the Law on Radiation Protection, Radiation Protection Center is the main institution in Lithuania responsible for solving the problems of Radiation Protection of population from the harmful effects of ionizing radiation.

The responsibilities and obligations of the users of the sources were definited in legal acts:

1. The Law on Nuclear Energy.
2. The Law on Radiation Protection.
3. The Law on Radioactive Waste Management.
4. The Law on Changes and Appendices if the Code of the Administrative Law Violations.
5. On the Establishing the State Register of the Sources of Ionizing Radiation and Exposure of Workers, Governmental Resolution.
6. On the Confirm an Regulation of Licensing the Practices with Ionizing Radiation Sources, Governmental Resolution.

After approval of the State Register of the Sources of Ionizing Radiation and Exposure of Workers, all the users of sources of ionizing radiation have to present the necessary data to the Radiation Protection Center after annual inventory of the sources, after installation of new sources, after decommissioning and etc. The Customs Department every week presents the information about all the sources of ionizing radiation, that were imported to or exported from Lithuania and the information on the companies, that made these procedures.

Under the requirements of the Law on Radiation Protection all activities with the sources of ionizing radiation is prohibited without license.

86 border checkpoints are supplied with control dosimeter equipment. There are plans to establish 103 ones, the same as 18 stationary check gates.

GLASS FIBER SENSORS FOR DETECTING SPECIAL NUCLEAR MATERIALS AT PORTAL AND MONITOR STATIONS

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United States of America

Nuclear Safeguards and Security Systems LLC (NucSafe) participated in the Illicit Trafficking Radiation Assessment Program (ITRAP) recently conducted by the Austrian Research Center, Seibersdorf (ARCS) for IAEA, INTERPOL, and the World Customs Organization (IAEA, *in press*). This presentation reviews ITRAP test results of NucSafe instrumentation. NucSafe produces stationary, mobile, and hand-held systems that use neutron and gamma ray sensors to detect Special Nuclear Materials (SNM). Neutron sensors are comprised of scintillating glass fibers (trade name 'PUMA' for Pu Materials Analysis), which provide several advantages over ^{3}He and $^{10}BF_3$ tubes. PUMA ^{6}Li glass fiber sensors offer greater neutron sensitivity and dynamic counting range with significantly less microphonic susceptibility than tubes, while eliminating transport and operational hazards. PUMA sensors also cost less *per* active area than gas tubes, which is important since rapid neutron detection at passenger, freight, and vehicle portals require large sensor areas to provide the required sensitivity.

Two PUMA glass fiber neutron and gamma ray sensor systems were designed that exceed the ITRAP detection and ancillary requirements for continuous SNM monitoring of: *1)* vehicles and *2)* pedestrians. Monte Carlo and first principal calculations were applied to model detection limits for both systems; e.g. Figure 1 displays modeling results for the glass fiber neutron sensors evaluated for the Vehicle Monitoring System. Accounting for Poisson variability of data (± 3.29 sigma) and an alarm set point of 5.2 sigma over background, required for reasonably low false alarm rate, at 3 meters WGPu is unquestionably detected in <4 seconds.

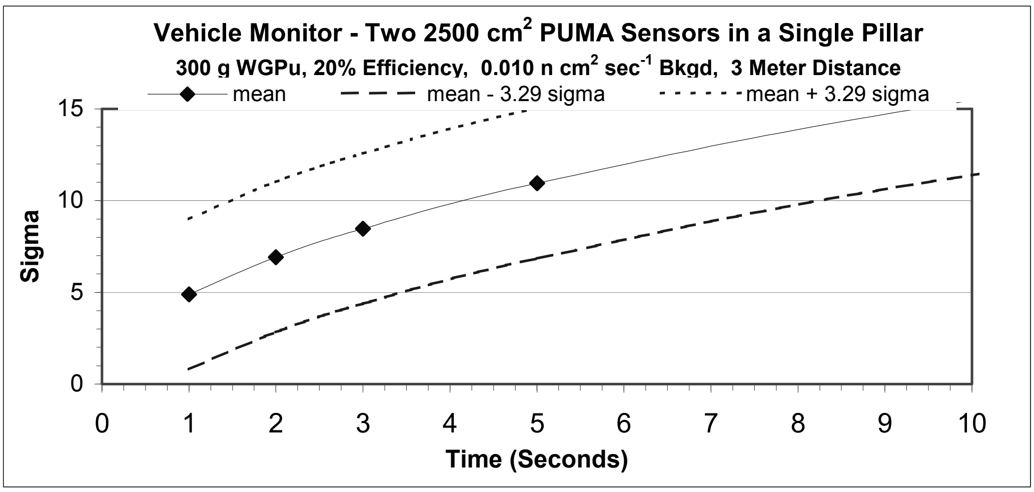

FIG. 1. A plot of net counts divided by background standard deviation (Sigma) versus time shows that neutrons from 300 grams of WGPu can be detected at a distance of 3 meters within 1 second and is unquestionably detected in < 4 seconds.

Additional modeling results (not shown) demonstrate that a Pedestrian Portal Monitor with a 2500 cm^2 PUMA detector detects 20 grams of WGPu at a distance of 50 cm in 1 second, 10 grams in 2 seconds, and 5 grams of WGPu in 8 seconds. Assumptions used in these models include a neutron background flux of 0.010 n cm^{-2} sec^{-1}, an intrinsic neutron efficiency of 20%, a 5.2 sigma false alarm rate, which represents one false alarm *per* month, and Poisson variability. These model results confirmed the designed systems are capable of reliably detecting SNM and other radionuclides within seconds. Neutron measurements collected with ^{252}Cf in elevated gamma ray fluxes validated the calculated data. Vehicle and Pedestrian SNM Monitors based on these designs then were produced and submitted for ITRAP evaluation. Both NucSafe "fixed installed" portal monitors were evaluated during ITRAP laboratory and field testing. The gamma ray detection sub-systems were evaluated in laboratory tests using a 0.2 μSv hr^{-1} ^{137}Cs background and required the sensitivity to detect an increase of 0.1 μSv hr^{-1} over a gamma energy range of 60 to 1500 keV for duration of 1 second (tested with ^{241}Am, ^{137}Cs and ^{60}Co). Laboratory neutron testing was with a gamma-shielded 0.01 g ^{252}Cf source emitting ~20000 n sec^{-1}. This ^{252}Cf source had to be detected over a 5 second duration at a distance of 2 meters. False positives had to be <1 *per* 10 000 measurements and false negatives <1 *per* 1000. Systems that passed all laboratory tests were then field tested. Field testing the vehicle monitor at the Austrian Nickelsdorf border station required detection of both gamma rays and neutrons from vehicles that could maintain speeds of 8 km hr^{-1}, ~3 meters from the single pillar detection system. The NucSafe Pedestrian Portal SNM monitor was field tested at the Vienna International Airport. Pedestrians could walk past the monitor without slowing their pace. NucSafe vehicle and pedestrian SNM monitors passed or exceeded all ITRAP test requirements (figure 2).

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CERTIFICATE

This document certifies that the PUMA fixed installed monitoring system developed and produced by NUCSAFE, Clinton, Tennessee, USA was tested during the Illicit Trafficking Radiation Detection Assessment Program (ITRAP) conducted by the Austrian Research Centers Seibersdorf (ARCS) in co-operation with the International Atomic Energy Agency (IAEA), the World Customs Organization (WCO) and the International Criminal Police Organization (INTERPOL), between September 1997 and June 2000. The test procedures were performed in accordance with the ITRAP minimum requirements laid down in the IAEA Technical Manual on Detection of Radioactive Material at Borders.

This instrument has met or exceeded all ITRAP minimum requirements for the detection of nuclear and other radioactive material as set forth in the IAEA Technical Manual on Detection of Radioactive Material at Borders.

Austrian Research Centers, Seibersdorf, AUSTRIA

July 7, 2000

Prof. Dr. Klaus E. Duftschmid
Technical Program Officer - IAEA

Dipl.-Ing. Dr. Christian Schmitzer
Head Health Physics Department - ARCS

Dipl.-Ing. Dr. Peter Beck
Technical Project Manager - ARCS

FIG. 2. Certificate issued by Austrian Research Centers, Seibersdorf (ARCS) to NucSafe for "fixed installed" systems, which met or exceeded all ITRAP testing requirements for the detection of nuclear materials as set forth in the IAEA Technical Manual on Detection of Radioactive Materials at Borders (in press).

IAEA-CN-86/65P

THE USE OF MERCURIC IODIDE IN INSTRUMENTS FOR SAFEGUARDS AND NON-PROLIFERATION APPLICATIONS

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Mercuric Iodide is a material exceptionally suited for solid state detectors operating at room temperature. The high density and the high atomic numbers of the constituent elements provide a large absorption factor and a high full-energy-peak efficiency at gamma ray energies. The large electronic bandgap results in a very high resistivity and therefore a low leakage current at temperatures within and outside the personal comfort range.

Constellation Technology has developed the technology to grow large, high quality crystals from mercuric iodide. Spectrometry grade detectors with dimensions of 25 mm × 25 mm × 3 mm and with an energy resolution of approximately 3% FWHM at 662 keV can be fabricated from these mercuric iodide crystals. The spectral resolution is primarily determined by the transport properties of the holes that at present still have relatively low values. When radiation of lower energy needs to be measured, it is possible to reduce the thickness of the detector and still maintain an acceptable detection efficiency. The spectrum of a 1.5 mm thick detector is shown in figure 1. The resolution of this detector approximately 1.8% FWHM and the peak-to-valley ratio is larger than twelve. Standard semi-Gaussian processing and no pulse-shape discrimination was used [1].

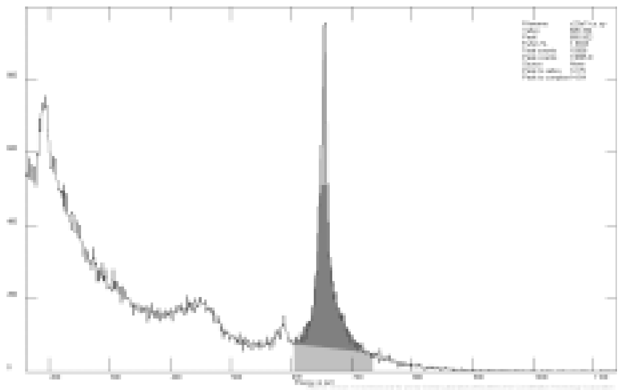

FIG. 1. Cesium Spectrum of Mercuric Iodide Detector

These detectors can be conveniently incorporated into hand-held instruments to detect weak sources or heavily shielded sources. Previous measurements have shown that the Minimum Detectable Activity (MDA) of a 3 mm thick mercuric iodide detector with dimensions as given above is about 10% less than the MDA of a 50 mm × 50 mm sodium iodide detector, due to the superior energy resolution [2]. Software methods are being developed to improve the identification of weak sources against a large background. Results of these measurements will be presented.

Smaller detectors can be used in safeguards applications where the intensity of the radiation is relatively high. The spectral resolution of the detectors is high enough to clearly identify the significant energy lines in the spectra of stored uranium and plutonium. The shape of the spectral peaks is constant over a large range of energies so that existing software systems can be used to analyze the spectra. The small size, ruggedness, temperature stability and high efficiency of these detectors makes them good candidates for hold-up measurements in piping and chemical processing facilities.

The detectors can be incorporated in modules that are geared to the specific applications. The standard module is shown in figure 2. It incorporates the detector and the front-end electronics. The module has three standard connectors for high voltage, signal output and power for the preamplifier.

FIG. 2.–Mercuric Iodide Detector Module.

REFERENCES

[1] VAN DEN BERG, L., VIGIL, R.D., "Fabrication of Mercuric Iodide Detectors", Proceedings of 11th International Workshop on Room Temperature Semiconductor X ray and Gamma Ray Detectors and Associated Electronics, NIM, (in print).
[2] QUAM, W.A., Special Technologies Laboratory, Bechtel Nevada; private communication.

COMPARISON OF LINEAR DECOMPOSITIONAL TECHNIQUES WITH ROBUST FITTING ANALYSIS FOR APPLICATIONS TO DETECTION OF ILLICIT TRAFFICKING OF SPECIAL NUCLEAR MATERIALS

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In a companion paper [1], the limits of detection for a special nuclear material of particular concern, ^{239}Pu, using an advanced high-pressure xenon detector (HPXe) and robust fitting analysis (RFA), are experimentally determined for a set of spectra with two different source strengths relative to the background and for collection times ranging from 8 minutes to 7.5 seconds. In this paper, the advantages and disadvantages of the application of another technique, linear decomposition (LD), are experimentally investigated and compared using the same set of data. It is found that while RFA, described in [2], clearly has the potential of the most sensitive detection capabilities, LD analysis may be better suited to applications in first-line customs applications due to its relative simplicity, speed, and small demand on processor and memory. RFA, on the other hand, appears to be the better choice of methods where at the level of higher echelons of response, time, specialized training, and greater computational resources are less of a concern compared to the need for the best possible analytical results.

HPXe detectors of the type used in this experiment are attractive candidates for portal monitoring systems because of their relative insensitivity to temperature changes and rough treatment, their full-energy peak efficiency over a wide range of energies, and their excellent energy resolution (1.9% at 662 keV with 3.0% efficiency and 1.3% at 1332 keV with 0.7% efficiency) without the need for cryocooling [3,4,5]. A disadvantage of HPXe detectors for field use has been their susceptibility to degraded resolution when subjected to acoustic influences, but significant progress recently has been made with HPXe vibrostability showing negligible degradation in resolution with acoustic noise up to 70 dB [5].

