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Report No. 1

A Systems View of Nuclear Security and Nuclear Safety: Identifying Interfaces and Building Synergies

IAEA
International Atomic Energy Agency

A SYSTEMS VIEW OF NUCLEAR SECURITY AND NUCLEAR SAFETY: IDENTIFYING INTERFACES AND BUILDING SYNERGIES

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AdSec/INSAG-1

A SYSTEMS VIEW OF NUCLEAR SECURITY AND NUCLEAR SAFETY: IDENTIFYING INTERFACES AND BUILDING SYNERGIES

A REPORT BY THE ADVISORY GROUP ON NUCLEAR SECURITY AND THE INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP

INTERNATIONAL ATOMIC ENERGY AGENCY
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Marketing and Sales Unit, Publishing Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
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FOREWORD

by the Chair of AdSec and the Chair of INSAG

The twenty-first century has witnessed events that have heightened the world's attention on the importance of ensuring safety and security at nuclear facilities of all kinds.

The accident at the Fukushima Daiichi nuclear power plant in 2011 reinforced the need for an expansive re-examination of the safety regime, particularly at nuclear power plants. It spurred extensive efforts to ensure that nuclear facilities can withstand extreme external events of all kinds (earthquakes, tsunamis, flooding, volcanoes), that special emergency equipment is available and that staff are trained in its deployment, that comprehensive emergency planning is undertaken, and that spent fuel pools are carefully monitored, among many other actions. Operators and regulators around the globe have taken extensive actions to enhance the capability to prevent and mitigate extreme accidents.

The attacks on 11 September 2001 and subsequent terrorist activities around the globe were not directed at nuclear facilities, but they nonetheless reinforced attention to security matters by operators, regulators and international organizations. Nuclear power plants and fuel cycle facilities have been a particular focus of this effort, given the awareness that a terrorist attack on a nuclear power plant might strike particular fear in the affected population.

Actions in the two spheres of nuclear safety and nuclear security have historically been undertaken independently of each other for the most part. But although nuclear safety and nuclear security have a somewhat different focus, they overlap and have a common goal — protecting people, society and the environment. Actions taken to further one activity can have implications for the other — either positive or negative. This publication focuses on the interfaces between nuclear safety and nuclear security with the aim of ensuring that nuclear safety and nuclear security actions are integrated and serve to reinforce each other. It seeks to establish a framework for a more holistic capability to further both nuclear safety and nuclear security.

This report was prepared by the members of the Advisory Group on Nuclear Security (AdSec) and the International Nuclear Safety Advisory Group (INSAG), working together in pursuit of our missions. We hope it provides a framework to advance both nuclear safety and nuclear security.

THE ADVISORY GROUP ON NUCLEAR SECURITY (ADSEC)

The Advisory Group on Nuclear Security (AdSec) is composed of experts with high professional competence to advise the Director General in the field of nuclear security. AdSec is convened by the International Atomic Energy Agency (IAEA) with the objective of providing the Director General of the IAEA with authoritative advice and recommendations on current and emerging issues in nuclear security approaches, policies and principles. AdSec reviews the Agency's current and proposed activities in the area of nuclear security; makes recommendations on measures to strengthen the Agency's role and activities in the area of nuclear security; advises on current and emerging nuclear security issues; and provides guidance on priorities regarding the Agency's activities in the nuclear security area.

THE INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP (INSAG)

The International Nuclear Safety Advisory Group (INSAG) is a group of experts with high professional competence in the field of nuclear and radiation safety and experience of working in regulatory organizations, nuclear industry, technical support organisations, research or academic institutions. INSAG is convened by the International Atomic Energy Agency (IAEA) with the objective of providing the Director General of the IAEA with authoritative advice and recommendations on current and emerging issues in nuclear and radiation safety approaches, policies and principles. INSAG addresses fundamental safety issues as well as current and emerging matters of importance relevant to the nuclear and radiation safety of all facilities and activities, including nuclear security issues insofar as they relate to nuclear and radiation safety.

EDITORIAL NOTE

The opinions and recommendations stated in this publication are those of AdSec and INSAG and do not necessarily represent the views of the IAEA or its Member States.

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EXECUTIVE SUMMARY

Nuclear safety and nuclear security[1] are fundamental objectives in the management of nuclear power and in other activities involving nuclear and other radioactive materials. This publication, jointly developed by the Advisory Group on Nuclear Security (AdSec) and the International Nuclear Safety Advisory Group (INSAG), examines the commonalities of and differences between nuclear security and nuclear safety, with a view to stimulating new thinking on how the common elements of nuclear security and nuclear safety can be further recognized to enhance excellence in the management of nuclear activities.

The common objective of both nuclear safety and nuclear security — namely, to protect people, society and the environment — promotes a synergistic perspective by which nuclear safety and nuclear security can be viewed and enhanced. It draws on a recognition of the increasingly rapid pace of technology development and the need for the nuclear and radiological industries to respond to new challenges and demands. The publication further summarizes developments that have occurred in nuclear safety and nuclear security over the past ten years.

A previous publication, INSAG-24 [1], explored the important relationship between nuclear safety and nuclear security for nuclear power plants. Since its publication in 2010, significant developments have occurred for both nuclear security and nuclear safety. It is therefore timely to address again the question of interfaces and synergies between nuclear security and nuclear safety. The present publication summarizes developments that have occurred in nuclear safety and nuclear security over the past ten years. However, it is not merely an update of INSAG-24. Its scope is much wider, and it delves much further into the relationship between nuclear safety and nuclear security.

The significant developments since 2010 have, inter alia, resulted in new and more comprehensive international requirements and guidance on nuclear safety and nuclear security. The publication provides a summary of the general background to this development, including the enhanced international legal framework for nuclear safety and nuclear security, and the resulting strengthening of the IAEA Safety Standards Series and IAEA Nuclear Security Series.

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[1] In this publication the term ‘nuclear safety and nuclear security’ is used generally to cover all activities involving nuclear and other radioactive materials. References to ‘safety’ should be understood to refer to both nuclear and radiation safety, and references to ‘security’ should be understood to refer to both nuclear and radiological security. The term ‘nuclear safety and nuclear security’ is intended to embrace the response to hazards arising from the authorized use as well as the misuse of nuclear and other radioactive materials.

The common purpose of nuclear safety and nuclear security is illustrated in three main themes: clear responsibilities, leadership and management, and risk management. This background leads into the core of the publication — a discussion on the synergies and differences of nuclear safety and nuclear security areas where they interact. Finally, conclusions are drawn and recommendations are provided to encourage more synergistic interactions between nuclear safety and nuclear security.

The main conclusions are the following:

— The common purpose of the protection of people, society and the environment forms the basis for effective and efficient interfaces between nuclear safety and nuclear security.
— There are common foundations for the effective delivery of nuclear safety and nuclear security: responsibilities, leadership and management, and risk management.
— There needs to be a change in the attitude and approach to the interplay of nuclear safety and nuclear security to better reflect the commonalities; to enable continued peaceful uses of nuclear energy and ionizing radiation for the benefit of people, society and the environment; and to meet a challenging future.
— To secure such change, policy makers and leaders need to take effective action to ensure a more coordinated approach to nuclear safety and nuclear security.

The publication provides the following general recommendations:

— When considering the development of policies, laws, regulations and relevant institutions, policy makers should consider nuclear safety and nuclear security together, with more recognition of the interfaces — including possible synergies — between nuclear safety and nuclear security, in addition to the special requirements for nuclear safety and nuclear security, in order to strengthen the national legislative system and enable effective management of nuclear safety and nuclear security.
— If there are separate national authorities for nuclear safety and nuclear security, effective and dedicated cooperation should be established at the national level to ensure the necessary interaction and coordination.
— A more advanced, integrated culture for nuclear safety and nuclear security should be established to bring nuclear safety and nuclear security implementation closer together. Rather than two separate cultures, a more advanced, integrated culture for nuclear safety and nuclear security, with emphasis on clarity in responsibility, risk management, accountability and

coordination, would strengthen nuclear safety and nuclear security at the national level and for operators.

