# Introduction to the Workshop

# Emergencies at Research Reactors and Lessons Learned

## Seminar

# Introduction

- Analysis of potential accidents is an essential step to Emergency Planning
- Severity of potential accidents defines the scope of the emergency plan
- The dominant radionuclides will define the environmental monitoring
- The time behavior of the release have an impact on the necessary timeliness of the response
- The emergency scenarios should be realistic

# Content

- Potential accidents
- Accident history and statistics
- Example of an accident on a research reactor
- Lessons learned from reactor accidents that are applicable to research reactors
- Summary

# Potential Emergencies

- **Uncontrolled reactivity insertion accidents; deficiencies in design of the reactor core and reactor safety systems**
- **Uncontrolled reactivity insertion accidents; deficiencies in operation of core components**

# Potential Emergencies (Cont'd)

- Loss of flow
  - Coolant channel blockage (ETR, USA, 1961)
  - Failure of pumps or valves in primary cooling system (CIRUS IN-2, India, 1993)
  - Unexpected flow redistribution (Dhurva, India, 1994)

# Potential Emergencies (Cont'd)

- Degradation of defense in depth
  - Fuel cladding failure
  - Demineralizer piping leak (U Virginia, USA, 1993)
  - Pool leak (SILOE, France, 1986)
  - Beam tube leak (U Michigan, USA, 1963)

# Potential Emergencies (Cont'd)

- **Degradation of defense in depth:**
  - **Containment degradation**
  - **Spent fuel storage pool failures**
  - **Liquid radioactive waste disposal system leaks**

# Potential Emergencies (Cont'd)

- Erroneous movement of fuel and radioactive materials:
  - Mechanical defect or failure in fuel handling tools (cable, crane, cask)
  - Violation of fuel movement procedures (CIRUS IN-2, India, 1994, SAROV, Russia, 1997 – 1 fatality)
  - Error concerning the movement of fuel assemblies (TRIGA, Romania, 1986)

# Potential Emergencies (Cont'd)

- Failures in the conduct of operation
  - Incorrect safety system setting
  - Noncompliance with limits and conditions for safe operation
  - Missing surveillance testing requirements
  - Noncompliance with commissioning process
  - Ignoring physical security requirements

# Potential Emergencies (Cont'd)

- Experiments
  - Inadequate design basis
  - Noncompliance with commissioning process
  - Failure in conduct of experiments (HFR, Netherlands, 1968)

# Potential Emergencies (Cont'd)

- **Releases of radioactive materials or exposure to radiation:**
  - **Releases of radioactive material that exceed prescribed limits whether they are confined to the site or extend beyond it (EWA, Poland, 1991)**
  - **Exposure to radiation that exceeds prescribed dose limits for members of the public or site personnel**

# Potential Emergencies (Cont'd)

- **Manufacturing Defects**
  - **Fuel clad failures (BR2, Belgium, 1972)**
  - **Inadequate welds**
  - **Improper/incompatible materials**

# Major Accident History

- Research Reactor Accident History:
  - NRX, Canada, 1952
  - RB, Vinča, Yugoslavia, 1958
  - SL-1, USA, 1961
  - RA-2, Buenos Aires, Argentina, 1983
  - VENUS, Belgium, 1965

# It can happen today!

**AUG-29-2008**

**The medical LAB IRE at Fleurus Belgium was emitting for at least one week radioactive Iodine gas, contaminating the area long term, no peak but vegetables and fruits from garden banned from eating. Children should not walk in the green. 20 000 PEOPLE will turn to bottled water and prepare for long term impact.**

**The European Commission said Friday it had received an overnight alert from Belgium concerning a radioactive leak at the Institute National de Radio-elements (IRE) in Fleurus.**

**There had been a release of gaseous Iodine-131 from this facility, said the commission, the executive body of the European Union (EU).**

**The incident had been classified Level 3 on the seven-level International Nuclear Event Scale on Tuesday.**

**Belgian authorities have implemented protective action on the basis of environmental sample analyses, with restrictions imposed on the consumption of local food produce -- vegetables and milk --up to a distance of 5 km.**

## Selected Events from Safety Report Series No. 53

- **35 reported events (1949 – 1994)**
  - **Criticalities:  12 events**
  - **Loss of flow: 8 events**
  - **Loss of coolant: 7 events**
  - **Other: 8 events**

- **Number of fatalities reported: 4**

# Example of an Actual Accident on Research Reactor

- **Critical excursion on RA-2 Critical Assembly in Buenos Aires, Argentina, 23 September 1983**
  - **Operator's error during core configuration modification**
  - **Reactor became prompt critical**
  - **Peak power 300 MW, energy released 10 MJ, fission yield 3E17**
  - **The operator received a fatal absorbed dose: 21 Gy gamma and 22 Gy neutrons**
  - **Root cause – Procedure violation?**

# Major Lessons - Overview

- **Single biggest cause of accidents and poor response - "It can not happen here"**
- **Staff did not recognize the problem or know to what to do immediately**
- **Staff could not mitigate the problem**

# Major Lessons - Overview

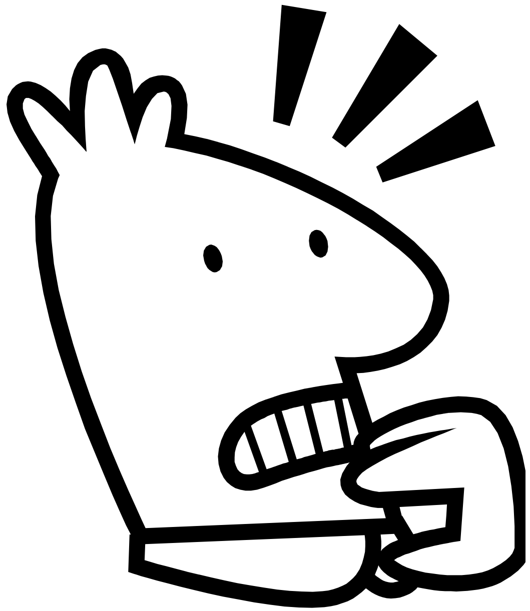
- **On-site personnel have not been protected**
- **Poor response to significant media and public reaction to actual or perceived risk caused major consequences**
- **Emergency workers not being protected**
- **Lack of a coordinated response**
- **Poor medical treatment**

# Single Biggest Cause of Emergencies and Poor Response

- **Can not happen here!**
- **Major cause of TMI, Chernobyl and others**
- **Results in:**
  - **Poor safety culture**
  - **Lack of planning and preparations**
  - **Failure or inability to recognize severity and potential consequences**

# TMI Lesson

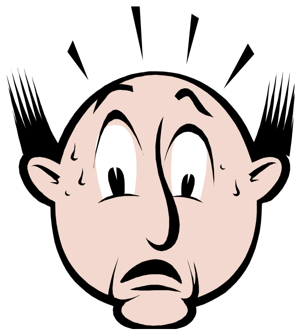
- **Managers directing initial response were ineffective**
  - **Were overwhelmed**
  - **Confused**
  - **Were unaware of plans**



- **Senior managers did not participate in training or exercise (too busy!)**

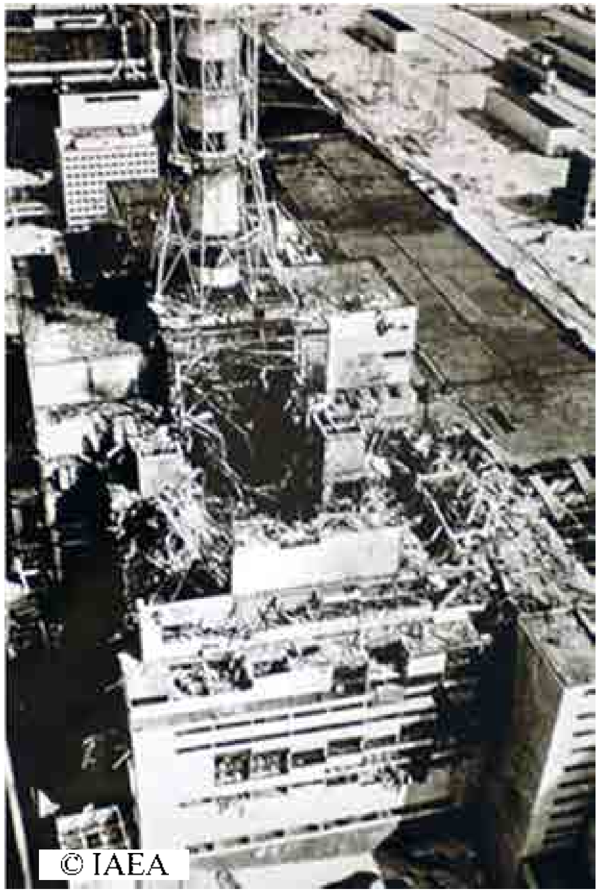
# Staff Did Not Recognize the Problem or Know to What to Do Immediately