The technique of linear decomposition is best described as a process that finds the best linear combination of the spectra from a reference library that combines together in relative proportions to compose the spectrum of interest, the "sample spectrum." Linear decomposition analysis is based on well-known methods of least-squares analysis described, for example, in [6]. As implemented in this paper, linear decomposition analysis uses well-known methods of least squares best fits and relies on Cholesky matrix inversion for a fast and stable solution of a large simultaneous set of linear equations. The matrix inversion, which is required to find the best set of linear coefficients of the library spectra to compose the sample spectrum, also yields the uncertainties in those coefficients in precise and well-understood mathematical terms. Thus, the inspector is informed not only of the most probable composition of the sample spectrum in terms of the spectra in the reference library but also of the estimated uncertainty of the results for each of the constituents. The ratio of the coefficient to the uncertainty for each constituent is used as a figure of merit, which here is called significance, to determine whether a particular isotope is present, whether it is not present, or whether its presence cannot be determined without a longer collection time. Finally, the linear combination of all reference spectra is reconstructed and compared to the sample spectrum to determine how well the sample is or is not composed of the reference spectra in terms of chi-square. If chi-square is too large, the analysis is declared invalid. Such invalidity can be due, for example, to the presence of an isotope in the sample that is not present in the reference library or due to an energy calibration that is not within specification. The result is that the inspector is informed whether or not the analysis is valid and, if so, of the confidence he may have in how much of each of the reference library isotopes is present in the sample spectrum. While LD is not able to take advantage of the extremely sensitive non-linear capabilities of RFA, it offers the advantages of speed (less than 2 seconds for analysis), simplicity (well-understood mathematics), and ease of use (a single, automated, non-interactive step). Like RFA, LD is capable of detecting the presence of multiple isotopes, each having very different activities, in a sample and, by the inclusion in the library of shielded spectra, of detecting the presence of shielded isotopes.

The plutonium source contained 1 gram of ^{239}Pu at a distance of 73 cm from the detector. The uranium source consisted of 8 grams of ^{235}U at a distance of 42 cm from the detector. To evaluate the ability to detect shielded sources with LD analysis, three spectra were included in the LD reference library for both ^{235}U and ^{239}Pu with attenuating thicknesses of lead ranging from zero to two millimeters. Additional spectra of ^{137}Cs, ^{133}Ba, and ^{60}Co were included in the LD reference library to test the ability of the LD method to discriminate between mixed sources and to test for false positive results.

The same 84 spectra that were analyzed with RFA for the companion paper were analyzed with LD analysis for this paper. These spectra were generated to correspond to a range of conditions typical of portal monitoring operations. The test spectra simulated an inspection 1 gram of unshielded ^{239}Pu at distances of 73 cm and 200 cm, with collection times for both distances ranging from 8 minutes to 7.5 seconds. The results of the LD analyses were then compared to the same results using RFA.

Statistical theory states that if an analysis process is valid, on the average the reduced chi-square will have a value of 1.00. With RFA in the companion paper, a maximum reduced chi-square of 2.30 was chosen as a value above which an analysis would be considered invalid. Although some of the chi-square values for the 84 RFA analyses in the companion paper exceeded the 2.30 reduced chi-square threshold, none of the chi-square values for any of the 84 LD analyses exceeded a value of 1.50. The values for reduced chi-square for the LD analyses at 73 cm ranged from 0.83 to 1.27 with the 7.5-second analyses having the lowest reduced chi-square values. The values for reduced chi-square for the LD analyses at 200 cm ranged from 0.59 to 1.49 with the 7.5-second analyses again having the lowest reduced chi-square values. Unlike RFA, LD analysis also yielded no results that were considered invalid due to computational problems.

Tables I and II show the significance of ^{239}Pu for each of the analyses, while Table III shows the background significance at 200 cm. Significance is the ratio of the coefficient to the uncertainty. Experience has shown that a significance of 4.0 or greater is a strong indicator of reliable detection, whereas a significance of 2.5 often indicates that a longer survey time is warranted. The significance for the detection of 1 gram of ^{239}Pu at 73 cm ranged from 6.96 to 103.95. The fact that these extremes do not correspond to the shortest or longest collection times, respectively, is a result of the random processes in nuclear spectra. The random processes in nuclear spectra also explain why different significances are found for spectra with the same collection time. All of the 73-cm spectra detected the ^{239}Pu with a significance greater than 4.0; but for the 200-cm spectra, only the 8-minute surveys consistently detected the ^{239}Pu with a significance greater than 4.0. However, in the 8-minute surveys at 200 cm, an indication (significance greater than 2.5) of ^{239}Pu always was reported after 1 minute, prompting further investigation.

None of the reference library spectra that were known not to be present were falsely reported as being positively present with a significance greater than 4.0. However, there were a total of 3 instances (out of the 84 LD analyses) in which a false indication of the possible presence of a library isotope was reported with significance between 2.5 and 4.0. In practice, in these three instances only, the inspector would continue his survey for a longer time until the analysis would yield a result either below 2.5 or above 4.0 for the isotope in question.

Table I. Detection Significances for Analyses of Spectra of 1 Gram of ^{239}Pu at 73 cm

Time	8 Min	4 Min	2 Min	1 Min	30 Sec	15 Sec	7.5 Sec
Series 1	36.65	20.30	93.22	65.65	22.90	7.91	15.78
Series 2	51.55	103.95	92.88	51.43	35.58	25.17	20.83
Series 3	100.38	65.69	71.24	64.33	6.96[1]	32.29	7.47
Series 4	49.80	35.77	17.69	49.25	46.39	30.98	22.07
Series 5	101.60	33.65	92.25	50.72	33.90	25.18	7.43
Series 6	84.65	101.05	92.48	65.20	45.91	43.01	29.68

[1] False indication of ^{235}U (0 mm Pb shielding) with a significance of 3.42.
Note: Except as noted in 1 above, all of the 8 library spectra that were not present in the sample spectrum were indicated with significances less than 2.50 in each of the 42 sample spectra that were analyzed.

Table II. Detection Significances for Analyses of Spectra of 1 Gram of ^{239}Pu at 200 cm

Time	8 Min	4 Min	2 Min	1 Min	30 Sec	15 Sec	7.5 Sec
Series 1	11.45	2.99	4.33	3.86	2.41	1.75	1.08
Series 2	7.04	8.02	2.85	2.32	4.02	2.64	1.13
Series 3	7.81	3.59	2.82	3.30	2.08	1.54	0.00
Series 4	9.07	2.88[1]	6.07	3.85	3.20	0.70	0.56
Series 5	10.27	4.34[2]	4.87	3.90	2.68	2.93	1.37
Series 6	10.31	5.31	5.32	4.09	1.17	2.23	0.00

[1] False indication of ^{235}U (0 mm Pb shielding) with a significance of 2.77.
[2] False indication of ^{235}U (1 mm Pb shielding) with a significance of 3.03.
Note: Except as noted in 1 and 2 above, all of the 8 library spectra that were not present in the sample spectrum were indicated with significances less than 2.50 in each of the 42 sample spectra that were analyzed.

Table III. Detection significances for Background

Time	8 Min	4 Min	2 Min	1 Min	30 Sec	15 Sec	7.5 Sec
Series 1	24.88	8.91	6.93	9.33	6.72	4.43	0.00
Series 2	14.50	16.96	9.33	2.34	4.70	2.70	1.05
Series 3	30.24	10.76	7.58	4.39	5.87	1.12	1.78
Series 4	28.80	9.88	12.54	9.75	4.53	5.41	1.77
Series 5	27.46	9.96	6.11	9.58	2.05	2.86	1.43
Series 6	27.71	9.58	12.61	6.99	3.40	2.49	9.73

In summary, analyses of ^{239}Pu spectra using the method of linear decomposition were compared with results using the method of robust fitting analysis. Additional spectra were added to the LD library to test multisource discrimination and false positive rates. No false positives were indicated, but three false indications did occur for which the inspector would remedy on the spot by surveying for a longer time. It was observed that if a survey can be made from a little closer (73 cm compared to 200 cm) to the target, the required time to produce a confident result is much less (7.5 seconds compared to 8 minutes). Based on these analyses, the technique of linear decomposition appears to be well suited for applications to the first-line detection and classification of illicit nuclear materials in the field due to its simplicity (easy-to-learn interface), speed (less than 2 seconds), and ease of use (a single, automated, non-interactive step) while retaining not only excellent sensitivity but also well-understood results in terms of probabilities and statistics. RFA, on the other hand, is generally more sensitive and comprehensive but requires greater expertise and more time to take advantage of its full potential making it more suitable for use by more sophisticated analysts once initial detection and classification have been accomplished.

REFERENCES

[1] G.P. Lasche, R.L. Coldwell, C.J. Cray, V.V. Dmitrenko, S.E. Ulin, V.M. Gratchev, D.V. Sokolov, Z.M. Uteshev, K.F. Vlasik, S. Haan, and S. Hustache, “Limits of Detection for Special Nuclear Materials with an Advanced High-Pressure Xenon Detector and Robust Fitting Analysis,” *Proceedings of the International Conference on Security of Material*, Stockholm, Sweden, May, 2001.

[2] R.L. Coldwell and G.J. Bamford, *The Theory and Operation of Spectral Analysis Using ROBFIT*, New York: American Institute of Physics, 1991.

[3] S.E. Ulin, V.V. Dmitrenko, V.M. Gratchev, O.N. Kondakova, S.V. Krivov, Z.M. Uteshev, K.F. Vlasik, Y.T. Yurkin, and I.V. Chernysheva, "A Cylindrical Ionization Chamber with a Shielding Mesh Filled with Xenon Under a Pressure of 50 Atmospheres", *Instruments and Experimental Techniques*, Volume 38, Number 3, Part 1, pages 326-330, 1995.

[4] K.F. Vlasik, V.M. Gratchev, V.V. Dmitrenko, S.E. Ulin, and Z.M. Uteshev, "High-Pressure Xenon Y-ray Spectrometers," *Instruments and Experimental Techniques*, Volume 42, Number 5, pages 685-693, 1999.

[5] V.V. Dmitrenko, I.V. Chernysheva, V.M. Gratchev, O.N. Kondakova, K.V. Krivova, S.E. Ulin, Z.M. Uteshev, and K.F. Vlasik, “Vibrostability of High-Pressure Xenon Gamma-Ray Detectors", 1999 IEEE NSS/MCI Conference Record, Seattle, WA, USA.

[6] [6] Philip R. Bevington and D. Keith Robinson, *Data Reduction and Error Analysis for the Physical Sciences*, Second Edition, WCB/McGraw-Hill, New York, 1992.

[7] G.P. Lasche, V.V. Dmitrenko, S.E. Ulin, S. Haan, S. Hustache, V.M. Gratchev, D.V. Sokolov, Z.M. Uteshev, K.F. Vlasik, R.L. Coldwell, and C.J. Cray, “Detection Sensitivity for Special Nuclear Materials with an Advanced High-Pressure Xenon Detector and Robust Fitting Analysis”, *IEEE Transactions in Nuclear Science*, in press.

LIMITS OF DETECTION FOR SPECIAL NUCLEAR MATERIALS WITH AN ADVANCED HIGH-PRESSURE XENON DETECTOR AND ROBUST FITTING ANALYSIS

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The limits of detection for a special nuclear material of particular concern, ^{239}Pu, using an advanced high pressure xenon detector (HPXe) and robust fitting analysis (RFA) was experimentally determined for a set of spectra with two different source strengths relative to the background, and for collection times ranging from 8 minutes to 7.5 seconds. The analysis of this data provides complementary information to recent results [1] in which the same source was attenuated with varying thicknesses of lead shielding ranging from zero to four millimeters. The objective of these studies is to better understand the advantages and limitations of using this combination of technologies in nuclear portal monitoring systems to directly detect illicit trafficking of sensitive nuclear materials.

HPXe detectors of the type used in this experiment are attractive candidates for portal monitoring systems because of their relative insensitivity to temperature changes and rough treatment, their full-energy peak efficiency over a wide range of energies, and their excellent energy resolution (1.9% at 662 keV with 3.0% efficiency and 1.3% at 1332 keV with 0.7% efficiency) without the need for cryocooling [2,3,4]. A disadvantage of HPXe detectors for field use has been their susceptibility to degraded resolution when subjected to acoustic influences, but significant progress recently has been made with HPXe vibrostability showing negligible degradation in resolution with acoustic noise up to 70 dB [4]. The cylindrical HPXe detector used in the experiment was modeled after the one described in [4], and differed only in that it had one, not three, rectangular cells. It contained 1.73 liters of xenon gas with 0.3% H_2 at a density of 0.25 g/cm^3.

In RFA analysis, the change in shape of the entire spectrum due to all the peaks of each isotope is fitted to the data as a single variable. RFA in this mode is a relatively new approach to nuclear spectral analysis, and is based on non-linear robust fitting techniques [5]. Exceptional results with weak plutonium sources using RFA recently have been reported [6,7] and with low-resolution CZT spectra [8], and significant increases in detection sensitivity with RFA have been reported in comparison with conventional peak-search data analysis methods [9].

A spectrum was collected at CEA/Saclay with an HPXe unit from MEPhI from a 1-gram ^{239}Pu source at a distance of 73 cm from the detector for 2450.5 seconds. A background spectrum with the source removed was taken for 2451.1 seconds. The source spectrum and the background spectrum were sampled using random sampling of a probability distribution to produce statistically-correct spectra taken for shorter collection times. This process was used again to produce a similar set of spectra but for a weaker source relative to the background. This weaker source corresponded either to a 0.13-gram source at a distance of 73 cm or to a 1.0-gram source at a distance of 200 cm. The objective was to produce a set of spectra with collection times and distances more typical of portal monitoring operations.