— Effective interactions between nuclear safety and nuclear security can be hampered by different use and different meanings of terms, as observed through the different glossaries published by the IAEA. It is recommended that one common glossary be developed to aid better understanding and interactions.

The following recommendations are also made to strengthen the implementation of nuclear safety, nuclear security and their interfaces:

— The IAEA safety standards and nuclear security guidance have been developed in two separate processes, although with coordination. It is likely that a common process of development would be both more effective and more resource efficient. A long term strategy to obtain a comprehensive series of international standards for nuclear safety and nuclear security should therefore be formulated.
— International activities (e.g. conferences, peer reviews) that aim to strengthen nuclear safety and/or nuclear security should draw attention to the management of interfaces between nuclear safety and nuclear security.
— There has been some use of nuclear safety assessment techniques for assessing nuclear security protection, but more work should be undertaken to develop an integrated approach to the assessment of nuclear safety and nuclear security.
— Sustainable human resource development for nuclear safety and nuclear security should provide a basis for increased knowledge and understanding of both nuclear safety and nuclear security, their specific objectives and their interfaces, for different staff categories. Already established support centres may provide both efficient use of resources and predictability.
— To increase a broad understanding of nuclear safety and nuclear security — especially the specific objectives, interfaces and interactions — more information of a non-sensitive nature should be made available, including on progress in achieving the common goals identified for nuclear safety and nuclear security and their interfaces. Mutual training (security experts training safety experts and vice versa) may constitute an appropriate means to improve the understanding of nuclear safety and nuclear security interfaces.

1. INTRODUCTION

The use of nuclear material for peaceful purposes evolved in part from the knowledge and experience gained in the development of nuclear weapons, although radioactive material had been employed in medicine and elsewhere earlier. It was recognized that nuclear energy had the potential to become a key factor in global development, while requiring the necessary arrangements to ensure that nuclear material remained limited to peaceful uses and that any unlawful purpose would be blocked. This recognition was the main reason for the establishment of the IAEA in 1957. The Statute of the IAEA emphasizes that the role of the IAEA is to promote peaceful nuclear activities and to implement safeguards to ensure that nuclear material remains limited to peaceful uses, as well as to develop safety standards[2] to protect humans from the unwanted effects of radiation. In parallel, the further development of nuclear activities for peaceful purposes was governed by multilateral cooperation agreements that also included requirements for the protection of nuclear material from theft, illegal uses and other unlawful activities for non-peaceful purposes. Such arrangements are referred to as security of materials and installations in which nuclear and other radioactive materials are used. Although the roots are different, it is clear that nuclear safety and nuclear security have been considered from the start of peaceful nuclear activities. The recognition that radioactive substances, such as sealed radioactive sources, also had to be protected from unlawful uses came later, primarily as a consequence of the rise in terrorist activities and threats.

This publication elaborates on the interfaces between nuclear safety and nuclear security from a contemporary perspective.[3]

OBJECTIVE

The objective of this publication is to provide a strategic vision for the effective synergistic implementation of nuclear and radiation safety and security.

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[2] The reference to *safety standards* in the IAEA Statute is indicative of a broad concept to protect persons from unwanted radiation and does not preclude the IAEA from addressing *security*.

[3] Since the publication of INSAG-24 in 2010, significant developments have taken place in several areas, for example the international legal framework for nuclear security has been significantly enhanced and the accident at Fukushima Daiichi provided new experiences in radiological response management.

SCOPE

This publication is applicable to facilities, locations and activities (including decommissioning, radioactive waste conditioning, storage and disposal activities) where nuclear and other radioactive material is used or involved, including the transport of nuclear and other radioactive material, the detection of material out of regulatory control, and preparedness and response to emergencies resulting from accidents and nuclear security events. This publication covers all stages of the life cycle of facilities and related activities: siting, design, construction, commissioning, operation (including shutdown, maintenance, etc.) and decommissioning.

TARGET AUDIENCE

This is a high level publication intended for State policy makers and upper management in State regulatory and other competent authorities, industry, international organizations and other relevant stakeholders.

2. BACKGROUND

Nuclear safety and nuclear security have evolved along two different tracks to address different threats and scenarios that may result in the release and dispersal of radiation or, in the case of security, the loss of control of fissile or radioactive material. However, both share a fundamental objective to protect people, society and the environment from the harmful effects of ionizing radiation.

Nuclear and other radioactive materials are components of a technical system composed of equipment, a power supply and the like, assembled for specific purposes in an industrial establishment such as a nuclear power plant or a fuel cycle facility, a medical or industrial facility using radioactive sources, or a system for the transport of radioactive substances (including nuclear material). The system is operated by a human organization within a legal and societal framework.

The origins of an accident in such an industrial establishment can be found in external or internal events, malfunctioning equipment, insufficient safety margins and, of equal importance, the human failings that occur without intention in combination with insufficient margins. The primary method to prevent accidents is to constantly address the safety features of equipment and

systems, and the competencies of staff. The principle of 'defence in depth' is applied to give reasonable margins for safety through high assurance that systems and components are reliable, through redundant and diverse means to respond to accident initiators, and through a capacity to both prevent and mitigate accidents.

The origins of a security event are different. The intention of a security event is to cause disruption, damage and adverse health effects, either at the place of the event or at another place later in time. This is visualized by the 'worst case scenario' in which vulnerable nuclear material is stolen from a nuclear facility and later assembled into an improvised nuclear explosive device that may be brought to a distant place for detonation. Other security relevant scenarios are acts of sabotage performed with an intention to cause the damage required to disperse radioactivity within or outside the facility, or theft of material, including sealed radioactive sources, that is transported to a selected place for dispersal of radioactivity. This means not only that nuclear and other radioactive materials that are declared will be subject to security arrangements, but also that arrangements have to be in place for detection of and response to material out of regulatory control (often referred to as MORC). Radioactive materials may also be inadvertently out of regulatory control (e.g. radioactive sources left behind or discarded).

Both nuclear safety and nuclear security must be vigilant in meeting new threats and challenges. New technological developments that concern both nuclear safety and nuclear security include more advanced software for instrumentation control and communication; new technologies to be applied at reactors and fuel cycle facilities; new and more users; and more sophisticated processes such as artificial intelligence and digital process control. Other new challenges for both nuclear safety and nuclear security include the use of drones, cyber technologies and information gathering techniques.

3. THE INTERNATIONAL LEGAL BACKGROUND FOR NUCLEAR SAFETY AND NUCLEAR SECURITY

3.1. THE EVOLUTION OF LEGALLY BINDING UNDERTAKINGS FOR NUCLEAR SAFETY

The international legal framework for nuclear safety has evolved over the past forty years, anchored in the Statute of the IAEA, which points to the development of safety standards as a core duty for the IAEA. At the time of the approval of the IAEA Statute in 1956, there were no international agreements on

nuclear safety, and it was broadly considered by the international community that nuclear safety was a responsibility for national governments. This view prevailed until the Chernobyl accident in 1986. The resulting dispersal of radioactive material over wide areas demonstrated clearly that a nuclear accident may have a serious impact on other countries and a global context. The consequences of this accident initiated the successive development and agreement of four international conventions with legal obligations for the State parties implementing nuclear energy programmes, the first two in less than one year. The nuclear safety conventions are as follows:

— The Convention on Early Notification of a Nuclear Accident [2] was adopted in 1986 and entered into force in 1986.[4]
— The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency [3] was adopted in 1986 and entered into force in 1987.
— The Convention on Nuclear Safety (CNS) [4] was adopted in 1994 and entered into force in 1996.
— The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [5] was adopted in 1997 and entered into force in 2001.