- Did not recognized severe conditions
- Did not know what initial actions to take
- Did not have the equipment needed
- Did not have the protection they needed
- Off-site support was not obtained promptly
- Off-site support was not prepared



# Severe Emergencies at Category I Facilities

- **Decision to implement urgent protective action was delayed for days**
  - **Could have resulted in off-site deaths**
  - **Did result in preventable thyroid cancers**
- **Preparation was not in place to make decisions quickly**
  - **No local decision maker with authority**
  - **No criteria/basis for immediate action**



# On-site Personnel and Emergency Workers Have Not Been Protected

- Were not notified
- Did not know what to do when informed
- Lack of training
- All possible people not considered
  - Visitors
  - Workman
  - People in near-by areas

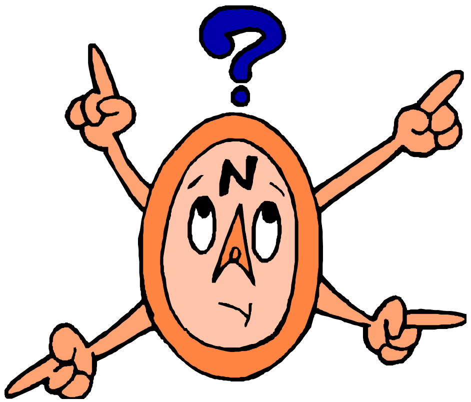
## Some Lessons Learned From Past Emergencies

- **Criteria developed after emergency did more harm than good**
  - **Much lower than international recommendations**

- **Based on criteria developed during emergency and associated with:**
  - **Mistrust**
  - **Emotions**
  - **Political pressure**

# Lack of a Coordinated Response

- Many locations being used to coordinate the response and make public statements
  - owner/operator
  - national officials
  - local official
- Result
  - confusion
  - inconsistent public statements
  - loss of trust in authorities



# Poor Medical Treatment of Overexposure

- **Facility and local medical staff did not gather information to determine appropriate treatment**
- **Local medical staff treated the overexposure without consulting experts**
- **Inappropriate medical advice for those unaffected or minimally affected**
- **Result - great unnecessary suffering**

# Some Other Issues

**Be prepared for the following, once the emergency becomes publicly known**


- **Failure of normal communications**
- **Immediate and immense media attention**
- **Non-requested assistance and suggestions**

# Summary

- In this Module we covered
  - Potential emergencies and examples at specific research reactors
  - Example of an severe accident on research reactor, and
  - Lessons learned from accidents at reactors that are transferable to any reactor

# Where to Get More Information

- **IAEA Incident Reporting System for Research Reactors (IRSRR)**
- **A review of criticality accidents / by William R. Stratton. Los Alamos, N.M. : Los Alamos Scientific Laboratory of the University of California**
- **IAEA Safety Report Series No. 53, Derivation of the Source Term and Analysis of the Radiological Consequences of Research Reactor Accidents, 2008**

# Introduction to the Workshop

# Objectives, Concepts and Basic Principles of Emergency Response

## Seminar – Part 1

# Introduction to the Workshop

# Objectives, Concepts and Basic Principles of Emergency Response

## Seminar – Part 2

# Content - Part 2

- Threat categories
- Emergency classes
- Research reactors emergency planning needs
  - Response strategy
  - Resources
    - Generic response organization
- Practical challenges

# Threat Categories

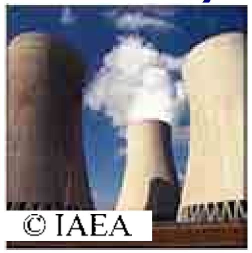
- IAEA GS-G-2.1 defines five threat categories based on type of accident and radiation hazard
- Threat categories are a tool to:
  - help determine the hazards for various practices
  - provide guidance on the planning and response requirements

# Threat Categories

| Threat Category | Radiological Threat |
|---|---|
| I | Severe deterministic health effects off-site |
| II | Warranting urgent protective actions off-site, severe deterministic health effects on-site |
| III | No urgent protective actions off-site are warranted, severe deterministic health effects on-site |
| IV | Minimum level of threat – all countries |
| V | Food contamination due to transboundary contamination necessitating food restrictions |

# Threat Categories - Categories I and II

- **Nuclear power plants, large research reactors, spent fuel storage sites, and fuel processing facilities**

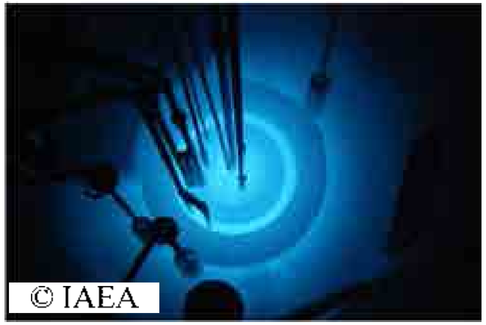



- **Accident probability low**
- **Wide-spread offsite consequences**

  - **mainly stochastic effects**
  - **very small probability of deterministic effects, but severe in worst case scenarios**

# Threat categories - Category III

- Small research reactors, radioactive materials manufacturing, waste storage, lost sources, and transportation accidents
- Accident probability moderate-to-high
- Mainly local consequences:
  - high probability of deterministic effects at the site
  - No effect off-site



# Threat categories - Categories IV and V

- Category IV: transport, lost sources, satellite re-entry

  - Accident probability moderate-to-high
  - Mainly local consequences unless a response is delayed
- Category V: transboundary contamination

# Emergency Planning Zones for Threat Category I, II & III

- Category I
  - Planning zones required up to 25 km for urgent protective actions
- Category II (large research reactors)
  - Planning zones required but smaller, usually a few kilometers
- Category III (small research reactors)
  - No planning zones required off-site

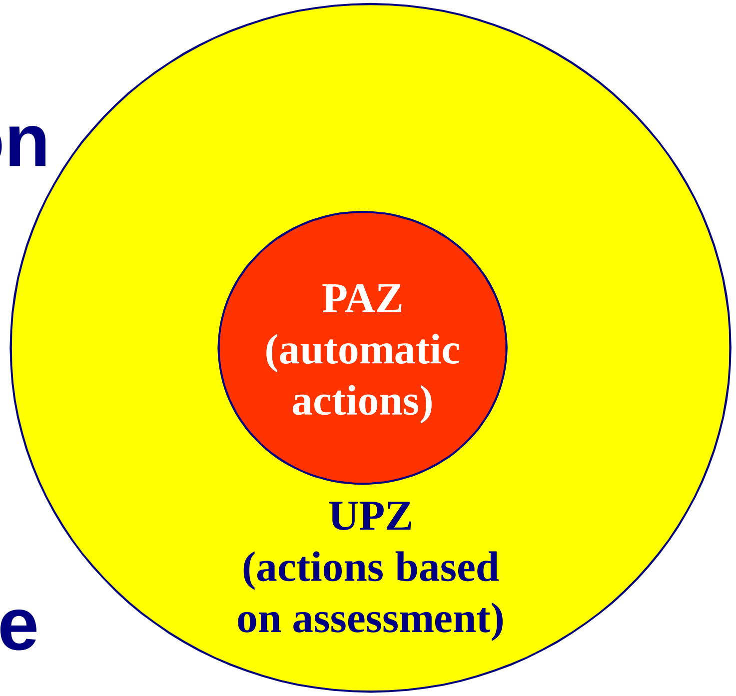
# Emergency Planning Zones
## Definitions

PAZ
(automatic
actions)

- Precautionary action zone (PAZ)
  - risk reduction to avert deterministic health effects for worst accident
  - preparations to promptly alert and evacuate the public and the workers
    - e.g. sirens
  - decisions based on the accident, before environmental measurements are available