Because nuclear spectra are variable due to random processes, spectra taken under identical conditions for short collection times and of weak sources can yield very different results when analyzed. To get an idea of how reliably weak sources with short collection times can be detected, six spectra were generated using the process described above for each of the seven collection times and for each of the two distances.

The series of six spectra for each of the two source distances and for each of seven collection times were then analyzed with RFA methodology to determine the limits of detection sensitivity as a function of source distance and collection time. Care was taken to the same one-step analysis with the same set of analysis parameters that were used in [1]. Better results can be achieved by using full interactive step-by-step analysis with varying parameters, but the automated, non-interactive, one-step analysis method was used to be consistent with the needs and realities of portal monitoring inspections for illicit trafficking of nuclear materials.

When an RFA analysis step is applied to a spectrum with very few counts, an unreliable result often can occur due to the random nature of radioactivity. In an interactive analysis, the analyst is able to appraise an analysis visually and make necessary corrections for the next step. However, for portal monitoring situations, an automated analysis procedure is required. Therefore, a maximum reduced chi-square was used to judge whether each analysis was reliable or not. The full set of 84 analyses for this study were visually appraised and a maximum reduced chi-square of 2.20 was found to lead to the rejection of only one visually acceptable analysis and to the acceptance of only one visually unacceptable analysis. Tables I and II show the significances of detection of ^{239}Pu for each of the analyses. Significance is the ratio of the area of all ^{239}Pu peaks to its own uncertainty. Experience has shown that a significance of 4.0 or greater is a strong indicator of reliable detection, whereas a significance of 2.5 often indicates that a longer survey time is warranted.

Table I. Detection significances for analyses of spectra of 1 gram of ^{239}Pu at 73 cm. Dashes indicate either a failed analysis or an unreliable result as indicated by a reduced chi-square exceeding 2.20

Time	**8 min**	**4 min**	**2 min**	**1 min**	**30 sec**	**15 sec**	**7.5 sec**
Series 1	18.30	13.30	14.70	10.30	7.60	7.68	2.64
Series 2	24.00	--	15.60	--	9.52	4.40	4.82
Series 3	--	17.30	14.80	--	5.14	--	1.48
Series 4	25.90	18.50	13.70	11.40	9.26	5.40	2.50
Series 5	26.30	19.60	16.50	11.20	6.14	--	5.02
Series 6	26.90	16.40	--	--	9.05	5.27	--

Table II. Detection significances for analyses of spectra of 1 gram of ^{239}Pu at 200 cm. Dashes indicate either a failed analysis or an unreliable result as indicated by a reduced chi-square exceeding 2.20

Time	**8 min**	**4 min**	**2 min**	**1 min**	**30 sec**	**15 sec**	**7.5 sec**
Series 1	7.01	4.53	9.14	2.83	--	--	--
Series 2	7.52	11.00	1.19	--	4.97	--	0.16
Series 3	--	8.25	4.02	--	2.08	2.11	1.07
Series 4	6.33	6.35	5.29	2.76	--	0.91	1.10
Series 5	9.16	7.07	5.22	4.18	1.96	--	5.33
Series 6	4.38	4.81	4.37	5.53	3.07	6.31	1.02

In summary, the combination of a single 1.73-liter HPXe detector unit and an automated RFA analysis procedure appears to provide a reasonably reliable means by which unshielded amounts of ^{239}Pu on the order of 1 gram can be detected with good confidence at a reasonable distance and collection time. A maximum reduced chi-square of 2.20 is an effective discriminator for reliable analyses and is rarely exceeded with surveys of 2 minutes or more, and infrequently exceeded with surveys of 7.5 seconds or more. If the reduced chi-square exceeds this threshold, the inspector need only continue the survey until a spectrum with sufficient chi-square statistics is obtained. At a distance of 73 cm with survey times as low as 15 seconds, the 1-gram plutonium source was consistently detected with a significance exceeding 4.0 in cases in which the chi-square criterion was met. At a distance of 200 cm with survey times as low as 2 minutes, with the exception of one of the six 2-minute spectra, the 1-gram plutonium source was consistently detected with a significance exceeding 4.0 in cases in which the chi-square criterion was met. While this work provides encouraging results for the detection of ^{239}Pu in portal monitoring situations, further work is needed to understand the likelihood of false detection of ^{239}Pu in spectra known not to contain ^{239}Pu.

REFERENCES

[1] G.P. Lasche, V.V. Dmitrenko, S.E. Ulin, S. Haan, S. Hustache, V.M. Gratchev, D.V. Sokolov, Z.M. Uteshev, K.F. Vlasik, R.L. Coldwell, and C.J. Cray, "Detection Sensitivity for Special Nuclear Materials with an Advanced High-Pressure Xenon Detector and Robust Fitting Analysis", *IEEE Transactions in Nuclear Science*, in press.

[2] S.E. Ulin, V.V. Dmitrenko, V.M. Gratchev, et al., "A Cylindrical Ionization Chamber with a Shielding Grid Filled with Xenon Under a Pressure of 50 Atm.", *Instr. and Exper. Techn.*, 1995, Volume 38, Number 3, Part 1, page 326.

[3] K.F. Vlasik, V.M. Gratchev, V.V. Dmitrenko, et al., "High-pressure Xenon Y-ray Spectrometers", *Instr. and Exper. Techn.*, 1999, Volume 42, Number 5, pages 114-122.

[4] V.V. Dmitrenko, I.V. Chernysheva, V.M. Gratchev, O.N. Kondakova, K.V. Krivova, S.E. Ulin, Z.M. Uteshev, and K.F. Vlasik, "Vibrostability of High Pressure Xenon Gamma-Ray Detectors", 1999 IEEE NSS/MCI Conference Record, Seattle, Washington.

[5] R.L. Coldwell and G.J. Bamford, *The Theory and Operation of Spectral Analysis Using Robfit*, New York: American Institute of Physics, 1991.

[6] G.P. Lasche, R.L. Coldwell, and J.A. Nobel, "Detection of Low Levels of Plutonium in Natural Environments from Gamma-Ray Spectra with Advanced Methods in Robust Fitting," *Nuclear Instruments & Methods in Physics Research*, A422 (1999), pages 455-462.

[7] R.L. Coldwell, G.P. Lasche, and J.A. Nobel, "Detecting Low Levels of Plutonium with HPGe Spectra, Compton Anticoincidencing, and Advanced Methods in Robust Fitting," *Proceedings of the 39th Annual Meeting of the Institute for Nuclear Materials Management (INMM)*, Volume XXVII, Naples, Florida, July 26-30, 1998.

[8] G.P. Lasche, R.L. Coldwell, and C.J. Cray, "Application of Robust Fitting Analysis Techniques to Low-Resolution Spectral Data," *Nuclear Instruments and Methods in Physics Research Section A: Accelrators, Spectrometers, Detectors and Associated Equipment*, ISSN 0168-9002, Volume 458, Issue 1-2, Elsevier Science B.V., North-Holland, The Netherlands, February 1, 2001, pages 491-497.

[9] R.T. Reiman, G.P. Lasche, R.L. Coldwell, and J.A. Nobel, "Performance Comparison of a New Approach to Nuclear Spectral Analysis with Commercial Codes", *IEEE Transactions on Nuclear Science*, Volume 47, Number 4, Part 1, August 2000.

TECHNICAL TESTING OF PORTABLE ISOTOPE IDENTIFICATION INSTRUMENTS

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The United States Customs Service has, as a part of its mission, the protection of the borders of the United States from the import or export of illicit radioactive materials. Of paramount importance is the ability to interdict the smuggling of special nuclear material, nuclear weapons and other radioactive materials that could be used as a weapon of mass destruction against the population and infrastructure of the USA or another country.

Radiation detection technology exists in the form of pocket size, hand-held and portal radiation detectors that have the ability to detect radiation with great sensitivity and low false alarm rates. US Customs has chosen to implement pocket size detectors or radiation pagers as the personal tool of each inspector for the detection of radioactive material.

In the search for illicit shipment of radioactive materials, innocent radiation detections may occur with some frequency due to common radioactive sources that may be encountered in day to day living. Examples include lantern mantles, some camera lenses, welding rods, certain dishware containing uranium glaze, and natural marble objects such as statues or architectural pieces. Perhaps the most common innocent detection encountered at the border and in public areas in general is due to the in vivo placement of radioactive sources for use in nuclear medicine therapy and diagnostics. Outpatients from such therapy can remain detectable for three weeks or more. Also, legal shipments of radioisotopes are common occurrences in cargo and express mail shipments.

The customs inspector who detects radioactive material in the course of his duties must decide whether detection is innocent; is indicative of a nuclear device or special nuclear material; or whether the source could be injurious to him/her or the general public. It is at this point that a portable instrument capable of identifying gamma or neutron emitting isotopes is essential to the customs examination procedure.

First generation portable isotope identifiers were identified and evaluated by US Customs [1]. Instruments from five vendors were put through a battery of tests according to delineated test procedures. The tests fell into five categories:

- Basic operation verification.
- Medical isotope identification.
- Individual isotope identification.
- Isotope pair identification.
- Dose rate calculation.

The tests can be summarized as an initial verification of correct instrument operation (including whatever calibration procedure was specified by the vendor), followed by three different isotope identification tests designed to verify the instrument's ability to correctly identify 19 isotopes specified by US Customs. The final test determined each instrument's ability to correctly display the dose rate from a wide energy range of gamma emitters.

The individual isotope identification test and the isotope pair identification test were performed with three types of intervening shielding. The first of these three types used the minimum packaging needed for safe source handling and was, in general, thin plastic. his type of shielding is virtually identical to a bare radiation source. The second type of shielding used 2.7 mm of steel to simulate the wall of a typical transportainer (or sea-tainer). The third type of shielding used 6.94 mm of lead to simulate typical industrial packaging or, perhaps, an attempt by the shipper to conceal the source without unduly increasing the weight of the shipment.

The isotopes tested were broadly categorized as:

- Special nuclear material (SNM).
- Medical, and
- Industrial.

These included 17 gamma emitters, 1 beta emitter, and 1 neutron emitter.

Each instrument was subjected to the following testing regimen:

First, each instrument was calibrated according to vendor's procedures. Instrument size and weight were recorded.

Next, the instrument's response to medical isotopes in their usual shipping containers was measured. This represents the most commonly occurring radioactive shipment. Response summaries in the form of a pass/fail listing for isotope identification for each of the three classes of gamma emitters (SNM, medical, and industrial) were recorded. Each instrument was then tested for response to the neutron source, Cf-252, a spontaneous fission isotope.

Each instrument's ability to identify several pairs of isotopes was determined. This test was intended to verify if the instrument could detect SNM when accompanied by a masking isotope.

Finally, each instrument's dose rate response to different energy gamma emitters was measured. One section of this test was conducted at a very low exposure rate, 10 microR/hr above background, and the second section conducted at 2 mR/hr above background. The latter dose rate represented the expected maximum exposure rate for a properly packaged medical isotope shipment. A third dose rate, 200mR/hr, was also used.

Tests also were conducted to determine the instrument's display visibility, audio alarms, and operational characteristics in electromagnetic fields and high humidity conditions.

REFERENCE

[1] QUAM, WILLIAM and PITTMAN, JOHN, "Radiation Detection Technology Assessment (RADTAP)," Phase II, Operational Tests of Isotope Identification Instruments, Special Technology Laboratory, Santa Barbara, California, July 1999.

PRINCIPLES OF PROTECTION AGAINST NUCLEAR SMUGGLING

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The smuggling of nuclear materials is a matter of grave consequence, and if allowed to occur in sufficient amount, could lead to nuclear terrorism or nuclear proliferation. This paper describes a framework created for the Department of Energy's contribution to national and international efforts to prevent and detect nuclear smuggling. With such a framework, opportunities for rapid gains in smuggling prevention can be found as well as funding gaps.

It is useful first to define the threat, which is then used to drive specifications and planning for technology and tactics. The exact numbers involved in the threat are not important here. It is enough to understand that the goal is to prevent the smuggling of sufficient quantities of weapon-usable material from a protected site to anywhere where it could be used for proliferation or terrorism. However, this should not be interpreted as a definition of some minimum amount of nuclear material that would be useful to detect and interdict. The useful amount can be smuggled in two, three or many individual smuggling trips, and so the quantity searched for may be considerably less.

Next, a range of possible actions can be listed. One category involves promoting deterrence of nuclear smuggling by portraying the likely consequences of nuclear smuggling as mostly negative for smugglers. Another category involves detecting nuclear materials, by anyone at anytime.

Increasing the probability of detection is not the same thing as enhancing deterrence. What deters is perception. If the perception that nuclear smuggling is unlikely to succeed is spread to potential smugglers, deterrence will be achieved. The cost of such a campaign is likely less than actually enhancing the probability of detection. There are major pitfalls in such a campaign, however. These include the release of information that might enhance the capability of smugglers and the chance that the campaign will be unconvincing.

Another mode of deterrence involves social consequences. If smugglers believe that any success in nuclear smuggling will lead to a greatly enhanced effort to combat smuggling, they may be deterred. Similarly, understanding the catastrophic results of the use of nuclear explosions may deter those with moral conscience.

These types of campaigns do not only affect deterrence. One very important detection mode is through informants, either those involved in the criminal enterprise or those who incidentally learn of it. Increasing the impression among such people that nuclear smuggling is likely to lead to apprehension of those involved, and even if it were to succeed, to social catastrophe, is important. The likelihood of an informant coming forward to reveal planned or in-progress nuclear smuggling will increase. Reduction in the economic needs of potential collaborators and informants is also useful.

Technology that can detect significant amounts of unshielded nuclear materials can be used to provide detection of certain modes of smuggling. Furthermore, it can be combined with other technology. For example, X ray examination of items would easily detect some shielding materials. These technologies are best deployed after a systematic analysis of possible modes and routes of smuggling. This analysis should be based on one goal, that of increasing the overall risk of detection of nuclear smuggling.