These conventions established a solid international legal foundation for nuclear safety and emergency preparedness and response. Periodic review conferences have provided a mechanism for a common approach to further improving nuclear safety.

The non-binding Code of Conduct on the Safety and Security of Radioactive Sources [6] is an important addition to the legal framework of equal relevance for nuclear safety and nuclear security. Although it is not legally binding, in an official letter to the IAEA Director General over 140 States have made a political a commitment to implement the Code as far as possible. This commitment, which has near universal support, has been transformed into a legal instrument that contains both nuclear safety and nuclear security measures.

The 2011 accident at the Fukushima Daiichi nuclear power plant ended a long period without nuclear accidents and pointed to a need to strengthen nuclear safety, both through better compliance with existing IAEA safety standards and, in some areas, through the development of enhanced standards. During the General Conference in September 2011, Member States endorsed the IAEA Action Plan on Nuclear Safety [7]. The plan defined a programme

[4] Both the Early Notification Convention and the Assistance Convention are explicitly applicable to nuclear and radiation emergencies.

of work to strengthen global nuclear safety, outlining actions to strengthen safety in twelve areas, including safety assessment of nuclear power plants and capacity building, IAEA peer reviews and safety standards, and strengthening of national regulatory bodies. The implementation of the Action Plan formed part of the Fukushima Daiichi Accident report [8] and its technical volumes as reported to the 2015 IAEA General Conference. The Action Plan has contributed significantly to the enhancement of nuclear safety worldwide, as has the Vienna Declaration on Nuclear Safety of 2015 [9]. The Vienna Declaration, adopted by the contracting parties to the CNS, adopted three guiding principles for the implementation of the CNS:

> "1. New nuclear power plants are to be designed, sited, and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term off site contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions.
> 2. Comprehensive and systematic safety assessments are to be carried out periodically and regularly for existing installations throughout their lifetime in order to identify safety improvements that are oriented to meet the above objective. Reasonably practicable or achievable safety improvements are to be implemented in a timely manner.
> 3. National requirements and regulations for addressing this objective throughout the lifetime of nuclear power plants are to take into account the relevant IAEA Safety Standards and, as appropriate, other good practices as identified *inter alia* in the Review Meetings of the CNS."

3.2. THE EVOLUTION OF LEGALLY BINDING UNDERTAKINGS FOR NUCLEAR SECURITY

During the early implementation of peaceful nuclear programmes, it was recognized that vulnerable nuclear material, notably highly enriched uranium and reprocessed plutonium, needed to be protected against theft. The possibility for States or non-State organizations to obtain the material required for an explosive nuclear device was recognized and served as the main reason to establish physical protection.

In 1987, the Convention on the Physical Protection of Nuclear Material (CPPNM) [10] entered into force. It established the need to protect nuclear material in domestic use and storage, but without indicating how this was to

be done. The CPPNM also established a set of obligations for the protection of nuclear material in international transport. These obligations are still valid as the target for how to protect nuclear material of different categories (i.e. the attractiveness of material for weapons purposes). During the late 1990s, as a result of the increased trafficking in nuclear material, it became evident that the CPPNM needed to be strengthened.

At the same time, the security of sealed radioactive sources or other radioactive substances was not addressed internationally. So-called orphan sources, left behind by military forces or otherwise left uncontrolled after use, began to be found as radiation accidents started to occur. Still, the concern was primarily radiation safety, not security. The prevailing view was that high activity radioactive sources were 'self-protected' and normal management practices to keep the sources or materials away from people to prevent accidental exposure were sufficient. This view changed drastically with the dramatic increase in terrorism during the past two decades.

The increased number of reports of illicit trafficking incidents, in which nuclear and other radioactive materials were found in places where they did not belong, further pointed to the need to strengthen the control and protection of radioactive sources or substances from theft and acts of sabotage. As a result, the international community has significantly strengthened the international legal framework for nuclear security with the adoption of two new international legal instruments:

— The Amendment to the CPPNM[5] [11] was adopted in 2005 and entered into force in 2016.
— The International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT) [12] was adopted in 2005 and entered into force in 2007.[6]

It was also recognized that nuclear and radioactive materials may be taken from one country to another in order to carry out a malicious act. Therefore, in 2004, the United Nations Security Council issued resolution 1540 [13], which addressed the threat to international peace and security posed by non-State actors for the proliferation of weapons of mass destruction. The resolution obliges all States to develop and maintain appropriate and effective border controls and law enforcement efforts to detect illicit trafficking and brokering in such

[5] The full name of the amended convention is the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities. As of 1 September 2021, there are 160 Parties to the CPPNM and 123 Parties to the CPPNM Amendment.

[6] As of 1 September 2021, there are 116 States Parties to ICSANT.

weapons and related materials. Implemented in an integrated manner, these new legal instruments (including United Nations Security Council resolution 1540 [13]) have significantly strengthened the international legal foundation for nuclear security.

The recognition that radioactive non-fissile substances may also be used in criminal and/or terrorist activities was a significant change in the policy for managing radioactive sources. Expanded use of 'non-nuclear' sources in medical, industrial or geological applications creates new challenges for effective security, although radiological safety has always been fully accepted for these uses.

Both ICSANT and the amended CPPNM include an obligation to establish appropriate penalties for criminal and/or terrorist activities under national law. The requirement to define certain criminal acts as punishable acts is reflected in publications in the IAEA Nuclear Security Series (see IAEA Nuclear Security Series No. 20, Objective and Essential Elements of a State's Nuclear Security Regime (the Nuclear Security Fundamentals) [14]. Protecting nuclear or other radioactive materials against malicious acts is an important matter that differentiates nuclear security from nuclear safety. The responsibility of the operator (the licensee) and others, as appropriate, is no different with respect to nuclear safety and nuclear security events, although the nuclear security response always involves external agencies.

3.3. DISCUSSION

The international legal foundation for nuclear security has been developed over a relatively short period. Although it still has some gaps, the framework, which has been established through various international undertakings, is strong. The conventions listed in the previous section underline, for both nuclear safety and nuclear security, the clear allocation of responsibilities and the need for cooperation within countries and internationally and for a graded approach to both nuclear safety and nuclear security. The most obvious differences between the legal frameworks for nuclear safety and for nuclear security are (a) the obligation to establish punishable offences in the case of security events, and (b) the obligations related to nuclear and other radioactive materials that move in circumstances outside regulatory control, their detection and response actions. The need for such a framework gained increased prominence after the malicious aircraft crashes in the United States of America on 11 September 2001. The IAEA Board of Governors and General Conference then recognized the need to accelerate the development and implementation of nuclear security.

The legally binding framework is not yet universally implemented, although a universal implementation is close. The number of Parties to ICSANT and the

CPPNM and its Amendment is high, indicating the priority States assign to these matters. The implementation also depends on the contributions of the IAEA, its standards and guidance as well as assistance and services, and on bilateral interaction and cooperation. The legal foundation anticipates a dedicated system for implementation and recognizes that this involves implementation both at the national level and by operators. Coordination and interaction within and between States is a common requirement in all conventions, for safety as well as for security. This underpins effective national implementation and key contributions from and through the IAEA and other international organizations.