# Definitions (cont'd)

- **Urgent Protective Action Zone (UPZ)**
  - **promptly perform environmental measurements**
  - **take urgent protective actions based on measurements**



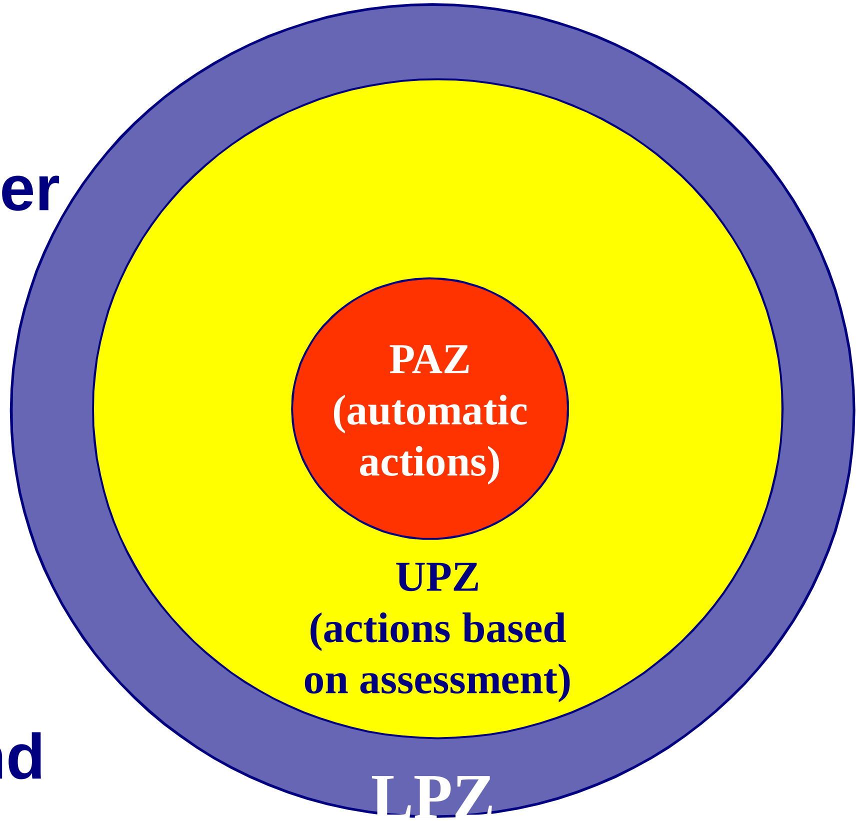
# UPZ and PAZ Sizes

| | Reactor Size | PAZ | UPZ |
|---|---|---|---|
| Threat Category I | > 1000 Mw<br>100 – 1000 Mw | 3 – 5 km<br>0.5 – 3 km | 5 - 30 km<br>5 – 30 km |
| Threat Category II | 10 – 100 Mw<br>2 – 10 Mw | On-site<br>On-site | 0.5 – 5 km<br>0.5 km |
| Threat Category III | < 2 Mw | On-site | On-site |

- **Precautionary Action Zone (PAZ) – Urgent protective action taken based on reactor conditions, without environmental monitoring data**
- **Urgent Protective Action Planning Zone (UPZ) – Normally protective action taken based on environmental monitoring results**
- **Reference: GS-G-2.1, Table 8**

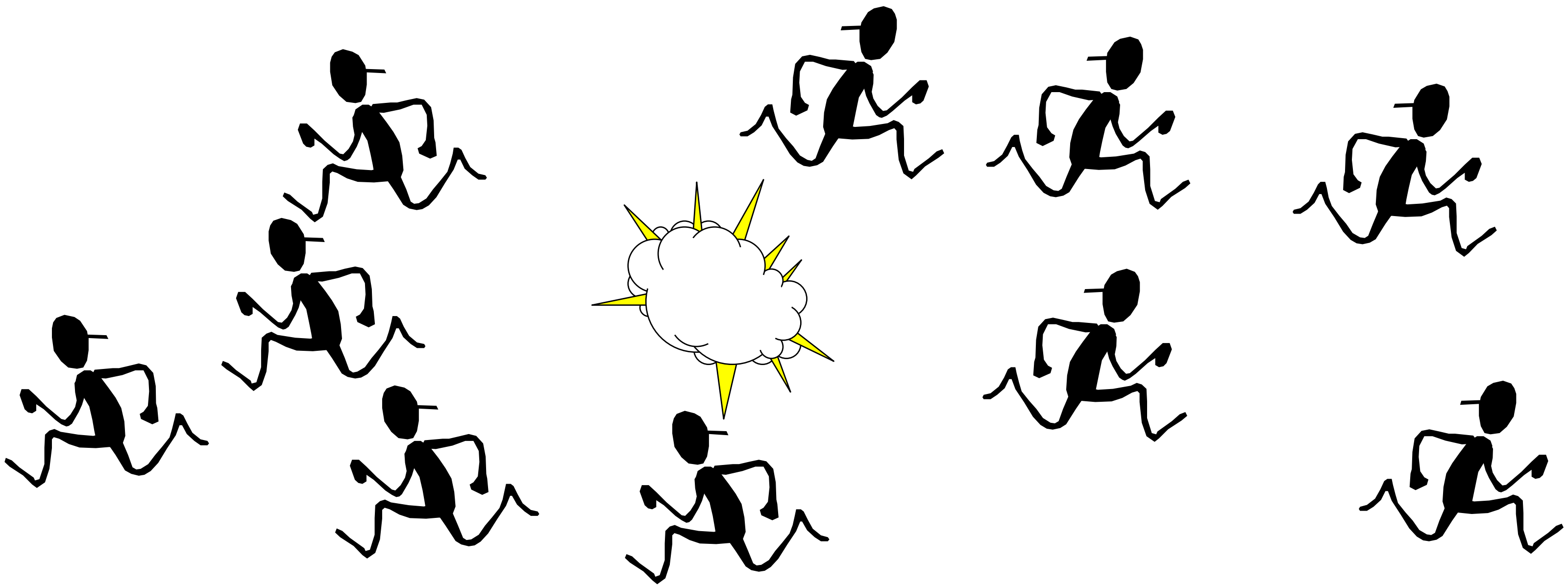
# Definitions (cont'd)

- **Longer-term Protective Actions Zone (LPZ)**
  - **Plans for monitoring of food stuff and water**
  - **Plans to take longer-term protective actions**
    - **ingestion control**
    - **relocation**
    - **resettlement**
  - **LPZ includes UPZ and PAZ**



# Planning Zone vs Response Zones

- **Planning Zones are for planning, i.e. this does not mean that protective actions will not be required outside those Zones**



# Emergency Planning Zones for Threat Category IV & V

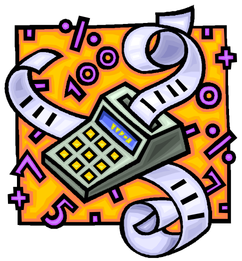
- Category IV
  - No fixed planning zones
  - Immediate action zone required (precautionary or safety distance)
- Category V
  - Extensive planning zone for agricultural counter-measures only

# Research Reactor Planning Needs

- **EP needs depend primarily on:**
  - **Size and type of facility**
  - **Availability of on-site resources**
  - **Coordination with local and national emergency plans**
- **First, you must do:**
  - **A threat/risk assessment**
  - **A needs analysis**

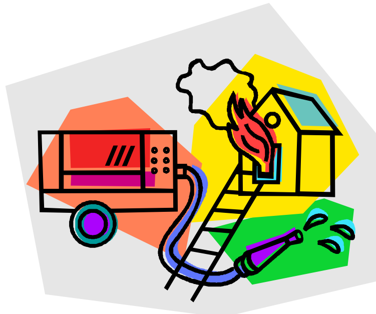
# Research Reactor Planning Needs

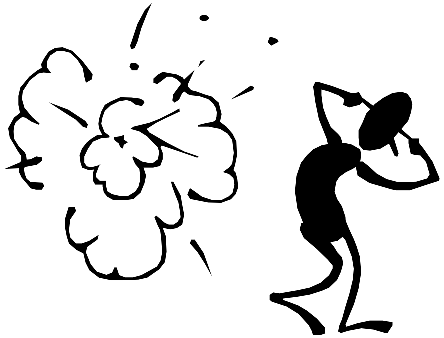
- Threat assessment:
  - What accidents are possible?
    - rank by risk of release of radioactive material and by quantity of the release
  - What are the potential consequences ?
    - Calculate consequences for
      - release to pool
      - release to interior of facility
      - release to external environment



# Threat Assessment

- Conventional hazards
  - Fire
  - Explosion
  - Chemical threats
  - Include threats from exterior events of this type – who are your neighbors?