Applying detection capability to a border point does more than just detect nuclear materials. It provides a motivation for smugglers to either transport only smaller amounts of material, which means more trips and more opportunities for detection, or to use shielding, which is itself detectable by weight, size and X ray image. It provides an impetus for smugglers to use alternate routes, which are hopefully more risky to them. Thus, the least risky smuggling routes need to be equipped with detection equipment first.

The determination of the least risky routes involves a comprehensive evaluation of smugglers' risks. With a carefully crafted public awareness campaign increasing the likelihood of informants and other accidental detections, pushing the smuggling into longer, more involved routes, with more transfers and personnel involved, will increase risk. Thus, the shortest, simplest, routes should be covered first, along with those where there is a history of successful smuggling of other types.

A crucial enhancement to the risk of smuggling involves improving awareness and training on the part of all law enforcement officials, starting with customs and border patrol, but extending to traffic police and any other group that might come into contact with smuggling. Civilian awareness spread to those who come into contact with the transport of commodities is equally likely to increase the smugglers' risks.

In summary, the principles of protection against nuclear smuggling include: 1) enhancement of public awareness, 2) reduction of motivations to smuggle, 3) detection technology applied to the smuggling routes that are initially least risky for nuclear smugglers, 4) use of a combination of equipment to make nuclear smuggling more cumbersome and involved, and 5) awareness and training for law enforcement and transport employees.

NUCLEAR FORENSIC SCIENCE — CASE HISTORIES AND INVESTIGATION METHODS AT THE INSTITUTE FOR TRANSURANIUM ELEMENTS

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Since 1994 the Institute for Transuranium Elements has been involved with the examination of cases of illegal trafficking in nuclear materials, and to date over twenty-five samples have been investigated. In many of the cases the material was relatively easy to identify since it consisted of unirradiated UO_2 fuel pellets, with characteristic dimensions and form which could be compared directly with information contained in the Institute's database of commercial fuel.

However several of the seized illegal samples were in powder form, or contaminated samples of other materials, and these required a more detailed investigation. Three cases which represent different aspects of the Nuclear Forensic Science investigations will be presented. These are:

1. A mixture of plutonium and uranium oxide powders confiscated at Munich airport.
2. A quantity of high weapons grade plutonium metal found by chance in a garage on the German-Swiss border, also in 1994.
3. Stainless steel scrap contaminated with enriched uranium, detected in a scrap metal yard in Karlsruhe in 1997.

A description of these cases will be given along with the methods used in the investigations.

1. The mixture of plutonium and uranium oxide powders

In 1994 a suspect suitcase was seized by officials at Munich airport following its arrival on a commercial flight from Moscow. The case was delivered to the Institute and after checking for conventional explosive devices was opened and found to contain, among other articles, a sealed package containing several hundred grams of a radioactive powder. An initial chemical analysis showed this to consist of a mixture of plutonium and uranium oxides, but only an average isotopic fingerprint could be determined by thermal ionisation mass spectrometry (TIMS), which was not attributable to a known source.

A further examination by scanning electron microscopy (SEM) showed that the powder was a mixture of three distinct components, which could be identified as follows:

- PuO_2 in the form of small flat platelets with an average side length of 3.4 µm, forming the largest fraction of the sample. Transmission electron microscopy (TEM) showed these platelets to have an unusually small PuO_2 grain size.
- PuO_2 particles with a rod-shaped form, with an average diameter of 8.8 µm and lengths varying from 25 µ to 75 µm, with a characteristic fibrous structure.
- U_3O_8 particles with a very characteristic form, that of short rod-shaped particles, with an average length of 46 µm and a constant hexagonal cross section with a hexagon side of 12.0 µm.

It was possible to separate out individual particles using a micromanipulator for examination by TIMS, and separate isotopic fingerprints could be established for the different components. The morphology of the particles cannot be attributed to any commercial process in the European Union.

The concept of the "Microstructural Fingerprint", developed in the Institute, could be used to exclude certain processes as the source of the material. This microstructural fingerprint is a collection of data on particle size and particle size distribution, grain size and grain size distribution, porosity, dislocation density and character and other microstructural features characteristic of a specific sample.

2. Weapons grade plutonium metal

A small lead cylinder was found by police during a house search in a village close to the German-Swiss border in 1994. Inside this container was a glass bottle which, when opened in the Institute, was found to contain a quantity of powder including several grams of metallic plutonium. This was mixed with several other substances containing antimony, mercury and iodine.

The plutonium metal was analysed by TIMS and proved to be high weapons-grade material with a ^{239}Pu content of 99.7 wt. %. Analysis in the TEM showed that the plutonium was Ga-stabilised delta phase, which is the form used in the production of nuclear weapons.

The presence of the other elements led to speculation that the sample contained so-called "Red Mercury". Several compounds containing antimony, mercury, iodine and plutonium were identified by electron diffraction and energy dispersive X ray analysis (EDX), but none of these corresponded to the formula $Sb_2Hg_2O_7$ which is normally attributed to this substance

3. Contaminated scrap metal

Two empty stainless steel containers triggered radiation detectors at a scrap metal yard in the harbour on the river Rhine in Karlsruhe. Swipe tests were taken from the inner surfaces of the cylinders and proved to be alpha active.

This case differed from the first two in that whereas in the first two cases ample material was available for analysis, the swipe tests revealed only a relatively low level of activity and the primary difficulty was the location and identification of the responsible particles.

The swipe tests were examined by in the SEM using EDX and uranium-containing particles were identified in the size range 2.5µm to 9.0 µm, but with a very low surface density of 12 cm^{-2}. The particles were identified as UO_2.

After identification of the particle positions in the SEM the sample was transferred to the secondary ion mass spectrometer (SIMS) where they were found to be enriched up to 90% in ^{235}U.

From the shape of the stainless steel containers, the composition of the steel and the presence of highly enriched uranium it could be deduced that the scrap metal came from an assembly for a test irradiation in a small fast-breeder reactor, such as the BN10 in Obninsk.

The trafficking in contaminated scrap metal is likely to be one of the foremost problems in the field of nuclear forensic science in the future.

In addition to TIMS and SIMS the Institute has electron microscopes which have been modified for working with contaminated samples. The transmission electron microscope, a Hitachi H700, is connected directly via the specimen entry port to a glovebox chain, and has facities for EDX and SEM. The scanning electron microscope, a Philips XL40, has the complete column and vacuum system mounted inside a glovebox. This is also equipped with EDX and has a "Gunshots Residue Programme" for the automatic identification and location of specific types of particle.

A PRACTICAL FIELD SURVEY ON EQUIPMENTS FOR PHYSICAL PROTECTION

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Presented in this paper are the results of data-gathering and evaluation tests on equipments for physical protection system, which, considering the trends in relating Technologies and changing threat environments, are most likely to be used in future Japanese nuclear facilities.

Following tests are carried out as parts of this program.

1. Out-door Sensor Test

Bistatic-Microwave Sensor, Buried-line E-field Sensor, E-field Sensor, and Tension-wire Sensor were selected and tested in Detection-Performance Tests and Environmental (False-Alarm) tests. Detection-Probability was provided as the results of Detection-Performance Tests (live-intrusion test), in which Detection-Probability was represented as a function of behavior mode of intruders (covert/overt) and the number of intruders.the Detection-Probability in these tests were fairly high, because of laboratory-test-like nature of these test. The correlation between the Detection-Probability and the number of intruders was not significant.

In Environmental Test, survey was done to clarify the correlation between False-Alarm rate of the sensors mentioned above and the atomospheric phenomena such as rainfall or direction/velocity of wind.

2. In-door Sensor Test

2 thermic- ray Sensors (Passive-IR Sensors) were set up in test-chamber for Detection-Probability Test and Environmental (False-Alarm) Test. Detection-Probability higher than 97% (which reliability level of 80%) was recorded in the former test. In the latter test, the detection-sensitivity of the sensor was set to provide 2 levels, ‘Standard’ and ‘High’. In ‘Standard’ sensitivity test, 8 false alarm were observed during the test, but the analysis of the situation revealed that all of them were caused by imperfect construction of the test-chamber, and no false-alarm, except for once in ‘High’ sensitivuty test, were generated after the improvement of the test chamber.

* This work is sponsored by the Science and Technology Agency, Nuclear Safety Bureau (NSB), Office of Physical Protection of Nuclear Material.

3. Performance Test of Entry-Control Equipment

Hand-Geometry Identifier (3-dimension type) was selected and subjected for the performance test. Over 30 men and women among the employee of our facility were randomly selected for the test. Each of them posed their hand for 120~280 times during the test. Both of Type I Error (rejection of authorized person) and Type II Error (acception of un-authorized person) were estimated. In standard setting, ≪ Type 1 Error≫ 〈〈 ≪ Type 2 Error,〉 but it was proved to be possible to realize the inverse situation if necessary, by shifting these setting.

4. Breaching-Test of indoor-barrier

Reinforced-Concrete wall, general-purpose door and reinforced door were selected, and exposed for breaching by hands using portable power-tools. Breaching of the reinforced-concrete wall was completed (cut aperture with enough size for passing human) in 88 minuts using eiectric-hammer, 48 minuts using engine-hammer. 264 sec. needed for melting down the latch of general-purpose door, and 1323 secs for burning off the aperture in reinforced door.

5. Blow-up Test of barrier

Reinforced-concrete wall (300 mm thickness), quasi-reinforced door I (50 mm thickness door composed of steel-plate with 2.3 mm thickness) and quasi-reinforced door II (50 mm thickness door composed of stainless- steel-plate with 2 mm thickness) were submitted for blow-up test using dynamite and shaped-charge block. 4~6 minute was needed for intrusion from reinforced-concrete wall, and 217 sec. 238 sec. for both type of quasi-reinforced door.

6. Alarm-Assessment system Test

In this test, we have measured the time needed to assess and evaluate the alarm by surveillance using CCTV. The outdoor-tests were carried out under various situation such as daytime/ night, covert/overt intrusion, fair weather/rainy day, and also under combined conditions stated above. The assessments were completed in all the cases. The time needed to assess and evaluate the alarm were 4.39 sec. min. and 15.4 sec. max. after the occurrence of the alarms. Similar tests were carried out in in-door test facility using 2 thermic-ray sensors.
In this test also, tests were done in daytime/night, convert/overt intrusion, fair weather/rainy day, and again the assessments were completed in all the cases.

The data gathered in these test will be valuable material for construction of data –base of Physical Protection**.**

RESEARCH AND DEVELOPMENT ACTIVITIES OF PHYSICAL PROTECTION IN JAPAN*

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From 1990 to 1999, Nuclear Material Control Center contracted to be engaged in the R&D theme "Investigating on establishment of physical protection system of nuclear facilities". The purpose of this activity is to define and propose the requirements which physical protection system applied to the large scale reprocessing plant should meet.

Some matters investigated here contain fundamental problems of physical protection and the outcomes are also useful to be applied to other major nuclear facilities. In this context, taking into consideration of the movement of INFCIRC/225, the activity had been carried out to be fed back to physical protection measures which nuclear facilities in Japan should take.

The principle outcomes of the activities are as follows;

1. Study for evaluation method of physical protection system

- Investigating on measures against insider.
- Analysis of potential threat of the insider in Japan.
- Attribution classification of insider in Japan.
- Measures suited for social circumstances in Japan against insider.

2. Investigation on protection measures for sabotage

- Proposal of protection measures based on following aspects.
- Power reactors: on the importance degree of safety function.
- Reprocessing plants: on the importance degree of earthquake-proof.
- Plutonium fuel fabrication facilities: on the importance degree.

* This work is sponsored by the Science and Technology Agency, Nuclear Safety Bureau (NSB), Office of Physical Protection of Nuclear Material.

SECOND LINE OF DEFENSE PROGRAM OVERVIEW LA-UR-00-5161

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The illicit trafficking of nuclear material is a major concern for non-proliferation and global stability. The nuclear Material Protection, Control and Accounting (MPC&A) program provides the first line of defense in protecting nuclear materials within Russia by upgrading safeguards and security measures at Russian nuclear facilities.

Second Line of Defense (SLD) is a cooperative program between the Russian Federation State Customs Committee (RF SCC) and the United States Department of Energy (US DOE) to minimize illicit trafficking of restricted nuclear materials through Russian border control points. This partnership was solidified with the signing of a protocol between DOE and the RF SCC in June 1998. The relationship will soon be formalized in a Memorandum of Understanding that will outline the working relationships and commitments to successful implementation of the SLD Program.

The Russians first acknowledged the threat of nuclear smuggling at a Nuclear Safety Summit in Moscow in April 1996. Nikolai Kravchenko, head of the Regional Information and Technical Customs Department of the RF SCC, subsequently stated in a July 1998 interview, “In order to stop trafficking and illegal shipment to other countries we [also] have to tighten security at the facilities and equip our borders with reliable technology”. At the September 1998 USA-Russia Presidential Summit, the then Chairman of the RF SCC, Valery Draganov, highlighted the illicit trafficking challenge confronting Russia and requested US assistance.

Since 1991, a myriad of cases associated with the diversion and recovery of nuclear materials appear to be linked to the FSU. In the majority of cases, the material’s origin was attributed to Russia. With more than 20 000 km of border contiguous to fourteen other countries, and more than 350 customs and border sites, addressing the threat posed by nuclear smuggling in Russia is not only an urgent but also an expansive problem requiring joint USA-Russian attention.