4. IAEA SAFETY STANDARDS AND SECURITY GUIDANCE

At present and in accordance with its Statute, the IAEA develops and publishes safety standards and security guidance in two separate series — the IAEA Safety Standards Series and the IAEA Nuclear Security Series. Implementation of these standards and guidance is voluntary for Member States, but the objective and expectation are that they will be used as a basis for national legislative systems, directly or indirectly. The two series take a similar hierarchical approach to the publication of standards/guidance, with a top tier publication addressing the fundamental principles (nuclear safety) or essential elements (nuclear security), supported by publications providing safety requirements and nuclear security recommendations, respectively. In both series, additional, lower tier guides are published providing more guidance and methods for implementing the requirements and recommendations. In both series, common themes may be identified.

The IAEA Nuclear Security Series, giving guidance on nuclear security, was established only in 2006. Prior to that, physical protection recommendations were drafted by a group of States and published by the IAEA as an Information Circular (INFCIRC/225 [15]).

The use and regulatory control of nuclear material was originally considered a strictly national responsibility with very limited international interaction. The sensitivity of information and the need to maintain confidentiality of security arrangements, notably physical protection, reduced international interactions. It was not until March 1972 that the first guidance, Recommendations for the Physical Protection of Nuclear Material, was published. In 1975, when the IAEA published updated recommendations on physical protection in INFCIRC/225 [15], the recommendations addressed only the theft of nuclear

material in use, storage and transport, together with its recovery, if stolen. The fifth revision of INFCIRC/225 was published in 2011; it covered both protection against theft and acts of sabotage and was published as IAEA Nuclear Security Series No. 13 [16].

The procedures to establish the safety standards and security guidance are solid and based on open and transparent processes. There are, however, some important differences in the ways that the safety standards and the security guidance are developed. The development of safety standards is supported by a total of five committees[7], plus the Commission on Safety Standards, while the development of security guidance is supported by one committee[8]. All Safety Requirements are approved by the IAEA Board of Governors, on the advice of the Commission on Safety Standards, while guidance in the IAEA Nuclear Security Series is approved by the Deputy Director General and the Head of the Department of Nuclear Safety and Security on the advice of the Nuclear Security Guidance Committee. However, there is one exception: the Nuclear Security Fundamentals [14], the top tier publication in the IAEA Nuclear Security Series, is approved by the Board of Governors.

Both series are applicable for the management of nuclear facilities, storage facilities or locations such as an industrial site or a hospital, and for the transport of nuclear and other radioactive materials.

The IAEA takes specific measures to ensure coordination of the security guidance with the safety standards, primarily to ensure that safety requirements do not negatively impact security and vice versa. An internal coordination committee has been assigned to ensure that interfaces between nuclear safety and nuclear security are identified. Interactive processes have been established for the development and publication of nuclear safety standards and nuclear security guidance.

The question of further integration of the two series was addressed in a joint task force of AdSec and the Commission on Safety Standards in April 2009. After several meetings, the task force concluded that nuclear security and nuclear safety are equally important and that the process for review and approval of IAEA safety standards and nuclear security guidance should reflect this. To ensure proper coordination, an option exists to draft publications in the two series in consultation and to review them to identify or define interfaces, if any. A specific process for this has been established and is currently being implemented. The

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[7] The Emergency Preparedness and Response Standards Committee (EPReSC), Nuclear Safety Standards Committee (NUSSC), Radiation Safety Standards Committee (RASSC), Waste Safety Standards Committee (WASSC) and Transport Safety Standards Committee (TRANSSC).

[8] The Nuclear Security Guidance Committee (NSGC).

task force also outlined a long term vision in which the IAEA Safety Standards Series and the IAEA Nuclear Security Series are merged and a revised committee structure is designed under the leadership of a 'Commission on Safety and Security Standards'.

The question of the future design of the IAEA safety standards and security guidance has progressed beyond the establishment of the Nuclear Security Guidance Committee and the safety–security coordination process. However, the long term vision projected in 2009 by the joint AdSec–CSS task force has not yet been realized. The implementation of nuclear power and other nuclear applications requires transparent processes and effective standards and guidance. The question has been raised whether safety standards and security guidance are best served by two processes and two different approval structures. The amount of effort by the various parties invested in the safety standards process is greater than that for nuclear security guidance, although they are of equal value, perhaps reflecting different challenges. This may be indicative of a need for reform relating to both the safety standards process and that for nuclear security guidance. Greater balance may be achieved based on considerations of risk.

5. ALLOCATION OF RESPONSIBILITIES

National governments have overarching responsibility for nuclear activities in the country and for the use of radioactive sources or other radioactive materials. This responsibility includes nuclear safety, nuclear security and the peaceful uses of nuclear material and technology. This responsibility cannot be assumed by any other country or organization.

5.1. NATIONAL RESPONSIBILITIES

Governments carry full responsibility for the nuclear programmes that are carried out in the country. The government may exercise its responsibility by means of different legal instruments, statutes and laws. International conventions and agreements all underline the importance of establishing a clear line of responsibility, from the government to organizations and individuals. The government determines the specific functions of the competent authorities to supervise, monitor or carry out certain functions in the national nuclear safety and nuclear security regimes. Of specific importance is the appointment of a regulatory body (or bodies) and the allocation of that body's responsibilities

at the State level. An appointed regulatory body will establish a regulatory programme and a strategy, set forth in its regulations or in national standards, to achieve the intended level of nuclear safety and nuclear security. In doing so, it is advisable for the government and/or regulator to be informed by the IAEA safety standards and security guidance, which identify, in some detail, the responsibilities of a regulatory body. The regulatory responsibility can be given to one or more organizations.

In many countries, the regulatory responsibilities in relation to nuclear safety, nuclear security and safeguards have been given to one organization. Examples are Canada, Sweden, United Kingdom and the United States of America. In other countries, regulatory responsibilities have been assigned to two organizations, one for safety and one specifically for security and nuclear material control. Examples are Australia and France. Most countries without nuclear energy programmes have one regulatory body that deals with all regulatory issues.

The operator, or license holder, has implementation responsibility and is responsible for nuclear safety and nuclear security at the operating site. It is also responsible for the accounting and operational control of nuclear material that follows from undertakings in safeguards agreements, and as a party to the Nuclear Suppliers Group (NSG) and its export control guidelines as well as bilateral cooperation agreements. To fulfill their responsibilities, operators use defined bases for the design of the nuclear safety and nuclear security systems that are established by the government or organizations designated by the government or in regulations.

For safety, a design basis accident (DBA) is derived by the operator and reviewed by the regulator. The operator is required to demonstrate that for the DBA there is no unacceptable radiological impact inside or outside the facility using established design criteria and conservative assumptions. Some accidents more severe than the DBA, covered by design extension conditions (DECs), are required to be considered in the design process using best estimate methodology; for such accidents any projected releases of radioactive material have to be kept within identified limits. Beyond DBAs may involve the government or other organizations in mitigating the impact through off-site emergency response.

In security, the government defines a design basis threat (DBT) in terms of the adversary and the type of attack that may be carried out. Such events can lead to a DBA, DECs or a more severe accident. The DBT is established on the basis of the prevailing security situation in the country and/or region and the characteristics of the attackers, such as number of persons, weaponry, explosives, information and insider connections. If the attack is carried out with means beyond the DBT (e.g. through an attack that is similar to an act of war), additional national response resources from those available for a DBT may be required to

counter the attack or to respond to the results of the attack. Different responses may be required depending on the purpose of the initial act: theft of vulnerable, perhaps weapons grade, nuclear material or other radioactive material, or acts of sabotage resulting in the dispersal of radioactivity.