# Threat Assessment

- Radiological hazards from reactor operations
  - Events causing increase in radiation levels
  - Events releasing radioactive materials
  - Events with both hazardous conditions

# Emergency Classification

- Four levels, increasing severity
  - Alert
  - Facility Emergency
  - Site Area Emergency
  - General Emergency
- Identifies the population at risk and the level of that risk

# Alert

- Facilities in Threat Category I, II and III
- Uncertain or significant decrease in the level of protection for the public and people on the site
- Prompt action to assess and mitigate the consequences
- Prompt action to increase the readiness of response organizations

- **Reference: GS-R-2**

# Facility Emergency

- Facilities in Threat Category I, II and III
- Major decrease in the level of protection for people on the site
- Prompt action to mitigate the consequences
- Prompt action to protect people on the site

- Reference: GS-R-2

# Site Area Emergency

- **Facilities in Threat Category I and II**
- **Major decrease in the level of protection for those on-site and those near the facility**
- **Prompt action to mitigate**
- **Prompt action to protect people on the site**
- **Promptly make preparations for protective actions off the site**

- **Reference: GS-R-2**

# General Emergency

- Facilities in Threat Category I and II
- Actual or substantial risk of release
- Warrants urgent protective action off the site
- Prompt action to mitigate
- Prompt action to protect people within PAZ and UPZ

- **Reference: GS-R-2**

# Needs analysis

- **What is the response strategy?**
- **What resources do I need?**
- **What resources do I already have?**

Strategy

→

Resources

# Response Strategy

CLAIM !

- **Classify**
- **Life saving**
- **Assess and protect**
- **Inform**
- **Manage**

# Classify

- Promptly detect the accident situation
- Very quickly rank it in terms of severity
  - the objective is <15 minutes
- Trigger automatic actions associated with classification level
- See module 7 for details

# Life-saving

- Evacuate people from the high hazard area
- Provide immediate medical first aid
  - See modules 12 and 13 for details

# Assess and protect

- Survey and monitor
  - See module 15 for details
- Determine need for protective actions
  - See module 8 for details
- Implement protective actions
  - Sheltering or evacuation
  - Stable iodine
  - Access control
  - Food ban in immediate vicinity

# Inform

- **Inform the public on protective actions needed**
- **Inform the media**
- **See module 9 for details**

# Manage

- Coordinate the facility response with outside services and off-site authorities
- Monitor the unfolding of events and actions
- Communicate
- Follow up

# Practical Issues Related to the Response Strategies

# Research Reactors

- Is there an accident classification system based on the facility conditions?
- Is the classification system well understood by staff and outside services?
- Is there a 24 hour contact point for the facility?
- Can the facility emergency response organization be activated 24 hours a day?

# Research Reactors

- Are there arrangements with off-site emergency services?
- Do these off-site services have appropriate training to respond to an emergency at the facility?
- How is radiation protection and dose monitoring provided to the off-site services?

# Research Reactors

- What is the minimum on-site staff when operating?
- Is this enough to adequately respond?
- How will the need for off-site protective actions be determined
- How will information be released to the news media?

## Summary

- There are five threat categories identified in EPR-METHOD
  - Research reactors are category II or III
- Research reactor planning needs are based on the reactor size and the resource pool available at the site
- Response strategy = CLAIM

# Summary

- Generic response organization can be adapted to fit most facilities
- The on-site emergency organization must be integrated with off-site
- Response can be challenging, especially if the appropriate arrangements are not in place in the plans

# Where to Get More Information

- IAEA EPR-METHOD 2003
- IAEA GS-G-2.1
- IAEA EPR-RESEARCH REACTOR

# Introduction

- Despite all the precautions that are taken in the design and operation of nuclear facilities and the conduct of nuclear activities, there remains a possibility that a failure or an accident may lead to an emergency
- The objectives of the lesson are to present goals, principles and basic concepts of emergency response in case of nuclear or radiological emergencies

# International Guidelines

1. Preparedness and Response for Nuclear or Radiological Emergency: **Requirements GS-R-2 (2002)**
2. Arrangements for Preparedness for a Nuclear or Radiological Emergency: **Safety Guide GS-G-2.1 (2007)**
3. Criteria for Use in Planning Response to Nuclear and Radiological Emergencies: **General Safety Guide GSG-2 (in printing)**

# Content - Part 1

- Why plan?
- Emergency preparedness and response objectives
- Intervention principles and levels for the public and workers

# Why Plan

- Because accidents happen
- Because planning helps save lives and minimize risks to health and the environment
- Because response with planning costs less than response without planning
- Because response without plans can affect the credibility of the authorities

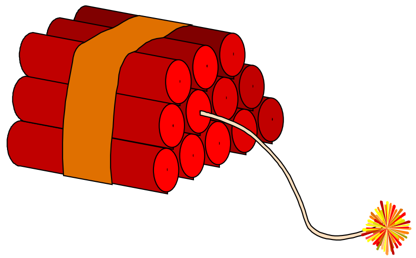
# Why Plan

- **Because there are basic Requirements*:**
  - **"The government shall ensure that an integrated and coordinated emergency management system is established and maintained."**
  - **"The government shall ensure that protection strategies are developed, justified and optimized at the planning stage, and that the response in an emergency is undertaken through their timely implementation."**

***Basic Safety Standards**

# How Much Planning is Required

- Depends on priorities
- Depends on the level of risk you are willing to live with
- Prevention vs response
  - Cost associated with both
  - Accidents happen
  - Cost of preparedness may be less than response



# Emergency Preparedness and Response Objectives

- Planning objectives
  - To enable prompt, appropriate and coordinated response
  - To enable effective and coordinated use of resources at the local, regional, national and international levels
- Response objectives
  - To save lives and minimize impacts

# EP Objectives

- **ICRP 40**
  - **"The preparation of emergency plans should be based on considerations of a wide range of potential accidents, including those having low probabilities of occurrence... [but] the degree of detail in plans should decrease as the probability of the accident decreases."**
- **ICRP-63**
  - **"Plan in detail for probable events in order to prevent stochastic effects. Make provisions (less detailed plans) for less probable events in order to prevent death."**

# Emergency Response Objectives

- Mitigate accident at source
- Prevent deterministic health effects
- Provide first aid and treat injuries
- Reduce stochastic effects
- Reduce psychological effects
- Protect the environment and property
- Prepare for resumption of normal activity

# ER Objective I: Mitigate the Accident

- Eliminate the source of the hazard
  - On-site emergency procedures to stop releases
  - Damage control to stop further degradation of the situation
  - Conventional response to contain the hazard:
    - Fire fighting
    - Spill control

# ER Objective II: Prevent Deterministic Effects

- Establish national intervention levels for taking urgent protective actions
  - Based on international standards
  - Implemented promptly, within hours
  - Adjusted when additional information is available
  - Discontinued when no longer  justified
- Thresholds for deterministic effects

# Radiation Physiological Effects

- Deterministic effects
  - have a threshold, and symptoms appear quickly – within hours or days
  - cause death, or reduced quality of life
- Stochastic effects
  - no threshold identified
  - symptoms develop in years and are indistinguishable from normally occurring diseases
    - cancer
    - hereditary effects

# GENERIC CRITERIA FOR PROTECTIVE ACTIONS TO AVOID OR TO MINIMIZE DETERMINISTIC HEALTH EFFECTS

## Acute external, local and contact exposure

| Organ or tissue | RBE-weighted absorbed dose (<10 hr) |
|---|---|
| Red marrow | 1 Gy |
| Foetus | 0.1 Gy |
| Soft tissue | 25 Gy at 0.5 cm |
| Skin derma | 10 Gy to 100 $cm^2$ |