The threat posed by the illicit trafficking of nuclear and nuclear-related materials and technologies must be addressed immediately by rapid upgrades of RF SCC’s detection capabilities. The highest priority of the SLD Program continues to focus on equipping strategic RF SCC sites with radiation detection equipment according to an agreed-upon site prioritization analysis. However, it is also necessary to lay the groundwork for long-term viability of border enhancements through development and implementation of technical curricula for the RF SCC’s training programs.

The SLD Program has an established process for equipment deployment and site upgrades. The goal of this process is to assure sustainability of upgrades, optimize equipment investments, and promote program accountability. The SLD Program deploys Russian manufactured nuclear detection equipment. The Program works with the equipment manufacturer and RF SCC to ensure deployed equipment is sensitive to special nuclear material (SNM), test new equipment designs, and upgrade outdated equipment and technology wherever possible. The SLD team prioritizes site selection; therefore, equipment is deployed at collaboratively determined strategic locations. After the in-depth site prioritization study is completed, thorough site surveys ensure that the appropriate equipment, security enhancements, and upgrades are employed at each site to the maximum extent possible in order to increase detection capabilities. Vulnerability assessments ensure maximum effectiveness and are completed during the site surveys. The equipment and upgrade recommendations are based upon the results of the site vulnerability assessment and the site survey team reports. The equipment is manufactured and the site upgraded by private Russian corporations. After the site upgrades have been completed, the SLD team conducts a site acceptance test of the radiation detection equipment, as well as other site upgrades.

The long-term sustainability of the SLD program requires employing Russian nuclear detection equipment. Since SLD's inception, DOE and its national laboratories have worked with private Russian firms to test and improve SNM-sensitive detection equipment. The Russian technology tested by the laboratories and the International Atomic Energy Agency (IAEA) has been found to meet the programmatic requirements. As additional border and customs sites are assessed for nuclear detection needs and new technical challenges are identified, the USA/Russian SLD team will address these technical issues through focused collaborative efforts.

Training is also a critical component of the SLD sustainability goal. Proper and safe use of nuclear detection instrumentation will be addressed through several phases of training. Upon equipment delivery, Russian specialists will conduct equipment operation, maintenance, and security procedures training. In addition to initial on-site training for customs inspectors, DOE and its affiliated labs will work with the RF SCC to create and implement training modules and courses tailored to the RF SCC's different tiers of personnel and their corresponding responsibilities in terms of identifying suspicious shipments or situations.

The immediate successes of the SLD Program have been driven by the importance of the nonproliferation problem associated with the illicit trafficking of nuclear materials and catalyzed by the strong commitments of the Russian collaborators of the US national laboratories, and of the US DOE. The technology implemented under the program has resulted in immediate improvements in the ability of the RF SCC to detect and deter the illicit trafficking of nuclear material. This concrete impact will be augmented by the ongoing and future activities in the areas of training and technology deployment. We look forward to continued collaboration and successes.

THE IAEA'S ILLICIT TRAFFICKING DATABASE PROGRAMME

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As part of its overall programme on nuclear material security, the IAEA has since 1995 maintained a database of incidents of trafficking in nuclear materials and other radioactive sources. The Illicit Trafficking Database Programme (ITDP) is intended to assist Member States by alerting them to current incidents, by facilitating exchange of reliable, detailed information about incidents, and by identifying any common threads or trends that might assist States in combating illicit trafficking. The ITDP also seeks to better inform the public by providing basic information to the media concerning illicit trafficking events.

Approximately 70 States have joined this programme for collecting and sharing information on trafficking incidents. Reporting States have the opportunity to designate what information may be shared with other States and what may be shared with the public. In cases where the IAEA's first information about a possible incident comes from news media or other open sources rather than from a State notification, the information first is evaluated, and then, if warranted, the relevant State or States are contacted to request confirmation or clarification of an alleged incident.

During 2000, as a result of experience gained working with information on illicit nuclear trafficking, the IAEA developed of a flexible and comprehensive new database system. The new system has an open architecture that accommodates structured information from States, in-house information, open-source articles, and other information sources, such as pictures, maps and web links. The graphical user interface allows data entry, maintenance and standard and ad-hoc reporting. The system also is linked to a Web-based query engine, which enables searching of both structured and open-source information.

For the period 1 January 1993 through 31 March 2001, the database recorded more than 550 incidents, of which about two-thirds have been confirmed by States.[1] Of these confirmed incidents, about half involved nuclear materials. The frequency of confirmed incidents has grown in recent years. The number of cases per year in 1999 and 2000 was roughly double the 1996 value, with most of this growth connected with incidents involving radioactive sources.

Of the confirmed incidents with nuclear material, one-third involved low-enriched uranium and 16 cases (10%) involved highly enriched uranium (HEU) or plutonium.[2] In most cases, the quantity of HEU and plutonium encountered is small compared with the amounts required for a nuclear explosive, although one should bear in mind that even small quantities of material sometimes may be samples of larger quantities available for purchase or at risk. After a three-year hiatus in incidents with HEU or plutonium during 1996-1998, six such incidents were confirmed in the two years since April 1999, including the seizure in April 2000 of nearly a kilogram of HEU in the form of fast-reactor fuel pellets.

[1] Some of these confirmed incidents reflect detections of contaminated scrap metal or unregistered sources that probably do not involve criminal intent.
[2] This figure does not include incidents with less than a gram of plutonium where the plutonium is known to be in the form of ionization sources or plutonium-beryllium neutron sources.

For incidents with radioactive sources where the source strength has been reported, about one in six involved sources of 1 Ci (37 GBq) or more. In eleven cases, the reported source strength exceeded 1000 GBq, and eight of those eleven occurred during the last three years.

Trafficking in nuclear material and other radioactive sources is a global concern, with confirmed incidents recorded in more than forty countries on six continents. The majority of confirmed incidents involving nuclear material have occurred in Europe, although in recent years, reported cases have become more pronounced in the southern Newly Independent States and nearby neighbours.

PLUTONIUM ROUND ROBIN TEST

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Synopsis

The goal of nuclear forensics is to develop a preferred approach to illicit trafficking investigations. This approach must be widely understood and acceptable as credible. The principle objectives of the Round Robin Test are to prioritize the forensic techniques and methods, evaluate attribution capabilities, and examine the utility of database. The Plutonium Round Robin has made a tremendous contribution to fulfilling these goals through a collaborative learning experience that resulted from the outstanding efforts of the six participating international laboratories.

A prioritize list of techniques and methods has been developed based on this exercise. Future work will focus on a Highly Enriched Round Robin and extent to which the techniques and methods can be generalized. The Plutonium Round Robin demonstrated a rather high level of capability to determine the important characteristics of the materials and processes using analytical methods. When this capability to was combined with the appropriate knowledge and database, it resulted in a demonstrated capability to attribute the source of the materials to a specific nuclear fuel, reactor, and reprocessing facility. A number of shortfalls were also identified in our current capabilities. These included alternative dating techniques, Light Water Reactor discrimination techniques, and the lack of a comprehensive network of data/knowledge bases. The result of the Round Robin will be used to develop guidelines or a "recommended protocol" to be made available to the interested authorities and countries to use in real cases.

The poster will present a summary of the results of the Plutonium Round Robin and describe the plans the subsequent Highly Enriched Uranium Round Robin Test.

FOUR YEARS OF INTERNATIONAL COUNTERPROLIFERATION TRAINING: THE US DEPARTMENT OF DEFENCE EXPERIENCE

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Over the last four years, the US Department of Defense has engaged 17 countries in the former Soviet Union, Eastern/Central Europe, and the Baltic states in two counterproliferation initiatives, i.e. the DOD/FBI and the DOD/US. Customs Service Counterproliferation Programs. These activities are designed to train and equip border security and law enforcement personnel to prevent, deter, and investigate incidents related to weapons of mass destruction, as well as the trafficking in chemical, nuclear, and biological weapons materials and technologies.

Though these programs have begun to produce tangible successes, some recipient countries have failed to demonstrate an earnest commitment to program goals. The US DOD has fielded varied training courses in the region, together with associated WMD detection equipment. In spite of demands by the political leadership in many of the engaged countries, the most successful training has proven to be the more basic rather than the advanced training. Similarly, the real equipment needs prove to be for low rather than high technology. The presentation will explore the systemic, political/military, and geographic factors contributing to this result.

The US Department of Defense will continue to engage participating nations in these international counterproliferation programs, and will continue to respond positively to assistance requests based on recipient country needs and honest commitment. Still there remain numerous opportunities for other donor states and international agencies to make positive contributions in the counterproliferation arena. Only with increased donor state commitment — fiscal, programmatic, and personnel — together with full donor state coordination, can international proliferation and trafficking problems be effectively deterred and resolved.

SUMMARY OF DISCUSSION

Session 1
THREATS AND RESPONSES

***Chairperson:* M. Gregoric (Slovenia)**

Main points

The speakers emphasized:

- the trafficking of highly enriched nuclear materials in the post cold-war period, focusing on smuggling from countries of the former Soviet Union;
- the capabilities of terrorist groups and other groups in acquiring, handling and delivering nuclear and radioactive materials;
- new threats such as nuclear, chemical, biological and cyber-terrorism;
- Interpol monitoring of nuclear threats, especially through “Project Nuclear” in 1994.

Also, a general idea was given from a police perspective of the kind of threats we may expect from terrorists and the methods they may use to achieve their goals.

The ease with which weapons of mass destruction could be manufactured and, finally, measures that could be taken to prevent terrorists from using them were discussed.

The speakers discussed the reported illicit trafficking incidents in the past few years and underlined that none of them were terrorism related and that most of the traffickers were amateurs.

Two important points were reiterated in this session. First, the possibility of a terrorist attack using weapons of mass destruction was relatively low, but not zero. Second, although the likelihood was low, the consequences of an attack using weapons of mass destruction would be severe. Therefore, there was a real need to prevent such an attack. Measures for prevention, accounting and control of nuclear materials should be strengthened.

It was underlined that there were three million kilos of weapon-grade nuclear material at large and plutonium stockpiles were increasing. These were important concerns worldwide.

Observations

- The probability of nuclear threat is low, but not zero.
- The know-how needed to construct a primitive nuclear device is available.

Recommendations

- Intelligence gathering should continue;
- Technical training of police and customs officers is essential;
- International co-operation should increase;
- The main inhibiting factor for fabrication of nuclear weapons is the procurement of nuclear materials. Therefore, preventing access to a significant quantity of nuclear material is vital.

Session 2
ASSESSING THREATS AND EVALUATING VULNERABILITY

Chairperson: **J.B. Fechner (Germany)**

Main points

A comprehensive overview was given of the regulatory measures implemented by the responsible authorities in one country with the objective of preventing and responding to the illicit use of nuclear material and radioactive sources. The measures also aimedt rapidly recovering the material and mitigating consequences to the public. The importance of co-ordination with other potentially affected institutions was emphasized (S. Fernandez Moreno, Argentina).

The importance of a comprehensive risk assessment for specifying the DBT was outlined, in particular the need not to focus on low probability/high consequence scenarios alone but also to include highly probable events with less serious consequences when deciding upon priorities for protection (J. Reynolds, UK).

The process for establishing the DBT on State and facility level was described with the influencing factors and conditions and also the problems encountered (S. Chetvergov, Kazakhstan).

The profound impact of he human factor on various threat elements, on the one hand, and on the efficiency of a physical protection system, on the other, was analysed with special emphasis on geopolitical, social, economic and cultural factors and on nuclear terrorism. Consequences for specifying the DBT were addressed (P. Ivanov, Ukraine). Some assessment was done of the threat from disatisfied workers in facilities.

Security studies used to analyse the ability of MC&A systems and physical protection systems to detect the unauthorized removal of nuclear material were described, taking into account the postulated threat and relevant test data, and determining critical scenarios that might require upgrades of the systems (R. Venot, France).

A PC-based method for assessing the vulnerability of physical protection systems against potential thieves of nuclear material was described. The method allowed for optimization of the system for cost-efficiency. Necessary parameters required laboratory tests on penetration times and detection probabilities (J. Bernard, France).

An approach for specifying physical protection measures against sabotage was outlined (A. Hagemann, Germany), including facilities other than NPPs.

Main points raised during discussions

The discussions following the presentation of the papers and the questions from the audience indicated particular interest of the participants in:

a) co-operation and co-ordination of all national authorities and institutions involved in detection and response to illegal uses of nuclear material and radioactive sources, in particular authorities responsible for safety, radiation protection, import/export control and law enforcement;

b) incorporation of high probability/lesser consequence scenarios in the process of specifying a DBT, the role of severe potential consequence scenarios; the relation between risk concepts and specification of the DBT, the role of response forces on-site and off-site;

c) ways to specify the DBT for countries showing a peaceful environment in the nuclear area;

d) strong influence of the reliability of the human factor on the DBT and on the effectiveness of physical protection systems; the need to assess and incorporate this factor into the DBT and physical protection system design in a more systematic way;

e) more systematic investigation of the threat posed by extremist and terrorist groups worldwide; exchange of assessment results between competent institutions such as criminal investigation authorities; intelligence services, Interpol;

f) the role of terrorism in the DBT;

g) the potential for and obstacles to harmonizing the DBT for specific geographical regions; enhanced multilateral exchange of information on the DBT;

h) tools for assessing the physical protection system's efficiency and vulnerability; ways to implement partial upgrades of MC&A and physical protection systems in order to compensate for deficiencies found; benchmarks for improvements;

i) prescribed detection levels for nuclear material (minimum quantities for radiation monitors at border crossings; responsibilities of customs authorities in import/export control.