A serious nuclear safety or nuclear security event with possible radiological release will require the involvement of the local or national emergency organization. Local or regional police will have responsibilities 'for law and order' (e.g. in the case of evacuation or for enforcement of radiation protection measures). In the case of a security event, the facility may also become a crime scene, which will require additional legal interventions (i.e. forensic evaluations, legal interventions and support in radiation protection efforts). The foreseen interaction requires close coordination between the operator and the organizations having responsibility for nuclear security, either in the planning stage (e.g. in the establishment of a DBT) or in the aftermath of a nuclear security event. Radiological emergency responses and criminal investigation will require insight and balanced approaches. Established procedures and interaction are required, as are periodic exercises.

Border guards and customs officers will have responsibilities regarding illicit nuclear trafficking (e.g. detecting material out of regulatory control). Coordination and interaction among the competent authorities and the operator will be necessary in both the planning and the response phase. The detection of illicit nuclear and other radioactive materials will require safety precautions and knowledge of how to handle the material seized. These are examples of practical situations in which both nuclear safety and nuclear security measures are implemented.

5.2. IAEA RESPONSIBILITIES

The position and function of the IAEA are determined by its Statute, by General Conference resolutions and in decisions by the Board of Governors. The entire programme of the IAEA aims at providing support and services to its Member States, through standards, guidance, technical cooperation and information. The international treaties for which the IAEA Director General is the depository create additional responsibilities. The IAEA's treaty verification role is only relevant with respect to safeguards agreements, for which the IAEA verifies the correctness and completeness of declarations of nuclear material in use, storage and transport. For States with safeguards agreements, the IAEA has the legal right of inspection and requesting additional, clarifying information.

Otherwise, IAEA responsibilities for nuclear safety and nuclear security do not include formal monitoring, oversight or mandatory assessment. They do,

however, include important voluntary functions such as peer review or evaluation of operational functions at facilities (e.g. through the Operational Safety Review Team (OSART) service or the International Physical Protection Advisory Service (IPPAS)) or of national regulatory systems (e.g. through the Integrated Regulatory Review Service (IRRS)). The IAEA may also, through technical cooperation or nuclear security assistance, provide specific assistance for staff training opportunities, critical equipment or other support. Such support must always be requested by the State.

5.3. PERSONAL RESPONSIBILITIES

It is the responsibility of all those involved in activities where nuclear safety or nuclear security is a concern to behave in a way that promotes the success of the enterprise, including ensuring compliance, a questioning attitude, and reporting and correction of deficiencies.

5.4. DISCUSSION

An increasing number of single national regulatory bodies are being established to cover all matters of a regulatory nature; namely, nuclear safety, nuclear security and nuclear material accountancy. Several countries have more than one regulatory body, one for nuclear safety and one for nuclear security, to one of which nuclear material accountancy is often connected. In both cases, the regulatory functions will require cooperation with other authorities such as law enforcement, intelligence and border guards/customs in matters of security.

Effective coordination depends on the degree of interaction and the existence of commonly recognized procedures. Regulatory functions for nuclear safety and nuclear security may be facilitated if the responsible staff are in one organization rather than more than one. It is not realistic, however, to aim for a regulatory organization that includes physical enforcement capacity, such as for law enforcement. The particular circumstances in each country determine how the regulatory responsibilities are allocated. However, in all arrangements of regulatory bodies there is obviously a need to identify areas (interfaces) where nuclear safety and nuclear security may affect each other and ensure effective interactions. Some countries with more than one regulatory body split the responsibility depending on the presence of nuclear material; all matters related to nuclear material are handled by one organization and all matters related to the use of other radioactive materials, such as radioactive sources, are handled by another separate organization.

The IAEA is recognized as the international lead organization in both nuclear safety and nuclear security. The IAEA's provision of services, assistance and information is highly appreciated by its Member States. An initial discussion of the validity of including nuclear security in the IAEA programme has been completely resolved, as evidenced in General Conference resolutions and through the International Nuclear Security Conference convened at the ministerial level every 3–4 years. General Conference resolutions have underlined the importance of the IAEA facilitating the process of coordination of safety–security interfaces, of developing safety–security publications and of fostering a cooperative culture [17, 18].

Wherever responsibilities for nuclear safety and nuclear security are divided (whether in international or in national bodies or organizations), effective cooperation and coordination arrangements are encouraged.

6. COMMON PURPOSE OF NUCLEAR SAFETY AND NUCLEAR SECURITY

IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles [19], identifies the overarching objective of both nuclear safety and nuclear security as the following: "**The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation.**"

This fundamental objective is also reflected in the IAEA's Nuclear Security Fundamentals [14]: "Nuclear security and nuclear safety have in common the aim of protecting persons, property, society and the environment."[9]

While nuclear safety aims at preventing and mitigating accidents (owing to internal and external events, equipment malfunction, wearing out of materials, human error, etc.), nuclear security aims at preventing the malicious release of radioactive materials (i.e. releases other than authorized discharges or disposal) and the misuse of nuclear energy, nuclear and other radioactive material and information. That is, nuclear security seeks to prevent individuals with malicious purposes from obtaining access to equipment, systems, material or information. Nuclear material and other radioactive material with properties that could make it

[9] Society, in this context, means not only the people but also the very fabric of society that binds people together. A nuclear accident or an act of terrorism may result in harm to or destruction of society. INSAG-24 also noted that the foundation of the decisions about the relationships of nuclear safety and nuclear security is the realization that they share a common purpose and aim, simply stated as the protection of people, society and environment.

useful in an explosive device require special attention. Some preventive measures are important for both nuclear safety and nuclear security, such as redundant systems, fulfillment of functions by diverse means, spatial separation, robust equipment and response measures.

The Fundamental Safety Principles [19] and the Nuclear Security Fundamentals [14] both define principles and measures that are important to achieve effective nuclear safety and effective nuclear security. Three themes are generally recognized as the common foundation for effective nuclear safety and effective nuclear security; these are reflected in the fundamental publications for nuclear safety and for nuclear security:

— *Responsibilities:* A clear allocation of responsibilities and related measures are equally fundamental both nuclear safety and nuclear security. Regulatory arrangements to both nuclear safety and nuclear security include ensuring that regulatory bodies have the mandate, enforcement authority and resources needed to effectively administer the prime functions of both nuclear safety and nuclear security regulators (i.e. to ensure that nuclear and other radioactive materials cannot be used, stored or transported without a proper authorization for both nuclear safety and nuclear security). For both nuclear safety and nuclear security, responsibility includes assessing compliance of activities with the regulatory system, regulatory inspections to ensure compliance and enforcement in the case of non-compliance with nuclear safety and nuclear security requirements.
— *Leadership and management:* The leaders of an organization set the vision and culture of the organization. Management systems are a vital tool of leadership. Thus, leaders express their vision and determine the culture by establishing and sustaining effective management systems — including for quality management — for both nuclear safety and nuclear security; promoting a nuclear safety and nuclear security culture for operation; ensuring the availability of the resources required for adequate attention to both nuclear safety and nuclear security; and creating a mutually supportive environment. Organizations normally maintain *one* management system that will function equally well in the implementation of both nuclear safety and nuclear security. It is most effective for leadership to give equal priority to both areas, using the same implementation tools.
— *Risk management:* Throughout the life cycle of all activities involving nuclear and other radioactive materials, addressing the risk of accidents and security events has to be considered a high priority. Systematic risk assessments of undesirable events are to be conducted in a coordinated manner at every stage, from conceptual design through periods of use, storage or transport until final decommissioning. Particular attention should be given to older

nuclear facilities and to periods of outage, service and repairs when normal operating procedures cannot be applied. The same design principles (diversity, redundancy, separation, multi-barrier, etc.) are applied to both safety and security to achieve robustness in the processes for assessment and risk management, and in the hierarchical control measures. At the same time, the risk assessment methodology for nuclear security will consider the dynamic security situation and assessed risk of attack, evaluation of protection measures and adversaries' action consequences[10]. Increasingly, there is cross-fertilization of methodologies (e.g. probabilistic assessment) that originated in nuclear safety, elements of which are becoming a useful tool in nuclear security. More work could be usefully undertaken in this area.