# GENERIC CRITERIA FOR PROTECTIVE ACTIONS TO AVOID OR TO MINIMIZE DETERMINISTIC HEALTH EFFECTS (2)

## Internal exposure from acute intake

| Organ or tissue | 30-day RBE-weighted absorbed dose |
|---|---|
| Red marrow | 0.2 Gy [radionuclides with Z>89];<br>2 Gy [radionuclides with Z<90] |
| Thyroid | 2 Gy |
| Lung | 30 Gy |
| Colon | 20 Gy |
| Foetus | 0.1 Gy |

# Intervention Principles

- For potential doses above acute threshold:
  - Take protective action to reduce the projected dose
- For potential doses below acute thresholds
  - Take protective actions if the radiological benefit > detriment due to the protective action
  - IF projected dose > generic criteria
    - THEN the protective action brings a NET benefit
- For workers, keep the dose received as low as reasonable
  - Limit depends on the benefit of the work done by the emergency worker

# Intervention Principles

## Preventing Deterministic Effects

- This normally means taking pre-planned, automatic, precautionary actions:
  - before a full assessment of the situation
  - to be adjusted as required after a full assessment

# ER Objective III: Provide First Aid and Treat Injuries

- Give conventional First Aid
  - Life-saving first aid always has priority
- Triage injured patients
- Decontaminate
- Treat radiation injuries
- Obtain specialist assistance

# ER Objective IV: Reduce Stochastic Effects

- Average natural background radiation ranges from 1 - 10 mSv per year (70 - 700 mSv lifetime)
- Cannot reduce total radiation dose to zero
- Intervention
  - reduces the risk of stochastic effects
  - also has penalties

# ER Objective IV: Reduce Stochastic Effects (Cont'd)

- **In practice**
- **There is a balance when the penalties outweigh the benefits**
- **The decision to implement a protective action is based on the projected dose**
- **Generic criteria**

# Generic Criteria

- Replaces GIL and GAL terms
- Forms the basis for a protection strategy
  - establish a reference level between 20 and 100 mSv
  - generic criteria for particular protective actions, set in terms of dose, are developed
  - If the numerical values of the generic criteria are exceeded, those actions, either individually or in combination, should be implemented.

# GENERIC CRITERIA FOR PROTECTIVE ACTIONS TO REDUCE THE RISK OF STOCHASTIC HEALTH EFFECTS

| Projected Dose | Action |
|---|---|
| 100 mSv in first 7 days<br>100 mSv to foetus in first 7 days | Sheltering, evacuation, decontamination, restriction of food, water and milk consumption |
| Thyroid dose 50 mSv in first 7 days | Iodine thyroid blocking |
| 100 mSv per annum<br>100 mSv to foetus, entire gestation | Temporary relocation, replacement foodstuffs |
| 100 mSv in one month<br>100 mSv to foetus, entire gestation | Medical screening, counselling |

# Intervention Principles
## In Practice

- Estimating dose (projected or avertable!) In the early stage of an emergency:
  - Takes time
  - Contains major uncertainties and assumptions and is confusing
  - Is difficult
  - Generates debates
  - Leads to delays in protective action implementation

# Intervention Principles
## Minimizing Stochastic Doses

- **Need for a quick criterion for taking protective actions**
- **This should be in terms of instrument readings**
- **It should correspond approximately to the Generic Criteria**

# Intervention Principles
## Minimizing Stochastic Doses

- This quick criterion is called an OIL
  - Operational intervention level
- For all situations:
  - temporary relocation: default OIL = 0.1 mSv/h ambient dose rate
  - evacuation: default OIL = 1 mSv/h ambient dose rate

# Guidance Values for Limiting Exposure of Emergency Workers

- Dose < annual limit (50 mSv)
- In special circumstances, this limit may be exceeded by volunteers giving informed consent:
  - actions to prevent a large collective dose
    - 100 mSv
  - actions would prevent development of catastrophic conditions or prevent severe deterministic health effects
    - 500 mSv
  - actions would save a life
    - 500 mSv
  - these are normally planned interventions

# ER Objective V: Reduce Psychological Effects

- Provide on-going, regular updates on the emergency to:
  - people who may be affected
  - people who think they may be affected
- Give clear, simple and timely advice
- Make sure the information is consistent
  - single authority for information
- Promptly correct false information
- Ensure protective actions are justified
- Do not compromise recovery
- Consider education and counselling

# ER Objective VI: Protect Environment and Property

- Control access to evacuated areas
- Limit spread of contamination

# ER Objective VI: Protect Environment and Property (2)

- **Control agriculture and water supplies**
- **Control forestry, fisheries and natural environment**

# ER Objective VI: Protect Environment and Property (3)

- **Control transportation and trade**
- **Manage waste**
- **Do not compromise recovery**

# ER Objective VI: Prepare for Resumption of Normal Activity

- Plan ahead
  - Before the emergency
    - levels of “safe” and “normal” in radiation protection terms
  - During the emergency
    - Keep recovery in sight, define when the emergency phase has ended
  - After the emergency
    - Apply criteria developed before the emergency

# EP Objectives: What It Means in Practice

- Develop postulated accident scenarios
  - What accidents may occur?
  - What would be the consequences?
  - What would be the most effective response?
  - How fast would the response need to be?
  - This is your “planning basis” - it must be documented

# EP Objectives: What It Means in Practice (cont'd)

- For the more likely scenarios:
  - Detailed plans, procedures and resources
  - Train for those scenarios
- For very unlikely scenarios:
  - Make contingency provisions
  - Detailed plans and procedures not always required
  - Expand capabilities that are based on the detailed plans

# EP Objectives: What It Means in Practice (cont'd)

- It is not possible to plan for every possible situation, but plan for most
- Be able to recognize when:
  - an accident is more severe than those anticipated in the planning basis
  - an accident is outside the planning basis
- Plans and procedures should be flexible enough so they can be adapted based on the situation

# EP Objectives: What It Means in Practice (cont'd)

- Know where to get additional resources
  - Example: neighboring country, IAEA
- Plan in advance how these additional resources will be coordinated and integrated into your own response organization

# Summary

- Intervention is justified if:
  - It keeps the dose received below acute thresholds
  - The projected dose more harmful than the disruption caused
  - For emergency workers, the dose received is below acceptable limits

# Summary

- Generic Criteria are in terms of projected dose
- Operational intervention levels are in terms of instrument readings and are related to Generic Criteria

# Development of a Response Capability

# Concepts of Operations and Responsibilities

## Seminar

# Introduction

**Will learn how to:**

- **develop a concept of operations**
- **assign responsibilities**
- **assure responsibility for critical tasks are clearly defined**

**Critical steps in the process of developing an emergency preparedness capability**

# Content

- Concepts of operations
- Critical tasks and responsibilities
- Summary

# Development of Concept of Operations (Con-ops)

- A simple overview of how the ideal response will proceed
- Describes the basic responsibilities of the major responders
- Used:
  - To assure all parties understand and agree to roles
  - Basis for development of detailed plans
- Must be completed and agreed to before planning begins

# Principal Parties to a Response

- **Operating Organization**
  - **Directly in control of a facility or activity**
  - **Directs the response in owner controlled area**
- **Emergency services**
  - **Provide Fire, police, medical support**
- **Local officials**
  - **Implement off-site protective actions**
- **National officials**
  - **Perform tasks that do not need to be implemented urgently to be effective**
  - **Nationwide actions**

# Con-ops for Alert

**Events involving unclear or significant decrease in the level of protection of the public or on-site personnel..**

- **Facility**
  - **Declare based on EALs**
  - **Notify off-site officials (within 60 min)**
  - **Activate appropriate part of response**
  - **Conduct off-site monitoring (if appropriate)**
  - **Take actions to mitigate the event**

# Con-ops for Alert

- Off-site
  - Increase readiness
  - Assure all governmental agencies are informed
  - Provide fire, police or medical support if requested
  - Initiate joint media briefings if media or public attention

# Con-ops for Facility Emergency

**Event resulting in a major decrease in the level of protection for the on-site personnel**

- **Facility**
  - Declare emergency based on EALs
  - Take life saving actions on-site
  - Account for all personnel, including visitors
  - Request off-site assistance
  - Notify and establish communications with off-site officials within 60 minutes
  - Protect on site personnel
  - Treat, decontaminate, estimate exposure and transport injured
  - Monitoring to confirm that no off-site actions needed
  - Take actions to mitigate the emergency
  - Initiate, with off-site officials, joint media briefings