Conclusions and recommendations

a) Because of the apparent need of several countries and in the light of the experience available, the IAEA should take appropriate steps to prepare guiding documentation and advice starting from an exchange of experience;

b) In spite of extensive work completed and still in progress pertaining to the specification of national DBTs, issues 2.b) to 2.d) may need additional attention. The IAEA should look for appropriate steps to analyse these issues, possibly in close contact with competent national authorities.

c) As terrorism and activities by extremist groups are or may become part of reality in many regions worldwide, an attempt should be made to get a comprehensive overview of the assessment results on these threat elements available from national competent authorities and services and from Interpol, in order to get a complete picture. Care should be taken to clarify whether these threat elements have the potential to aim at nuclear activities as well, and which regions could be affected in particular. Reassessments on an annual basis should be considered.

d) The IAEA should keep training on methods and tools for assessing the efficiency and vulnerability of physical protection systems as an important part of its training programme.

e) National responsibility was stressed in all reports, but experience from other countries is a valuable tool for development of validation of national systems.

Session 3
PHYSICAL PROTECTION I

***Chairperson:* Y. Volodin (Russian Federation)**

The keynote address was held by Mr. G. Bunn, Stanford University, USA, who provided a resumé of the various initiatives currently under way to strengthen international physical protection practices. He noted that Article 3 of the NPT and the CPPNM were deficient, that no State was required to publish information on its system of physical protection, and that the nuclear-weapon States were totally excluded from any obligations. The current Working Group meetings to consider whether there is a need to revise the CPPMN were mentioned.

The first speaker, Mr. I. Kokhan, from the NAEC Ukraine, emphasized that illicit trafficking could only be defeated by joint efforts at both the national and international level and then outlined the Ukrainian initiatives at the national level.

Mr. P. Cahalane of the DOE's Office of International Material Protection and Emergency Co-operation spoke about the current status of joint US-Russian efforts on nuclear material security. He summarized achievements since 1995 and described the DOE's partnership with MINATOM.

Mr. C. Englefield described his group's work on an integrated and comprehensive approach to combating illicit trafficking. The intelligence-led approach is based on risk management principles. He mentioned the UK's intention to implement the national response plan to IT required by regulators, customs and police — a theme common to many presentations this week.

Mr. J. Sedlácek of SUJB presented the effort of his State Office in preventing and combating illicit trafficking in the Czech Republic.

Mr. J. Fechner of the German Ministry for the Environment, Nature Conservation and Nuclear Safety spoke about the German system for prevention, detection and response to IT. Germany was well advanced in its planning — the German system could be a useful mode for other States to follow.

Mr. L. Nylén of the Swedish Police described where his service fitted into the Swedish physical protection system.

Mr. E. Powell of the Jamaican Constabulary, Marine Operations, described the problems a small island nation had when having to combat illicit trafficking and terrorism.

Sessions 4 & 5
PHYSICAL PROTECTION II AND III

***Chairperson:* D.M.G. Flory (France)**

Sessions 4 & 5 were devoted to two different aspects of physical protection.

The first aspect was the positive experience of States and/or operators in the complex operations of upgrading the physical protection of nuclear material and facilities.

A number of examples were given, from which the main lessons to be learnt concerned the need to upgrade, which might

- arise from the fact that the relevant facilities or PP systems had been designed or built at a time when national regulations ere less severe, or the threat was considered lower;
- arise from the evolution of the political or administrative conditions prevailing in a State;
- be a direct result of an IPPAS mission, which then clearly showed the interest in the follow-ups to these missions;
- arise from a clear decision to follow the new recommendations of the Fourth Revision of INFCIRC 225.

Upgrading physical protection

- upgrading physical protection is a complex operation, in direct relation to the complexity of the facilities, which greatly benefits from the co-operation and co-ordination of specialists from different fields.
- factors of complexity range from climatic conditions to the need for continued operation of the facility concerned.
- as a direct consequence, international co-operation and support, bilateral or multilateral, was shown to be a valuable, if not indispensable, factor for the success of many operations.

From the ensuing discussions, it was clear that the use of a DBT for evaluating the levels of necessary upgrades was sometimes, though not always, lagging behind the operation of the upgrade itself. This might be attributed to the recent introduction of the DBT into INFCIRC 225.

The sessions have also addressed a second very important aspect of the life of a State system of physical protection: the interactions between operators and the State entities having responsibilities in physical protection (competent authority, response force).

These interactions included:

- the early consultations prior to the design of a facility (the ideal case);
- the process of evaluation, through expert groups, of the sensitivity and vulnerability of a nuclear facility;
- the process of inspection by the authority as the rightful means to verify compliance, but also possibly as part of the evaluation of the effectiveness of PP systems;

- planning the response force's actions in conjunction with the operator and the authority. A good knowledge of the facility as well as in situ training of the response force were shown to be major factors of effectiveness.

In conclusion, if the three main lessons to be drawn from these sessions were:

- prepare your physical protection system with all actors involved, in accordance with their varying responsibilities;
- co-operate with all actors necessary to implement the systems as planned;
- plan and exercise reactions to foreseeable as well as unforeseeable malevolent actions.

This must already be in incorporated into INFCIRC 225/Rev 4.

Session 6
INTERNATIONAL OBLIGATIONS, STANDARDS & NATIONAL REGULATORY SYSTEMS

Chairperson: C. Price (UK)

National regulatory systems underpin arrangements to prevent illicit trafficking through ensuring that nuclear material and radioactive sources are properly controlled and protected during legitimate use, storage and transport. They reflect a State's international obligations and take due account of IAEA standards and guidance. However, they must also reflect national circumstances and needs. The addressing of an identified need by a State may lead to its solution being recognized as international best practice. This, in turn, may lead to its incorporation into international conventions, standards or guidance. Thus, national regulatory systems are continually evolving in the light of both external and internal pressures. This session illustrated the continuing evolution of both international and national regimes to help prevent illicit uses of nuclear material and radioactive sources.

During the past 18 months, a major review of the international physical protection regime for nuclear material has been carried out in order to answer the question posed by the Director General of the IAEA as to whether there is a need to revise the Convention on the Physical Protection of Nuclear Material. The review included an examination of illicit trafficking, the support and assistance provided by the IAEA in the physical protection field, bilateral support programmes and the rationale for revising the Convention itself. The report to be considered by the Expert Group in two weeks' time recommends that the scope of the Convention be broadened to encompass the protection of nuclear material in domestic use, storage and transport against the risks of theft and sabotage. However, the report recognizes that the Convention is not the only tool available to help ensure effective physical protection and it contains a number of recommendations to help further improve the valuable guidance, advice and training provided by the IAEA to Member States in this important area.

At the same time, the IAEA is actively engaged in two other programmes relating to the security of radioactive material. Whereas one is directly related to countering illicit trafficking in such material, a complementary programme reflects the increase problem of "orphan sources", i.e., radioactive sources which have never been subject to regulatory control or have fallen out of regulatory control. A number of these sources have caused serious injury, even death, to members of the public who have come into contact with them whilst others have contaminated scrap metal, a matter of major concern to industry and the public alike. An Action Plan, endorsed by the General Conference, to address this problem is currently being implemented. Fundamental to the success of this plan will be assistance to improve regulatory infrastructures, possibly supported by an international undertaking. Effective regulatory systems to control radioactive material should not only reduce the number of 'orphan sources' in the longer term, but also prevent the future loss or theft of sources, thereby helping address the problem of illicit trafficking of these sources.

At the national level, adherence to an international undertaking helps provide the political support necessary to establish a legal and regulatory infrastructure under which a competent authority may implement IAEA guidance in a flexible manner. A recent study of the level of readiness to reduce the threats arising from loss of regulatory control of radioactive material concluded that, even where the necessary legal framework existed, there was room for further improving the enforcement of control in some countries. Effective enforcement may be especially difficult in some cases due to the limited resources (finance, equipment and trained staff) available.

Some States are revising their physical protection regulations to take account of a more modern regulatory approach. For many years, competent authorities laid down the detailed measures to be taken by operators to protect nuclear material and facilities. This had the effect of placing the onus on the competent authority for ensuring that these measures delivered effective security. Competent authorities are now setting regulatory objectives, with the obligation firmly placed on the licensee to demonstrate to the competent authority that these objectives have been met. In parallel, the IAEA Working Group report has recommended that a revised Convention on the Physical Protection of Nuclear Material should incorporate objectives and fundamental principles as basic obligations for the establishment and implementation of national systems of physical protection. The necessary flexibility on how these basic obligations are implemented nationally is thereby maintained, allowing individual States to take into account local threats and circumstances.

Although the primary aim of international undertakings and national regulatory systems in this area is to support non-proliferation and to protect public health and safety and the environment, there are also financial implications if these systems fail. Although compensation may be available to those who have suffered as a result of nuclear damage occasioned by an operator located within that country, the rights of those in other countries affected by cross-border pollution (occasioned, for instance, by ‘orphan sources’) to obtain financial redress are less clear. A number of countries have now learnt that the inadvertent smelting of a radioactive source with scrap metal leads to serious damage in terms of recovery costs, shutdown and market loss. As a result, some States have made the radiation monitoring of scrap metal a regulatory requirement. The current tendency is for nuclear operators and users of radioactive material not only to pay the costs of complying with regulations but also the costs of the national regulatory system itself.

Despite natural uranium, depleted uranium and thorium accounting for over 25% of the cases on the IAEA illicit trafficking database, international requirements do not extend beyond protecting it “in accordance with prudent management practice”, a level which has never been more fully defined. In France, this material is subject to what is known as a “declaration regime”. This is a lighter regulatory regime than licensing, but still requires operators to declare annually how the material is protected. Protection is reinforced by inspection. Interestingly, the requirements set by national authorities for the protection of radioactive sources comply with those set by the competent authority for the physical protection of depleted uranium. This may be yet another small example of best practice which could be incorporated into IAEA guidance documents to provide more comprehensive advice on appropriate means to ensure that both radioactive sources and source material are adequately protected against theft.

Session 7
ILLICIT TRAFFICKING — INTERNATIONAL ISSUES AND RESPONSES

Chairperson: **S. Magnusson (Iceland)**

The session consisted of a keynote address and four papers. Several of the speakers focused on the need for more national and international co-operation between different authorities and organizations fighting illicit trafficking, not only with regard to information-sharing but also at the operational level.

Mr. P. Williams of the University of Pittsburgh gave a keynote address on “Trends and Patterns in Illicit Trafficking”. He noted that we knew very little about the black market in nuclear and radioactive materials and stressed that a shift in trafficking routes, from western routes in central Europe to southern routes in central Asia, had taken place since 1966–97. The pattern of trafficking was centered around transactional or direct networks or hybrids of both. He also highlighted different trafficking groups, their trafficking methods and indicators. He gave an overview of different types of organized crime and stated that there was some involvement of organized crime in cases of illicit trafficking. Professor Williams addressed the use of undercover operations to fight illicit trafficking, stating that these were somewhat politically controversial and should be used with a clear sense of purpose and end-game. He noted that there had been considerable success in their use and concluded that undercover operations were important but needed to be more diverse than just “buy and bust”.

Mr. D. Smith of the US Customs Service presented a paper on behalf of the World Customs Organization (WCO) on its partnership concept. The paper stated that the WCO had an important role in fighting illicit trafficking and that lack of internationally accepted investigation standards was increasing the scale of the problem. The paper also stressed that comprehensive and co-ordinated national plans that included customs services were needed, and that national institutes needed to develop their own action plans in compliance with national plans and to review them regularly. The WCO had developed an enforcement programme to respond to illicit trafficking and there was close co-operation with the IAEA and Interpol. The paper reported that a customs enforcement network for the customs community to exchange encrypted information and intelligence had been created. One database in the system was for nuclear and radioactive material seizures.

Mr. J. Sjöberg of the Swedish armed forces reported on how open source information could be used to combat illicit trafficking and proliferation. He stated that the Internet with the Worldwide Web had made open source information widely accessible through various available search engines. Open source information was cost-efficient and could be shared inside and outside organizations, but could not replace classified or confidential information. He pointed out that using different sources and appropriate comparison decreased the risk of misunderstandings. Mr. Sjöberg stressed the risk of information overflow and the need for open sources to be used with caution since there were no established benchmarks for validation of such data. In conclusion he stated that open source information should be an integral part of any intelligence gathering — also that related to illicit trafficking.

Mr. O. Reistad of the Norwegian Radiation Protection Authority reported on “Russian spent marine fuel as a global security risk”. He stressed that about 140 nuclear submarines with at least 200 reactor cores were ready to have their spent fuel unloaded and placed in preliminary storage on shore in the far east and northwest of Russian Federation and that large amounts of spent naval fuel had been stored at Russian military bases for decades. He went on to assess the security risk associated with Russian spent marine fuel and concluded that the most serious proliferation concerns were related to spent fuel with particularly low and particularly high initial enrichment.

Mr. K. Duftschmid of the Technical University of Graz, Austria, reported on “Technical considerations for detection of and response to illicit trafficking in radioactive materials”. He stated that technical measures to prevent, detect and combat illicit trafficking would be applicable to all radioactive material and nuclear material. However, all nuclear material should, in all countries, be subject to safeguards for non-proliferation purposes and physical protection to avoid unauthorized diversion. He described the close co-operation between the IAEA, the WCO and Interpol to conduct joint studies, meetings and training programmes to support Member States in their border control activities. He stated that technical information derived from the ITRAP project conducted by the IAEA in co-operation with the Austrian Government on requirements and methods to detect and respond to illicit trafficking had been provided to Member States. Mr. Duftschmid discussed detection and response strategies and stated that an intelligence network between authorities involved was needed as part of a realistic detection strategy.

The main conclusion of Session 7 is that the key to success in fighting illicit trafficking in radioactive and nuclear material is more comprehensive and extensive national and international co-operation between different authorities and organizations sharing not only information and intelligence but also technical measures which have been found to be effective.