The different structure of the Fundamental Safety Principles [19] compared with the Nuclear Security Fundamentals [14], which contains objectives and essential elements of a State's nuclear security regime rather than the principles contained in the safety fundamentals, offers an understanding of both the commonalities and differences between nuclear safety and nuclear security. The nuclear security essential elements are not, and cannot be, translated into principles given their more prescriptive nature. Recognizing that there is this basic difference in the scope of the nuclear safety and nuclear security fundamentals, it becomes possible to embrace the idea that most of the nuclear safety principles are also relevant for nuclear security.

A proposal to merge the nuclear safety and nuclear security fundamentals does not offer a simple solution. If common nuclear safety and nuclear security fundamental principles were to be defined, there would still be a need to maintain the essential elements of a State's nuclear security regime, in an appropriate format.

[10] The DBT assessment, which is a jointly applied methodology for nuclear safety and nuclear security.

7. INTERFACES AND INTERACTIONS OF NUCLEAR SAFETY AND NUCLEAR SECURITY

Nuclear safety–nuclear security interfaces[11] are features or conditions of sites, civil structures, technical systems, information (including software), organizations, cultures, human activities, and regulatory standards and requirements through which nuclear safety and nuclear security interact or where consideration of the interplay of nuclear safety and nuclear security is needed. The interaction can result in mutual benefit (synergy) or in one compromising the other (opposition). The interface is of relevance during the whole life cycle of a nuclear facility and therefore needs to be considered from the very beginning in legislation and standard setting, through the design and construction phases, and including operation, decommissioning and disposal. The assessment of the interfaces and of interactions mediated by them is a common activity of operators and nuclear safety and nuclear security authorities (including their respective technical and scientific support organizations), although the prime responsibility rests with the operator.

The management of activities involving nuclear material or radioactive sources or substances is invariably assigned to the operator, although the government maintains a final national responsibility. The operator has the clear responsibility to ensure that the processes and materials are effectively managed and that nuclear safety and nuclear security measures and the requirements for peaceful uses of nuclear materials, including accounting, are fulfilled. The effectiveness of management depends on institutional strength, associated with leadership and accountability. It is important to communicate the identification of interfaces between the well established nuclear safety and the more recent nuclear security, their equal value and priority within the organization, and a recognition that the systems need to be mutually reinforcing. This is consistent with implementation of international undertakings and IAEA safety standards and security guidance.

There are some topics or activities where the interfaces are obvious (e.g. computer security, which is important to protect for both security and safety reasons) and others where differences may occur (e.g. instances where transparency and openness are key for nuclear safety whereas the opposite is true for nuclear security). At the same time, in both nuclear safety and nuclear security communication is of key value, and that requires information. The identification and consideration of the interfaces between the well established nuclear safety

[11] In simple terms, an ‘interface’ is where safety and security considerations come together, and ‘interactions’ refers to how they do so.

system and the more recent nuclear security system is vital, including in corporate communications (e.g. when discussing energy production priorities), in order to reflect the equal value and priority given to nuclear safety and nuclear security.

Important interfaces and interactions are identified below.

7.1. ALLOCATION OF NATIONAL RESPONSIBILITIES AND COORDINATION

National responsibility for both nuclear safety and nuclear security remains unchallenged; this is also reflected in the various relevant international legal undertakings. A wider range of organizations have responsibilities for nuclear security (anti-terrorist agencies and forces, customs officials, etc.) than is the case for nuclear safety. Accordingly, an effective mechanism for coordination and cooperation will be required, which is also a high level interface. Both nuclear safety and nuclear security require independent regulatory oversight, with objective authorization, inspection and enforcement.

Typically, nuclear security regimes are more prescriptive, based on local experience and threats, than those for nuclear safety and do not involve public consultation or participation in the development of authorizations, regulatory standards or guidance. They are also generally more dependent on other agencies for certain aspects of their functions, such as threat determination. However, there is a growing realization that nuclear safety regimes and nuclear security regimes have more in common with, and opportunities for learning from, each other than not. In some cases, commonly where the nuclear safety and nuclear security regulatory functions are in the same body, there have been moves to bring the functions more in line with each other. In all cases, close cooperation and coordination are required.

7.2. INSTITUTIONAL STRENGTH IN DEPTH

In developing or assessing a nuclear safety or a nuclear security system, principles of strength in depth[12] are identified for both nuclear safety and for nuclear security. The principle of strength in depth may be applied to examine the interactions between the two systems. The processes used may differ, as may the details of the system model. However, safety or security by design, peer

[12] In this publication, the term ‘strength in depth’ is used to emphasize the positive aspects of a robust nuclear safety system and to avoid confusion with the use of ‘defence in depth’ in the technical application of the latter concept.

reviews, staff competencies and constant learning are examples of measures that build institutional strength in depth for both nuclear safety and nuclear security. In both cases a systems approach should be adopted to look at both components and interconnections.[13]

7.3. MANAGEMENT AND LEADERSHIP: SAFETY CULTURE AND SECURITY CULTURE

At a nuclear facility, the responsibility for the many operational processes, priorities and other responsibilities are established in the management structure. The ultimate responsibility for operation rests with management, to ensure that the work is performed effectively and according to the policy established and the licence conditions. This covers both nuclear safety and nuclear security. A nuclear power plant is also an organization with an economic structure, but it is one where it is essential that its product be delivered with excellence in both nuclear safety and nuclear security. Hence, management has to be in control of both nuclear safety and nuclear security within the protected areas and establish appropriate drivers for the behaviours of its staff.

To underline the importance of safety after the Chernobyl accident in 1986, INSAG introduced the concept of *safety culture* in its Summary Report on the Post-accident Review Meeting on the Chernobyl Accident [21]. Later, when security was recognized as being of equal priority, the *security culture* concept was identified. The necessity of establishing and maintaining a security culture was recognized as a fundamental principle for physical protection of nuclear material and nuclear facilities and included as an obligation in the Amendment to the CPPNM [11][14]: "All organizations involved in implementing physical protection should give due priority to the security culture, to its development and maintenance necessary to ensure its effective implementation in the entire organization."

In the IAEA Nuclear Security Series, nuclear security culture is defined as "The assembly of characteristics, attitudes and behaviour of individuals, organizations and institutions which serves as a means to support and enhance nuclear security" [22]; safety culture is defined as "that assembly of characteristics and attitudes in organizations and individuals which establishes

[13] INSAG-27 [20] provides a model that may be useful for the establishment of a resilient and robust nuclear safety and nuclear security system in a country based on the principle of strength in depth.

[14] See Ref. [11], Fundamental Principle F: Security Culture.

that, as an overriding priority, protection and safety issues receive the attention warranted by their significance" [23].

The principal shared objective of a culture for nuclear security and for nuclear safety is to limit the risk resulting from nuclear and other radioactive material and associated facilities. This common objective is largely based on shared principles (e.g. an open and questioning attitude, rigorous and prudent approaches, effective communication and open, two-way communication). While the common objective is clear, there will be occasions when the nuclear safety and nuclear security cultures differ. However, an organization in charge of nuclear matters must promote an approach that integrates nuclear safety and nuclear security in a mutually supporting manner.

Both nuclear safety and nuclear security are driven by the cultures of behaviours that are promoted within the organization. While in the past, reference has been made to a 'nuclear safety culture' and a 'nuclear security culture' separately, both are driven by one organizational leadership, under one banner. Shared cultural objectives drive operational compliance with nuclear safety and nuclear security procedures, with a questioning and challenging attitude, problem solving and continuous improvement being common desirable behaviours.