# Con-ops for Facility Emergency

- **Off-site**
  - **Limited activation**
  - **Assure all governmental agencies are informed**
  - **Provide fire, police or medical support if requested**
  - **Provide treatment with experts for injured, contaminated individuals and overexposures**
  - **Initiate, with on-site officials, joint media briefings**

# Con-ops for Site Area Emergency

**Events resulting in a major decrease in the level of protection**

- **Facility**
  - **Declare emergency based on EALs**
  - **Take life saving actions on-site**
  - **Request off-site support**
  - **Activate full response**
  - **Notify off-site officials (15 min) and establish continuous communications**
  - **Protect site personnel and visitors**
  - **Conduct off-site monitoring near facility**
  - **Take actions to mitigate the emergency**
  - **Conduct joint media briefings**

# Con-ops for Site Area Emergency

- Off-site
  - Prepare to implement protective actions with recommendation from the site
  - Alert the population
  - Coordinate all monitoring - incorporate plant data
  - Provide emergency services
  - Provide medical treatment with experts
  - Coordinated response with a single manager under Incident Command System (ICS)
  - Inform all governmental agencies
  - Initiate joint media briefings

# Con-ops for General Emergency

**Events resulting requiring implementation of urgent protective actions off-site**

- **Facility**
  - **Same a Site Area Emergency except**
    - **Recommend protective actions to off-site officials within 15 min**
    - **Participates in the incident command system (ICS) - command group with off-site officials**

# Con-ops for General Emergency

- Off-site officials
  - Same as Site Area Emergency except:
    - Implement urgent protective actions promptly
    - Notify IAEA - nearby countries

# Identification and Assignment of Critical Tasks

- Ongoing major problem - conflicting and gaps in responsibilities
- Must have responsible clearly established and agreed to before progress can be made
- Worksheet from EPR-METHOD 2003, Chapter 3, is provided to assist you

# Identification and Assignment of Critical Tasks

- Distribute worksheet to all that may have role in off-site response:
  - National ministries and agencies
  - Regional ministries and agencies
  - Governments within the UPZ (for fixed facilities)
  - Operating Organization
  - Emergency services (medical, police, fire fighting services)
  - Non-governmental organizations

# Identification and Assignment of Critical Tasks

- Each organization should:
  - complete the portions they believe apply to them
  - identify lack of resources and capabilities
  - indicate if they are responsible for the task
- Assessed at the national and local levels to
  - identify gaps
  - overlaps
  - conflicts
- Resolve issues and get signed agreement

# Relationship With National and Regional Planning

- Planning for research reactors must not be done in isolation
- Must be integrated into the regional (local) and national plans
- Approval by regional and national planners is one way to accomplish coordination
- Exercise are the only way to verify the planned coordination actually works

# Summary

- **Demonstrated the role of the Con-ops in coordinating the planning**
- **Discussed the Con-ops for several events possible at research reactors**
- **Discussed the importance of assigning responsibilities**
- **Provided a tool (worksheet) to identify and resolve gaps and conflicts in responsibility**
- **Make sure your planning is coordinated with national planning - not done in isolation**

# Where to Get More Information

- **Information Con-ops and assignment of responsibility:**
  - **EPR-METHOD**
- **Response to accidents:**
  - **Reactors**
    - **TECDOC-955 for NPP**
    - **EPR-RESEARCH REACTOR**
  - **Radiological – TECDOC-1162**
  - **Medical – EPR-MEDICAL 2005**
- **Questions?**

# Emergency Preparedness and Response

# Accident Management vs Emergency Management

## Seminar

# Introduction

- This module presents basic concept of accident management centering on Emergency Operating Procedure (EOP) for research reactor
- It gives overview of general guideline for preparing Emergency Operating Procedure for RR

# Content

- Safety objectives for Research Reactor
- Basic concept of Accident Management
- Current Status of EP in research reactor
- Guideline for preparing EOP for RR
- Summary

# Safety Objectives for Research Reactor

**"General Nuclear Safety Objective:**

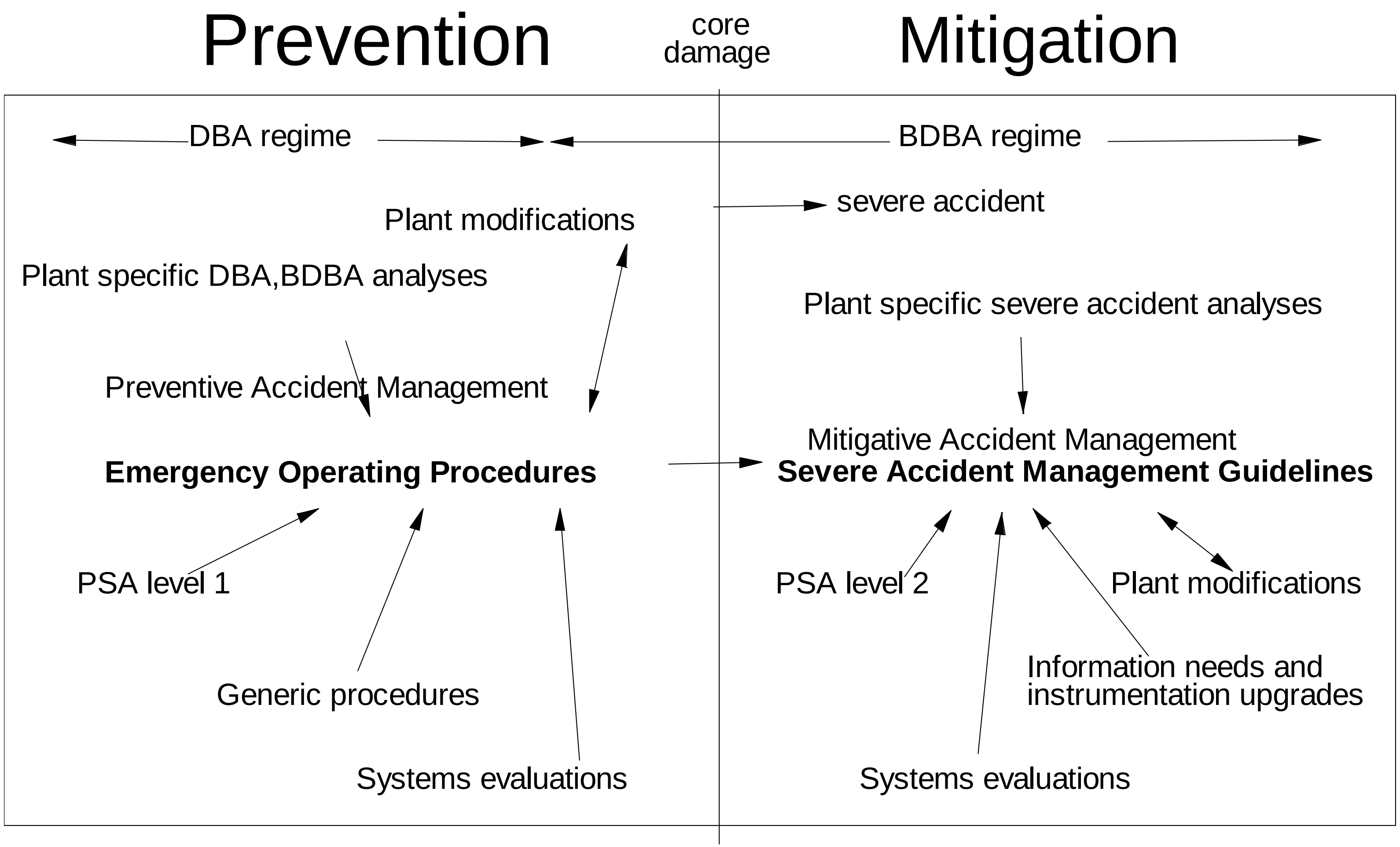
*To protect individuals, society and the environment from harm by establishing and maintaining in nuclear installations effective defenses against radiological hazards.*"

**from IAEA Safety Requirements No. NS-R-4**

# Definition of Accident Management

- A set of actions taken during the evolution of an event sequence towards beyond design basis accident
  - To prevent the escalation of the event into a severe accident
  - To mitigate the consequences of a severe accident
  - To return the plant to a controlled safe state