Session 8
ILLICIT TRAFFICKING — TECHNOLOGY AND METHODS

***Chairperson:* D.S. Ionescu (Romania)**

This session drew our attention to the efforts made by scientists and technical experts to give the proper tools and instruments to law enforcement, customs and security forces in order to prevent and detect illicit trafficking in nuclear material.

The first presentation given by Mr. R. Arlt from the IAEA and also the last presentation delivered by Mr. C. Hull from Nuclear Safeguards and Security Systems, USA, presented a new generation of neutron/gamma detectors (CZT [CeZuTe] detectors and fibre glass detectors). These technologies may be the neutron/gamma detector technologies of the future.

In the second presentation, Mr. J. Safar from the Hungarian Atomic Energy Authority pointed out a very challenging task: "Detection of smuggling of nuclear materials covered by a legal transport of a radioactive material". The main conclusion of this study was that, using the proper tools and proper procedures, such a task can be successfully completed.

In the third presentation, Mr. C. Schmitzer from the Austrian Research Centre showed us the efforts made by scientists and engineers in harmonizing and improving the equipment used for detection of radioactive material in general and nuclear material in particular. Results had been very promising.

The fourth presentation, given by Mr. M. Bahran from the National Atomic Energy Commission, Sana'a, Yemen, contained a proposal for an international tagging system for radioactive sources. This idea represented a future issue and a challenge for the international community.

In the fifth presentation, Mr. D. Ek from Sandia National Laboratories, USA, presented a recent effort evaluating the vulnerability of ports and harbours to nuclear smuggling. The methodology presented could be considered by the States concerned about protection against nuclear illicit trafficking on sea routes.

The presentations made it clear that the efforts made by the scientific community were merging with those made by national and international authorities to enforce nuclear material security for the future.

Session 9
NATIONAL RESPONSES

***Chairperson:* M. Bahran (Yemen)**

During the afternoon presentations of Session 9, there were eight speakers, from Turkey, Syria, Ethiopia, Indonesia, Nigeria, Ghana, India and Bangladesh.

The speakers described their different national programmes (laws, activities, measurement and monitoring programmes) to combat illicit trafficking. Even though problems are not serious in some countries, preparations have been made by installing appropriate national plans. Some countries had experienced several incidents between 1993 and 2000 but others could not confirm any such events. The activities to combat illicit trafficking of any radioactive material range from improved and strong regulations and monitoring, to setting up first work plans and regulatory strategies.

In addition to illicit trafficking, other concerns were described including those involving 'orphan sources' and contaminated scrap metal.

Turkey reported a possible transit route for illicit trafficking crossing the country. Several incidents were documented between 1993 and 2000 involving 30% radioactive and 70% nuclear material. The origins were believed to be former Soviet military areas. TAEA is working out the framework for preventing, detecting and responding illicit trafficking.

Since 1997, after the Chernobyl accident (1986), assessed radiation contamination has increased in Syria (contaminated food, contaminated scrap, one radium source). Syria has therefore adopted stringent regulations and national monitoring stations are operating at several locations. It has been found out that smugglers hide radioactive material by using fertilizer, Syria has elaborated national restrictions in order to prevent contaminated food or the illicit trafficking of any source into or through the country.

Ethiopia does not yet have a strategic programme on illicit trafficking, but plans to establish a stronger control system. Ethiopia is aware of this problem and activities are included in the health physics protection programme. A programme has been developed including border controls (1000 km border) and training of customs and border police. A national radiation protection proclamation has existed since 1993. The national registration and licensing process now accounts for 95% of all national radiation sources.

Indonesia gave an extensive description of the activities of its regulatory body. The Nuclear Energy and Control Board, BAPETEN's mission is to establish regulations, issue licenses, and to inspect nuclear facilities

In 1998, the Nigerian Government started participating in the IAEA's Illicit Trafficking Data Base. Nigeria started supervision programmes and monitoring. Six institutes at several locations take responsibility for radiation protection, co-ordinated by the Sheda Science and Technology Complex. Its Technical Committee provided supervision programmes, guidance monitoring at seaports, airports, border crossings and hinterland, assistance with radiation monitoring equipment, and training programmes.IAEA assistance is needed in training, monitoring and equipment procurement.

Ghana is developing a programme for combating illicit trafficking. Three official border crossings were recognized where illicit trafficking could probably come from Nigeria. Ghana is less concerned about nuclear illicit trafficking than about orphan sources of radioactive material in the country. Ghana has developed a work plan for upgrading legislation, seminars, training, developing of technical measurements, and developing regional collaborative agreements

India has established a regulatory infrastructure wherein the use and numbers of sealed industrial and medical sources are registered, including industrial radiotherapy sources, nucleon gauges, well-logging sources, and brachy therapy sources. The speaker summarized several radiation incidents caused by improper storage, temporary suspension of use of sources, improper labelling, illicitly imported sources, and unattended mobile industrial sources, e.g. for radiography. In India, there was still a need for the establishment of a regulations framework, surveillance procedures, an inventory of all sources, safe and secure storage, regular training and awareness programmes. Border monitoring has been recognized as very difficult because of the size of the country and large number of border crossings.

Bangladesh outlined its newly formed regulatory controls by the Bangladesh Atomic Energy Commission. National survey inspection started in 1999 to be completed in 2000. The programme covers survey findings, key legal issues and regulatory infrastructure. The main conclusions indicate the need for providing the regulatory infrastructure and for work on training and motivation of the concerned persons. This should provide the necessary basis for radiation protection against ionizing radiation to fulfill the BBS requirements.

Session 10
LESSONS LEARNED AND FUTURE NEEDS

Chairperson: **L. van Dassen (Sweden)**

The conference was concluded with a round table discussion, which the session chair, Ms. A. Nilsson (IAEA), opened by introducing a panel of seven selected conference participants who had contributed actively during the conference and who, she felt, would fuel an interesting discussion. They were Mr. D. Flory (France), Mr. C. Price (UK), Mr. Y. Volodin (Russian Federation), Ms. S. Fernandez Moreno (Argentina), Mr. H. Strauss (USA), Mr. N. Kravchenko (Russian Federation) and Mr. L. van Dassen (Sweden). Before opening the discussion to the floor, Ms. Nilsson addressed a range of questions to members of the panel.

How smug can we be?

Her first question was whether they believed that nuclear security was a substantive matter that should be followed closely in implementing nuclear programmes or whether, finding the incidence of illicit trafficking statistically low, one could regard it with complacency.

Mr. Price commented that loss of control over any radioactive — including nuclear — material, always presented a range of risks. The public expected the material to be looked after properly. Also, loss of regulatory control always had cost consequences. However, depending on the type of material, risks could be much more serious, including radiation damage from mishandling high active sources and — most serious — proliferation risks arising from sensitive quantities of nuclear material.

Mr. Volodin mentioned the dilemma of determining what illicit trafficking related to — whether to security, safety or safeguards. He felt all three were components of national security and suggested developing a unified model security-response plan — possibly co-ordinated through the IAEA — to enable those countries that already had such a plan and those that were working on one to move in the same direction. In future, this unified plan could simplify international interaction.

Mr. Flory, agreeing with Mr. Price's comments, pointed out that the risks addressed at the conference covered a wide range of potential consequences. Seen from a State's point of view, the proliferation of nuclear weapons could have worldwide economic, ecological and health consequences. Illicit trafficking — whether malevolently, with the terrorist threat of constructing a nuclear explosive device, or inadvertently, through loss of control over sources — should make us work on understanding all these consequences through conceptual research on risk analysis. The approach must be global and adapted to the potential consequences as well as to the probability and frequency of illicit trafficking events.

New approaches?

Ms. Nilsson described the traditional way of approaching a problem, i.e. to define the areas of concern, sometimes referred to as boxes of competencies and responsibilities. During the conference, however, there had been some proposals to do it differently: for instance, to take an "all risk" approach, as touched on by Mr. Flory when he mentioned the threat assessment methodologies pointing to various risks.

Ms. Fernandez Moreno emphasized that, irrespective of the cause of radiation release, protection of people was the most important consideration. The threat (e.g. illicit trafficking, terrorism, sabotage) was another concern. Therefore, co-ordination of measures — at both the national and international level — was the key point, and this included PP measures, good SSAC and export-import control.

Mr. Van Dassen commented, adding to his earlier presentation, that it was necessary to understand who was active in the field and how the actors were linked: through organized crime, at the State level, via terrorist networks, or possibly in some combination of these. Extended databases were needed to support greater efforts in drawing co-ordinated conclusions from investigations.

New mechanisms for acquiring knowledge?

Ms. Nilsson wanted opinions as to whether the knowledge base needed strengthening or improving and whether new mechanisms were necessary for that. She asked Mr. Kravchenko, who had accumulated some statistics on border seizures that were different from those publicly known, to comment.

Mr. Kravchenko began by returning to the second question, the reason for threat. The problem of illicit trafficking was found where several means of control — PP of NM, export-import control, safety regimes — overlapped. Its solution was delayed by lack of appropriate procedures. As to the immediate question, he pointed out that many statistics presented at the conference were inaccurate, being based on materials detected without adequate technical means. Russian experience had shown that the amount of material detected increased in direct proportion to the improvement in technical means on borders. Therefore, organizations responsible for border control should increase their efforts to create procedures that would prevent illicit trafficking in nuclear and other radioactive material. Mr. Kravchenko commented that the IAEA had focused on this problem in the past four years and had produced a number of TECDOCs, as had the WCO, to assist border and customs officials combat illicit trafficking. Endorsing Mr. van Dassen's initiative, he advocated creating a co-ordination group to solve this important and complex problem. Since a significant objective threat existed because of the increase in applications of nuclear energy and in the amount of radioactive waste which needed to be processed or moved, we should deal with it.

Mr. Strauss believed that a much better knowledge base was needed. Since the problem of illicit trafficking was significant and since those working on combating it currently only saw a fraction of the whole picture, he urged that databases be expanded and all efforts be combined.

How to move on?

Ms. Nilsson asked the panel what kind of support was needed on national and international levels and what activities they regarded as desirable and urgent in order to improve security.

Mr. Volodin regarded the prevention of illicit trafficking as a national problem. Each State should take measures to protect people and the environment from the consequences of illicit trafficking. He distinguished between producers and users of nuclear material and radiological substances. The producers, including producers of waste, should take more responsibility for requirements and measures for prevention and protection. For the users, he found that methods of assessment of risk and of technical vulnerability were well developed and that enough procedures had been established to create international recommendations. On the other hand, risk assessment associated with the production of materials was less developed and some additional efforts on the part of the international community were necessary. Who would take on the role of co-ordinator — the IAEA?

For several years, Mr. Strauss had been assisting 17 countries in combating illicit trafficking, with varied success. He found a number of changes necessary in both providing and receiving assistance. Donor States should provide greater transparency in order to avoid duplication or waste of effort (e.g. redundant training, incompatible equipment). Co-ordinated strategic planning and the development of an information data bank were needed, for which international organizations should assume responsibility themselves or establish an ad hoc committee. Since the threat came not only from nuclear material, but from chemical and biological substances as well, it was vital to look at the larger picture and to include all involved agencies. Recipient States needed to understand the threat better and make structural reforms in relevant agencies in order to absorb assistance effectively. Also, co-ordination of crisis management and the problem of corruption needed to be addressed. Moreover, recipient countries should work together with their neighbours and donor countries should give assistance regionally; not to just one country at a time.

Ms. Fernandez Moreno found it difficult to generalize as situations varied between countries and regions. It was essential to have a clear idea about what was needed, to be aware that knowledge was a strong tool and therefore to train relevant staff, and to establish legislation for an adequate regulatory infrastructure.

Mr. Flory agreed that training was most important. Not only international but also national training courses should be opened across borders to create a security culture, to increase efficiency and to expand the network of co-operation.

For Mr. Price, the prime objective was to establish conditions where illicit trafficking could not occur, i.e. prevention. Therefore regulatory control must be established. He pointed out that the IAEA offered a physical protection advisory service and could help States to prioritize their training and regulatory assistance needs. He believed that the IAEA offered a similar service for implementing the BSS with regard to radioactive material and recommended that States use it as a starting point to confirm where they needed assistance.

Mr. Van Dassen, like Mr. Strauss, advocated better co-ordination of technical assistance to eliminate duplication and neglect, for which an international file of records was necessary. Also, he felt that unhealthy competition between donor States existed, which should be replaced by co-operation. On the topic of knowledge, he thought that too many myths surrounded illicit trafficking, and that they should be dispelled (e.g. that trafficking was profitable).

More R&D?

Ms. Nilsson’s final question to the panel was whether more research and development into ways of combating illicit trafficking was necessary.

Mr. Kravchenko agreed with Mr. Volodin and other speakers that, while preventing illicit trafficking was mainly a national task, international organizations like the IAEA could contribute initiative and co-ordination, explore issues that could not be resolved at the national level and assist countries in resolving these issues. In this regard, he commended the initiative of the IAEA and the Austrian Government in conducting ITRAP missions, which had developed recommendations for technical means of detection and response to be used at borders. He was eagerly awaiting the publication of the two relevant documents prepared by the Working Group in order to use the recommendations to improve technical procedures at Russia's borders. Mr. Kravchenko observed that there were, nevertheless, problems not yet covered by current activities, such as smuggling during legal export-import of NM, which would necessitate identifying nuclear and other radioactive material at customs rather than in laboratories. He hoped that the IAEA would contribute here too, as with ITRAP, producing recommendations for the customs service.

Mr. Volodin reiterated that R&D should be a national concern as each State had specific problems. Russian Federation, for example, had many more internal problems with illicit trafficking than transboundary ones. On the international level, the problem was technically well defined if not fully solved. Detection equipment could be upgraded at borders, and mechanisms for information exchange could be created with the help of international organizations. At the national level, a major difficulty was the expense of installing an adequate monitoring system inside the country: it was unaffordable to install sufficient equipment on roads and in cities. Thus, R&D should remain a national issue while the exchange of its results could be carried out at the international level.