As the ultimate responsibility for the implementation of the safety culture and the security culture rests with the leadership of the facility, the question of how close should, or could, nuclear safety and nuclear security culture be brought together may be raised.

In any case, both nuclear safety and nuclear security cultural expectations have to be reflected in the management systems, procedures and training, which have to be logical and coherent in preventive and mitigation measures for nuclear safety and nuclear security.

7.4. IDENTIFICATION OF VITAL AREAS

One objective of physical protection at a nuclear facility (and for other nuclear or radiological activities) is to protect against sabotage that may result in unacceptable radiological consequences. An analysis should be performed to determine the radiological consequences that could be associated with each nuclear facility. The operator should identify equipment, systems or devices or nuclear material whose sabotage could directly or indirectly lead to unacceptable radiological consequences. For this analysis, the result of safety analyses[15] will provide essential input. Such equipment should be located within a vital area and

[15] For example, from a probabilistic safety analysis, performed for a nuclear facility, or from other means to identify safety critical equipment.

be protected by an additional layer of detection, access control and delay beyond that for the protected area. This is to provide defence in depth[16].

The process of identifying vital areas to be protected against sabotage is a particularly useful example of a safety–security interface; the safety analysis is a useful (and necessary) component in the identification of vulnerable equipment. In practice, for complex nuclear systems, only nuclear safety experts at the pre-design stage can identify vulnerable equipment (or targets) for principal protection. On the basis of this information, the nuclear security experts can determine the vital areas and, with the established DBT, apply suitable protective measures. The ultimate objective is to protect against an act that would result in the dispersal of or excessive exposure to radioactivity. In the development of new technology, considering nuclear safety and nuclear security by design obviously serves this objective. This provides a fundamental example of the common goal of nuclear safety and nuclear security.

7.5. OPTIMIZATION

For all activities involving the use of radioactive material there is no such thing as absolute safety or security. The relevant nuclear safety principle is 'as low as reasonably achievable'[17], which seeks to minimize the risk in balance with the time, trouble and expense of doing so. In nuclear security, the establishment of a DBT provides the basis for a judgement on what is an acceptable residual risk with implementation of effective physical protection. With limits on resources and the identification of disbenefits, decisions may have to be made on the optimization of nuclear safety or nuclear security but also on nuclear safety versus nuclear security. Optimization in both nuclear safety and nuclear security is achieved through a system of good practice, codes, standards and cost-effectiveness.

For both nuclear safety and nuclear security optimization, recognizing the common overarching objective provides the means to allocate the efforts to minimize or eliminate the risk and to ensure that the attention applied is commensurate with the level of the consequences of failing protection.

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[16] While in its detailed application and use, the term 'defence in depth' may be different for nuclear safety and nuclear security, it is the same in principle; namely, multiple barriers providing redundancy and diversity in protection at different levels.

[17] In some jurisdictions referred to as 'as low as reasonably practicable'.

7.6. HUMAN RISK FACTORS

While both nuclear safety and nuclear security can be detrimentally affected by human errors, security considerations relate to intentional/malicious human threats, especially 'insider' threats (i.e. threats that employed persons would commit, or facilitate, criminal or malicious unauthorized acts, including to help outside intruders in their malicious intent). The predominant human risk factors for nuclear safety are related to human errors.

For both purposes, the reliability and trustworthiness of the workforce are essential, including the lack of a criminal record and of drug use. Thus, the personnel system has to include a procedure to ensure and maintain the trustworthiness of the workforce, recognizing that security requirements for trustworthiness typically go beyond safety requirements for trustworthiness. The procedure may include pre-employment screening and national security vetting of individuals, depending on the vulnerability of the position.

Particular attention to the insider threat is warranted, as this is recognized as an important risk factor for an outsider intrusion at a nuclear facility. The DBT should consider attributes and characteristics of potential insider adversaries and include them in the threat assessment. The protection against the insider threat is embedded in various systems implemented at the facility that are established for other purposes (e.g. computer systems, general vigilance regarding staff as part of a nuclear safety and nuclear security culture). Accounting procedures for nuclear material as part of domestic or international safeguards as well as control of radioactive sources for safety purposes are other examples of internal procedures that serve two or more functions. Clearance arrangements and induction training for staff in sensitive positions are also of importance.

The joint use of relevant human resource processes and procedures therefore can be referred to as a safety–security interface.

7.7. INFORMATION AND COMMUNICATION

Information and communication are of utmost importance for both nuclear safety and nuclear security. Transparency and exchange of technical information as well as operational experiences are of core value for nuclear safety. While, in principle, this is also the case for nuclear security, there is an important difference. Nuclear security information includes specific information about security systems, the threat basis and how risks are perceived. Similarly, safety case information may have a potential for use by those with malicious intent. Such information is deemed to be sensitive, and maintaining confidentiality of this information is essential for the effectiveness of the security systems. General information

(e.g. the principles for establishing physical protection, information about illicit trafficking) and experiences in general would not reduce the effectiveness of the security system, it may rather contribute to deterrence. Exchange of information among operators is also recognized as having high value.

These seemingly conflicting principles can be reconciled by appropriate cooperation, risk assessment and management, together with professional evaluation of the confidentiality of different kinds of information. For both nuclear safety and nuclear security, the information must be available and communicated effectively to those who require information, irrespective of when and how. In circumstances of an event affecting nuclear safety or security, correct updated information can be critical.

The availability of information for the international community is relevant and of value. The striving towards a common approach to nuclear security in different Member States requires insight into principles for how systems are built up and information about experiences, such as in annual reports at national or operational levels. The reports should contain statements of both nuclear safety and nuclear security, as a result of the priority given to maintaining a high level of nuclear safety and nuclear security and to account for investments made.

In all cases, effective communication is required, albeit within constraints, between nuclear safety and nuclear security communities, among different organizations, between organizations and the public, and between governments and the public. In all cases, a balance has to be struck between openness and the need for confidentiality.

7.8. COMPUTER SECURITY

Computer security is becoming increasingly important for both nuclear safety and nuclear security, as more operational systems move from an analog to a digital platform. With the increased digital control of operational processes and increased sophistication of cyber access, greater attention has to be paid to the security of these systems and their vulnerability. External, unauthorized access to digital control systems may, in the worst cases, cause safety failures. Furthermore, measures implemented to check for malware may themselves create paths for software infections. Consequently, information technology systems offer obvious examples of a vital need for an effective safety–security interface, being equally valuable for both nuclear safety and nuclear security.

7.9. EMERGENCY PREPAREDNESS

An accident or a security incident will always require some response. In some cases the response is simple, but in other cases it is a complex procedure that involves radiological emergency measures and, for security incidents, law enforcement. In the case of release of radioactive substances, whatever the reason (accident or security event) international obligations of early warning and assistance apply. A security event with external involvement makes the facility and surrounding area a crime scene, triggering a response by law enforcement. In the case of theft of nuclear material or a radioactive source, the perpetrators must be located and, if possible, the stolen material retrieved. In some cases, the retrieval of radioactive material out of regulatory control may also trigger investigation by the police. In the case of an act of sabotage or attempted sabotage, the operator, the police and possibly other competent authorities or organizations must interact to secure the facility at the same time that the perpetrator is pursued, resulting in additional burdens on resources.

While there may be different organizations involved in the response to an accident or security event, coordination and cooperation are paramount. In the early stages of an event the likely cause, whether security or safety, may be unclear. Accordingly, emergency preparedness stands out as an obvious interface between nuclear safety and nuclear security.