# Scope of the Accident Management



# Safety Performance

- **Safety = Min (S, A, F, E, T, Y)**

**Where**

**S: Safety Culture**

**A: ALARA**

**F: Functionality or Reliability**

**E: Effectiveness**

**T: Technology**

**Y: Yield to Principle and Procedure**

# Accident Prevention

- Preventive accident management measures
  - To eliminate Hazard Source
    - Design modification or Back-fitting
  - To monitor functionality and defense in depth margin and to Delay degradation of safety function
    - Preventive Test and Maintenance Program
    - Ageing Manage program and safety culture
    - EOP

# Accident Mitigation

- Preparation of Mitigation Strategy and Procedure
  - Identification of vulnerability to significant radiological release
  - Preparation of mitigation strategies
    - Information about the facility status limited
    - Equipment outside the required environmental conditions
    - Alternative or external equipment to be considered
    - An action typically has both positive and negative consequences

# Accident Management Procedures

- On site Radiological Accident Management
  - Design Base Accident Management
    - Abnormal Operating procedure
    - Emergency Operating procedure
  - Beyond DBA Accident Management
    - Severe Accident Management Procedure
    - On-site radiation emergency procedure
- Off-Site Accident Management
  - Emergency Preparedness and Planning

# Emergency Planning in RR facilities

- **Facilities were operating without having an adequate and comprehensive emergency plan**
- **Facilities did not plan cooperation with off-site organizations as appropriate**
- **Facilities have to improve or obtain on-site equipment and materials for an emergency condition**
- **Facility plans are not exercised or are exercised, but without off-site responses**

# Generic Issues of EP in RR facility

- Lack of technical continuity between EOP and EP for nuclear facilities
  - No specified entry point of EP in the EOP
  - Co-incident implementation of EOP and EP
    - Increasing mental load
    - Deteriorate inter- or intra-communicational quality

# Generic Issues (Cont'd)

- **Current EPs severely oriented to off-site management rather than on-site accident management**

- **EP for RR should pay attention to On-site management for protection of radiation workers**

# Guideline for Preparing EOP

- **Ensure that EOPs are adequately reviewed and commented during training programs**
- **Ensure that qualified operating staff review and practice all EOPs over a period of time (Part of continuous training program)**
- **Ensure that EOPs cover all important emergency situations for the Facility**
- **EOPs should be field tested to ensure maximum realism is built into the procedures and to determine if actions can be done as expected**

# Guideline for Preparing EOP

- Develop EOPs in a way to make the best use of ALL available resources (Helps reduce the workload on authorized staff)
- Develop a code of conduct for all staff in the Facility during emergencies (e.g. trades reporting to Control Room (C/R) for duties)
- A generic EOP should be developed for dealing with unknown/uncertain situations

# Format of EOP

- EOPs should have a common structure if possible (Easier for training and use during incidents)
- Breakdown the procedure for field and C/R actions and make sure that the C/R publication contains a copy of all field publications. Text should be limited to clear, simple precise actions
- One action per line as much as possible
- Start actions by a verb whenever possible

# Format of EOP

- Ergonomic (Users friendly)
- Easily recognized in C/R and simple labeling
- Well located in C/R for rapid access
- Entry conditions clearly shown on 1st page
- Verification elements for ALL Critical or important actions taken
- Frequent monitoring of CSP (Critical safety parameters) should be built-in the EOPs directly

# Format of EOP

- Put clear criteria for Decision points and clear indications on where to go in the EOPs if it is “Yes” or “No”
- Have clear and complete instructions for field staff and include steps for feedback to the C/R when completed.
- EOPs should be self-contained whenever possible
- Precautions and risks should be clearly highlighted with the word “Attention” or “Caution” and shown before the actions that they refer to

# Use of EOPs

- **Frequent use by all operating staff as part of a continuing training program**
- **Realistic scenarios with minimum amount of simulated actions**
- **Exercises need to be well planned, with limitations on drill conditions, safety monitors where appropriate, and an evaluation of individual performance afterwards**

# Summary – Accident Management

- Main objective of accident management is to prevent endangering human, society and environment from radiological accident in the nuclear facility.
- Preventive and mitigative accident management measures
- AM for RR should be focused on preventive measure (EOP) and onsite AM.
- Guide for preparing EOP for RR

# Where to Get More Information

- IAEA Safety Requirements No. NS-R-4
- IAEA Code of Conduct on the Safety of Research Reactors
- Operational Limits and Conditions and Operating Procedures for Research Reactors, Safety Guide No. NS-G-4.4

# Introduction

Emergency management means overall strategic management of the emergency response

Objective of this lecture is to present and explain requirements, concepts and functions of emergency management as applied to response to a nuclear or radiological emergency at a research reactor

# Content

- Requirements for emergency management
- Emergency management role
- Facility Response Manager's tasks
- Emergency phase actions
- Post-emergency phase actions
- Summary

# Response Requirements

- **On-site emergency response shall be promptly executed**
- **Off-site emergency response shall be effectively managed**
- **Emergency response shall be coordinated between all responding organizations**
- **Information necessary for making decisions on allocation of resources shall be appraised throughout emergency**
- **Jurisdictions and response organizations that fall within the UPZ shall coordinate their emergency responses and shall provide mutual support**

# Preparedness (1)

- **Transition from normal to emergency operations shall be clearly defined and made without jeopardizing safety**

- **Arrangements shall be made to coordinate the emergency response of all the off-site organizations with the on-site response**

# Preparedness (1)

- **Arrangements shall be made for the implementation of a command and control system for the response to a nuclear or radiation emergency**

- **Arrangements shall be made for coordinating response to a nuclear or radiation emergency between the response organizations and jurisdictions that fall within the UPZ**

# Practical Goals of Emergency Response

- **To take mitigatory action at the scene**
- **To prevent occurrence of deterministic effects**
- **To render first aid and to manage treatment of radiation injuries**
- **To reduce occurrence of stochastic effects in population**
- **To limit occurrence of psychological effects**
- **To protect environment and property**
- **To prepare for resumption of normal social and economic activity**

# Important Aspects

- **Most important aspects of managing radiation emergency**

**Ability to promptly and adequately determine actions to protect members of the public and emergency workers**

**Ability to take those actions efficiently**

# Facility Response Manager

- **Facility Response Manager is in charge of the overall strategic emergency management**

# Role and Functions of the Facility Response Manager

- Who is designated as Facility Response Manager?

  Document in the response plan
- Knowledge/skills required
- Operational location

# Emergency Phase

- Obtain briefing from operations staff; alert/activate other responders
  - Initial Information
  - Plant Conditions to classify the event
  - Emergency Notification Record to alert affected area/public

# Emergency Phase Actions

- Identify necessary responders
  - Who is needed may vary
  - Alert/Facility Emergency
    - no off-site risk expected
- Plan the automatic response
  - reduces time for decisions
  - allows attention on other actions

## Initial Response

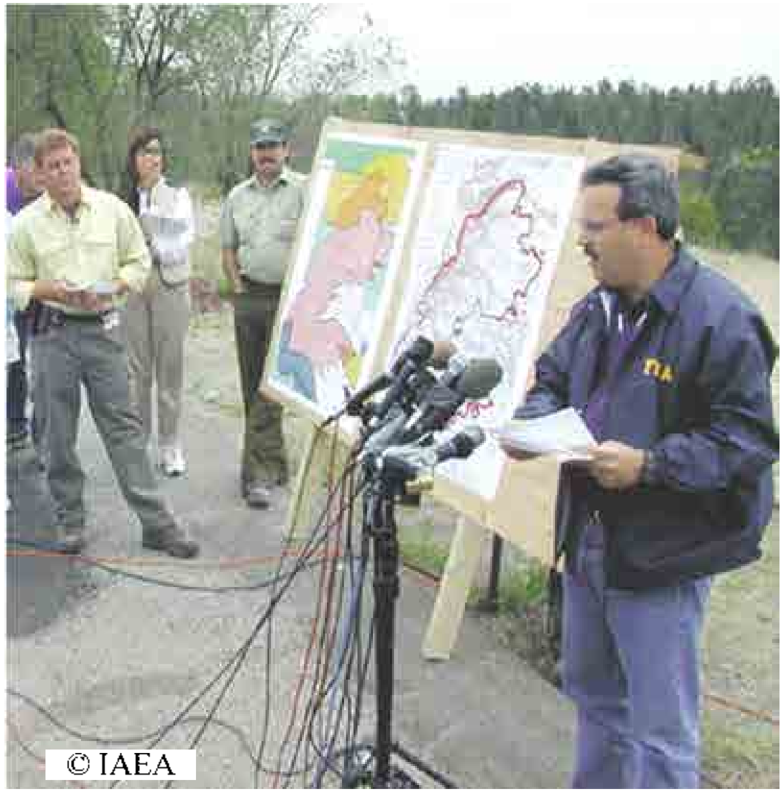
- Emergency Response Priority list gets actions started
- Available on-shift personnel determine
  - Shift Supervisor workload
  - Rapidity of completion
- Arriving responders
  - accept duties without gaps and with formal turnover
  - report turnover to Facility Response Manager