Mr. Flory pointed out that, while R&D was necessary to develop technology for detection systems, it was also vital in developing the expertise to operate PP systems.

Open floor

At this point, Ms. Nilsson opened the discussion to further questions from the floor.

Mr. D. Ionescu (Romania) commented that, in the fight against nuclear terrorism and smuggling, there were three barriers: prevention, detection and response, the cheapest of which was prevention. Therefore, good control over NM and radiation sources and a good PP system were essential; otherwise, detection would be difficult.

Mr. K. Hirano (Japan) appreciated Mr. Van Dassen's model, elaborated in his keynote address, for co-ordination and integration of security, safety, safeguards and import-export control. It was useful to have a clear perspective of the work to be done in each field and an integrated aim. Mr. Hirano felt, however, that a broader concept was necessary, i.e. that the objective of the framework should not be limited to illicit trafficking, but should encompass national security (Volodin) and health and safety (Fernandez Moreno).

Ms. A. Alexandrovskaya (Ukraine) supported the ideas expressed by the panel, in particular Mr. Van Dassen's concept and the idea of the IAEA creating a working group to co-ordinate national and international tasks. Understanding the threat, Ukraine had developed appropriate standards, and knew the direction to move in order to eliminate it.

Mr. D. Becker (Germany) commented that detection at border crossings was only a first step. The next step should be mobile detection within countries.

Mr. D. Ek (USA) viewed threat in terms of first and second lines of defence. Whereas the second line was more freely discussed among the international community, the first line was regarded as more of a national issue because of the intelligence involved. Mr. Ek advocated assigning some basic level of outsider threat to the first line of defence, to which nations could add individually. This could be then be co-ordinated internationally to eliminate discrepancies.

Mr. J. Koziel (Poland) felt that, with the growing threat of terrorism, it would be useful for the IAEA to make joint recommendations on nuclear safety and PP (i.e. for NM and radiation sources) since they were indivisible.

Mr. F. Steinhäusler (Austria) proposed a five-point action plan for the international PP community, who should: (i) agree on conducting integrated risk-consequence-cost assessment; (ii) identify those areas where exchange of information on threats and technology was possible; (iii) identify R&D efforts where technology could be transferred to those who had to do the job; (iv) address financial requirements; and (v) organize a one-day information seminar for decision-makers to elicit political and financial support for the necessary actions.

Mr. V. Erastov (Russian Federation) was surprised at the lack of interest in this conference on the part of the media. He had not noticed any cameras or reporters. He felt that the media could be helpful in dispelling the myth that acquiring nuclear material would make you rich.

Conference summary

Having been congratulated by Mr. Flory on her work on the preliminary conclusions, Ms. Nilsson requested the panel to deliver their concluding comments on the conference before she officially closed it.

Mr. Price remarked that it had been an interesting week. Having heard about all the difficulties in detecting and responding to illicit trafficking, he felt it was better to ensure prevention in the first place.

Mr. Volodin was very satisfied with the results of the conference, where new ideas had emerged. He looked forward to a follow-up in two years' time.

Ms. Fernandez Moreno drew attention to two points: (i) prevention — in view of limited resources — as the key issue and (ii) the need to co-ordinate.

Mr. Strauss concluded that we were on the brink of the unknown and that every day brought a new challenge. However, the challenges of today might not be the problems of two years hence, so continuing awareness and alertness were necessary.

Mr. Kravchenko, endorsing Ms. Fernandez Moreno's idea that knowledge, people and power were the key to success, would add technology to the list.

Mr. van Dassen commented that an international working group within the IAEA invested with the co-ordinating skills evident at the conference could only inspire confidence in future efforts.

Conclusions

CONFERENCE SUMMARY DOCUMENT

GENERAL OBSERVATIONS

- Over the last twenty years developments in civil nuclear programmes have resulted in many more nuclear facilities and much more nuclear material in use and storage, and the dismantlement of nuclear weapons has resulted in increased inventories of sensitive nuclear materials in peaceful use and storage. Unless thoroughly controlled and protected at the national and facility level, this material may be vulnerable to theft or sabotage.
- IAEA Member States and other international organisations have become increasingly aware of the consequences which might result from illegal activities involving these materials. Where nuclear material is involved the primary danger is in the proliferation of nuclear weapons, whether to States or sub-national groups. Where other radioactive materials and radioactive sources are involved, the dangers are the radiation and health effects, and damage to property and to the environment. These dangers can be the consequence of radioactive materials being used in radiological weapons.
- Incidents involving illicit trafficking reported during the last decade have prompted a range of both national and international measures. These are designed to prevent the loss of material and, if loss occurs, to ensure that measures to recover material are rapidly enacted and that any consequences are mitigated.

TREATIES, CONVENTIONS, AGREEMENTS AND RECOMMENDATIONS

Observations

- A number of international undertakings are relevant for the security of nuclear material and other radioactive materials, in particular;
  - Treaty on the Non-Proliferation of Nuclear Weapons (NPT)
  - Convention on the Physical Protection of Nuclear Material (CPPNM)
  - Convention on Early Notification of Nuclear Accident
  - Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency
  - Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management
  - Convention on Nuclear Safety
  - Code of Conduct on the Safety of Radiation Sources and the Security of Radioactive Materials.
- INFCIRC/225/Rev.4, published by the Agency, contains recommendations for the physical protection of nuclear materials against theft and sabotage. Functional requirements for a State’s system of accounting for and control of nuclear material (SSAC) contained in INFCIRC/153 contribute to combating illicit trafficking by guiding the establishment of technical and administrative control systems for nuclear material. Basic Safety Standards provide the requirements in the field of safety and the protection of health.
- The CPPNM, a foundation stone in measures for the physical protection of nuclear material, opened for signature in 1979 and has 69 States parties.

- In November 1999, the Director General of the IAEA convened an 'Informal, Open-Ended Expert Meeting to Discuss Whether There is a Need to Revise the CPPNM'. A Working Group of the Informal Open-Ended Expert Meeting examined the issues related to the question raised, and concluded that there is a *need to strengthen the international physical protection regime.*

Summary Statements

States' initiatives to strengthen the international physical protection regime are strongly supported.

Whilst steps have already been taken to improve the physical security of nuclear material and other radioactive materials, continued efforts are required at both the national and international levels.

Steps for the future

- Work towards adopting the measures proposed to strengthen the international physical protection regime.
- Encourage States to join the CPPNM, including States which, though they have no domestic nuclear programme, are used as transit routes for nuclear material.
- Convene a conference in 2003 to review progress on measures to improve security of nuclear and other radioactive materials and to counter illicit trafficking.

THREATS AND RISKS

Observations

- The continued occurrence of cases of illicit trafficking in nuclear material and other radioactive substances is a downstream consequence of inadequate protection, control or management at the source of the material. Such cases may be inadvertent or the result of a deliberate act, aiming at causing damage or to obtain undue financial gain.
- The risks of theft and sabotage of nuclear material and other radioactive substances, and the risk of sabotage of nuclear facilities should be considered as part of a comprehensive approach which also involves nuclear safety and radiation protection considerations. Such an "all risk" approach should take into account, in a graded and adapted manner, the wide spectrum of potential risks; national and sub-national, individual and group, theft and sabotage, and the range of consequences including; nuclear weapon proliferation, radiological contamination and environmental damage.
- The risk of terrorist attacks on nuclear facilities should be considered by States in the development of their 'Design Basis Threat'. A low level of perceived national threat does not justify the complete absence of security arrangements for nuclear material, other radioactive materials, or nuclear facilities.
- Training on methods and tools for assessing the effectiveness and vulnerability of physical protection systems is important.

Summary Statements

Improved methodology, improved information on illicit trafficking and other events involving theft, sabotage or threats thereof, and on potential sources of threat, together with better *information exchange and improved co-operation with competent international organizations, would contribute to improving threat assessments.*

Steps for the future

- Improve and strengthen the mechanisms for information exchange in the area of security of material.
- Increase information exchange, including information on theft, threat of theft, sabotage or other illegal events involving nuclear material and other radioactive substances.

PREVENTION

Observations

- Nuclear security includes the establishment of measures for nuclear material accountability, physical protection, nuclear safety, radiation protection and export/import control, as well as law enforcement, detection and response measures.
- National regulatory systems underpin arrangements to prevent illicit trafficking by ensuring that nuclear material and radioactive sources are properly controlled and protected during legitimate use, storage and transport. They reflect States' own interests as well as international obligations and are guided by internationally formulated recommendations, guidelines and standards, as well as national circumstances and needs.
- Effectiveness depends on the comprehensiveness of the system, and on recognition of the synergy between the different measures. Gaps in the coverage of the system increase its vulnerability and will reduce the overall level of protection.
- One or several regulatory authorities with relevant statutory powers and duties may carry implementation responsibilities. No single law enforcement body can deal effectively with illegal events involving nuclear material or other radioactive substances. Various national regulatory and law enforcement authorities are likely to have a role to play in what must be collective effort.
- Internal co-operation between national bodies with the relevant responsibilities, and national co-operation with the appropriate international organisations are fundamental components of a comprehensive approach to nuclear security.

Summary Statements

A comprehensive and co-operative approach is required for threat assessment and for the selection and implementation of counter-measures. States should ensure that their regulatory systems cover the different measures necessary in a comprehensive approach to counter theft, sabotage or other illegal intention. There is synergy between the different measures.

Continued and increased efforts are required to assist States establishing the necessary technical, administrative and regulatory measures.

Steps for the future

- States should establish a comprehensive legislative and regulatory system that covers technical, administrative and regulatory systems for the prevention, detection and response to illegal activities involving nuclear and other radioactive materials. The IAEA should increase its efforts to assist States in these efforts, including developing a framework for a comprehensive system and evaluating, upon request, established systems.

PHYSICAL PROTECTION

Observations

- Measures to strengthen nuclear material protection and to ensure material accountability are increasingly established in States. The Action Plan for Safety of Radioactive Sources and Security of Radioactive Material is being implemented. Improvements have also been made to increase the effectiveness of controls over the import and export of nuclear material and radioactive sources.
- Several countries have amended their criminal code for illegal possession of nuclear or radioactive materials.
- States are upgrading the physical protection of their nuclear material and nuclear facilities because:
  - facilities were constructed when the requirements were less severe,
  - the political or administrative conditions prevailing in the State have evolved
  - they are responding to the results of an IPPAS mission,
  - they have decided to implement the recommendations in INFICIRC/225/Rev. 4.
- The establishment or upgrading of physical protection measures is a complex operation. The degree of complexity depends upon the size and type of facility.
- The design of physical protection measures benefits greatly from co-operation and co-ordination amongst the relevant specialists and from the availability of internationally acceptable guiding documents.
- Interaction between licensees and holders of authorizations, State authorities and response forces are vital for the implementation of physical protection systems.
- International co-operation and support, bilateral or multilateral, is an important factor for the success of the endeavour.
- The development of the Design Basis Threat should also serve as the basis for the evaluation of the effectiveness of physical protection measures in a performance-based approach.

Summary Statements

Whilst steps have already been taken to improve the physical security of nuclear material and other radioactive substances, continued efforts are required at both the national and international levels.

Steps for the future

- Improve available recommendations, guidelines and standards for nuclear security. Initiate the development of additional guiding documents to assist States in their efforts to establish the necessary technical, administrative and regulatory systems for the various functions. Develop a conceptual model for a national regulatory and co-operation structure.

- Increase information exchange, including information of theft, threat of theft, sabotage or other illegal events involving nuclear material and other radioactive substances.
- Obtain an overview of threat elements including the terrorist groups, in co-operation with national competent authorities and with Interpol, as relevant for nuclear applications. The purpose would be to establish a knowledge base available for the establishment of Design Basis Threats.
- Further develop the threat and vulnerability assessment methodology and include the necessary training in the Agency's training programme.
- Increase co-operation with all actors, at national or international levels as applicable involved in the planning, establishment and maintenance of the physical protection system.
- Plan and exercise responses to potential malevolent actions.

ILLICIT TRAFFICKING.

Observations

- Incomplete reporting of cases of illicit trafficking continues. Insufficient information is available on many cases reported to the Agency's Illicit Trafficking Database Programme, sometimes also to the Point of Contact.
- A database containing the designs of containers approved for transport of radioactive material could help customs officers to detect illicit transport in legally approved containers.
- Detection equipment is being provided in a few States to law enforcement authorities, including hand-held, fixed and mobile equipment for border monitoring.
- The capabilities of existing detection equipment are limited. Continued research and development is needed into improving detection capabilities and usability.
- Forensic capabilities need to be available at national and international levels. Further research and development is needed in the field of nuclear forensics.
- Internationally agreed normative documents are not available for radiation monitoring at border crossings.
- An international tagging system for radioactive materials might help accountancy, tracking and determination of the origin of materials involved in trafficking incidents.
- States which are vulnerable to being used as transit routes for illicitly trafficked material deserve increased attention.
- There is a need to develop or enhance international or cross-border co-operation in the field of illicit trafficking. International organizations; IAEA, Interpol, WCO can provide assistance to national authorities involved in combating illicit trafficking.
- Training should be made available to all staff involved in combating illicit trafficking.

Summary Statements

More and better information is needed on incidents of illicit trafficking.

There is a need to improve the effectiveness of border monitoring through better detection equipment, by better trained staff and by having improved types and quality of information available.

Steps for the future

- Implement the Co-ordinated Technical Research Programme to improve technology needed for detection and response to illegal activities involving nuclear material and other radioactive substances.
- Establish the framework for the necessary analytical capabilities at national and regional levels.

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