7.10. INTERNATIONAL COOPERATION AND INTERACTION

International cooperation plays an important role in both nuclear safety and nuclear security, especially in risk management. Such interaction can take place bilaterally, multilaterally through the IAEA, and to a certain degree through the United Nations 1540 Committee[18]. Conventions and United Nations resolutions normally underline the value of the international exchange of information and mutual support among the State parties. The IAEA's nuclear safety and nuclear security activities receive substantial contributions from its Member States, from the European Union and through the specific programmes of the IAEA. The nuclear security programme depends on these extrabudgetary contributions.

The cooperation relates to a multitude of activities. The programmes of the IAEA provide assistance and various services to Member States, including regulatory support and support to deal with urgent needs. The cooperation is basically of a similar nature, whether for security or safety objectives. On the recipient side, personnel from different organizations participate. This is mostly

[18] The Security Council Committee established pursuant to resolution 1540 in 2004.

relevant for nuclear security interaction, in particular regarding the detection and response to material out of regulatory control.

International cooperation, which often comprises activities that are important for both security and safety, is an example of an important safety–security interface.

7.11. DISCUSSION

All areas referred to above are good examples of safety–security interfaces. For some issues, such as computer security, there is no difference in either the nature of the work involved or how it is carried out for nuclear safety or nuclear security. For other issues there is a clear difference, such as how information for nuclear safety and nuclear security, respectively, is handled, reflecting the principle of openness for nuclear safety and maintaining confidentiality for nuclear security. At the same time, insufficient information is shared in the nuclear security field, which has a negative impact on its effectiveness because of a reduced understanding of the challenge faced and the principles for how the threat is met, at facilities and nationally. Other issues, such as identification of vital areas and insider threat, indicate a strong interface and mutual dependence between nuclear safety and nuclear security.

The separation into two cultures, one for nuclear safety and one for nuclear security, was necessary and useful when the strengthening of nuclear security became a priority. Now, fifteen years after the CPPNM Amendment was negotiated, it may be a more effective approach to move towards enhanced coordination between nuclear safety and nuclear security cultures, not excluding a long term goal of establishing a joint safety–security culture that corresponds with the clear allocation of responsibility at the site of the operator and nationally and that underlines the very clear need to recognize a common, overarching goal and the need for staff at the different levels to work together.

There are other important interfaces (such as transportation, new technology or design processes) and other interfaces for which details could be explored further (such as defence in depth or regulatory practices). These areas can be usefully addressed in separate, more detailed publications.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1. CONCLUDING COMMENTS

While both nuclear security and nuclear safety share a fundamental objective to protect people, society and the environment from harmful effects of ionizing radiation, there are also differences in how this objective is achieved. Nuclear safety aims at preventing accidents (from external events, including natural hazards; internal events; equipment malfunction; wearing out of material; and human error). Nuclear security aims at preventing malicious acts (preventing individuals with malicious purposes from obtaining access to equipment, material or facilities) and must therefore liaise with outside forces (e.g. law enforcement, border control authorities). There is, however, broad recognition that the measures applied must work in concert to achieve maximum effectiveness in relation to the shared fundamental objective, although some of the functions are different in scope and measure (e.g. how information is shared or kept confidential). Also, in some circumstances there will be duplication, as an unplanned event can have implications for both nuclear security and nuclear safety (e.g. hacking into computer systems).

The evolution of new nuclear technology and the changing nuclear energy landscape, as well as continuing medical and industrial uses of radioactive substances, require excellence in all aspects of nuclear safety and nuclear security, effective communication and seamless implementation. Continuous improvement in the safety–security system will enable continued access to the benefits of the peaceful uses of nuclear energy and ionizing radiation in the future.

The separation into two cultures, one for nuclear safety and one for nuclear security, initially was necessary and useful when the strengthening of nuclear security became a priority. Now, in recognition of the new international legal framework for nuclear safety and nuclear security, the time appears ripe to move towards a strongly coordinated culture for nuclear safety and nuclear security that builds on complementary interaction, seamless interfaces and, equally important, clear allocation of responsibilities, as well as the common, overarching goal to protect people, society and the environment from harmful effects of ionizing radiation.

This publication has pointed to several of the many interfaces that exist between nuclear safety and nuclear security, and the need to enhance close interactive operation, noting the common purpose, common foundations and the need for change to face a challenging future using a more coordinated approach. The following conclusions and recommendations will contribute to achieving the

shared fundamental objective of nuclear safety and nuclear security to protect people, society and the environment from harmful effects of ionizing radiation.

8.2. CONCLUSIONS

— The common purpose of the protection of people, society and the environment forms the basis for effective and efficient interfaces between nuclear safety and nuclear security.
— There are common foundations for effective delivery of nuclear safety and nuclear security: responsibilities, leadership and management, and risk management.
— There needs to be a change in the attitude and approach to the interplay of nuclear safety and nuclear security to better reflect the commonalities; to enable continued peaceful uses of nuclear energy and ionizing radiation for the benefit of people, society and the environment; and to meet a challenging future.
— To secure such change, policy makers and leaders need to take effective action to ensure a more coordinated approach to nuclear safety and nuclear security.

8.3. RECOMMENDATIONS

8.3.1. General recommendations

— The national legislative system for nuclear safety and nuclear security constitutes the foundation for effective management of both nuclear safety and nuclear security. When considering the development of policies, laws, regulations and relevant institutions, policy makers should consider nuclear safety and nuclear security together, with greater recognition of the interfaces — including possible synergies — between nuclear safety and nuclear security, in addition to the special requirements for safety and security, to strengthen the national legislative system and create effective management of nuclear safety and nuclear security.
— If there are separate national authorities for nuclear safety and nuclear security, effective and dedicated cooperation should be established at the national level to ensure the necessary interaction and coordination.
— A more advanced, integrated culture for nuclear safety and nuclear security should be established to bring nuclear safety and nuclear security implementation closer together. Rather than two separate cultures, a more

advanced, integrated culture for nuclear safety and nuclear security, with emphasis on clarity in responsibility, risk management, accountability and coordination, would strengthen nuclear safety and nuclear security at the national level and for operators.

— Effective interactions between nuclear safety and nuclear security can be hampered by different use and different meanings of terms, as observed through the different glossaries published by the IAEA. It is recommended that one common glossary be developed to aid better understanding and interactions.

8.3.2. Recommendations to strengthen the implementation of safety, security and interfaces

— The IAEA safety standards and security guidance have been developed in two separate processes, although with coordination. It is likely that a common process of development would be both more effective and more resource efficient. A long term strategy to obtain a comprehensive series of international standards for nuclear safety and nuclear security should therefore be formulated.

— International activities (e.g. conferences, peer reviews) that aim to strengthen nuclear safety and nuclear security should draw attention to the management of interfaces between safety and security.

— There has been some use of nuclear safety assessment techniques for assessing nuclear security protection, but more work should be undertaken to develop an integrated approach to the assessment of nuclear safety and nuclear security.

— Sustainable human resource development for nuclear safety and nuclear security should provide a basis for increased knowledge and understanding of both nuclear safety and nuclear security, their specific objectives and their interfaces, for different staff categories. Already established support centres may provide both efficient use of resources.

— To increase a broad understanding of nuclear safety and nuclear security — especially the specific objectives, interfaces and interactions — more information of a non-sensitive nature should be made available, including on progress in achieving the common goals identified for nuclear safety and nuclear security and their interfaces. Mutual training (nuclear security experts training nuclear safety experts and vice versa) may constitute an appropriate means to improve the understanding of nuclear safety and nuclear security interfaces.

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MEMBERS OF THE ADVISORY GROUP ON NUCLEAR SECURITY

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