# Emergency Phase Actions

- Maintain a Log
  - What was done
  - When was it done
  - Notifications
  - Decisions
- Maintain status boards/displays

# Additional Considerations

- **Public Information**
- **Media Interest/Response/Relations**



# Recovery Phase

- Establish conditions to terminate emergency phase, minimum conditions should be:
  - Stable plant conditions
  - No further releases
  - Monitoring identified all urgent protective action locations
- Prepare recovery phase plan, organization and responsibilities
- Agreement with facility and off-site authorities
- Ensure all actions, decisions, recommendations are documented, save records

# Summary

**This part of the lecture provided**

- **International requirements for establishing emergency management**
- **Initial response concepts**
- **Facility Response Manager responsibilities**

IAEA Training Course for Research Reactor Emergency Response

# Emergency Preparedness and Response

# Emergency Classification

## Seminar

# Introduction

- In this module you will learn how to classify abnormal conditions in a reactor facility
- The module
  - Suggests tools to classify the abnormal conditions
  - Presents the tables in EPR-RESEARCH REACTOR as convenient tools to classify emergency situations
  - Suggests the incident reporting system

# Introduction (Cont'd)

- **Presented classification method**
  - **Must be reviewed and revised to fit the potential accidents, local conditions, national criteria and other unique characteristics of a research reactor where it may be used**
  - **Is consistent with international guidance**

# Content

- Tools needed to determine emergency class
- Examples and problems
- Summary

# Emergency Classes

- There are four emergency classes:
  - Alert
  - Facility Emergency
  - Site area emergency
  - General emergency
- Classification Goal – 15 minutes
- Classification Decision – made by personnel at the reactor when an emergency situation is recognized
- These are not INES classes

# ALERT

- Man-made events
  - security threats
  - civil disturbance
- Natural phenomena
  - tornado in the reactor vicinity
  - hurricanes
  - earthquakes felt in the facility
- Unexpected media inquiry

# ALERT (Cont'd)

- **Fire, toxic gases**
- **Abnormal fission product activity in coolant**
- **Unexpected off gas activity in the vent stack**
- **Abnormal radiation levels**

# FACILITY EMERGENCY

- Containment boundaries exist to reduce releases of fission products
  - Potential failure of fuel cladding
  - Potential failure of fuelled experiment
  - Local release of radioactive materials as a result of experiment failures
- Only localized (within the facility/site) radiological threats
- Note: some sites with multiple facilities may use a Site Emergency class that implies no off-site risk, but risk beyond the damaged facility

# SITE AREA EMERGENCY

- **Major decrease of safety due to radiation**
- **One additional failure results in severe core damage or could cause severe core damage**
- **High dose  on-site**
- **Off-site radiation levels approaching 10% of the OILs**

# GENERAL EMERGENCY

- **Substantial risk of major release with need for off-site protective actions**
- **Actual or projected severe core damage**
- **High dose off-site**

# Basis for the Classification Table

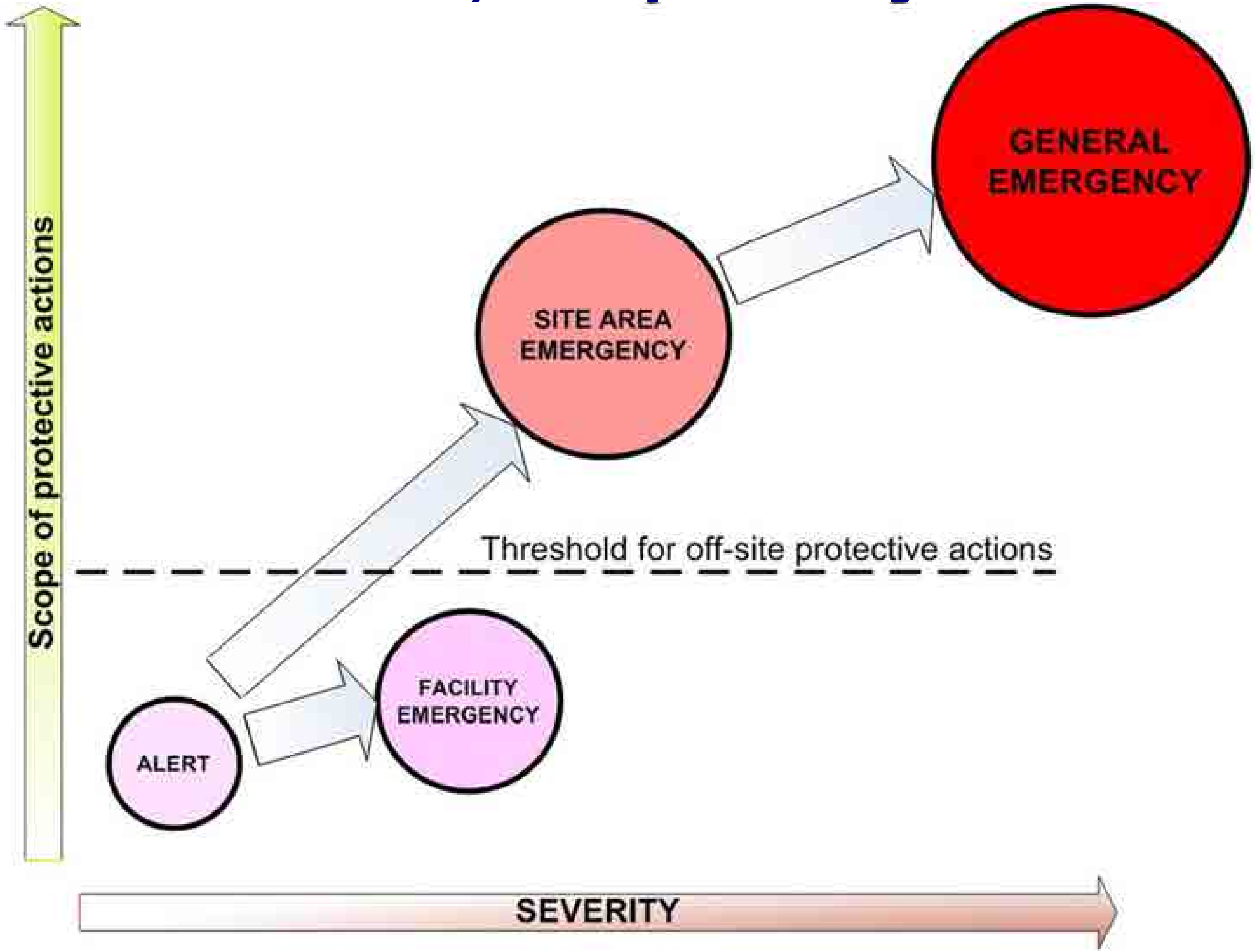
- The Table provided is an example, not a set of required conditions and associated classification criteria
- It shows a wide range of emergency situations with suggested classifications
- Make it your Table by
  - What are the emergency situations
  - What are the potential severity criteria, as detailed as necessary

# Classification Table

## EAL Table Format

| For the following entry conditions: | Declare a General Emergency if: | Declare a Site Area Emergency if: | Declare a Facility Emergency if: | Declare an Alert if: |
|---|---|---|---|---|
| Define the symptoms of a particular emergency condition. Be as detailed as necessary to guide the Emergency Director. | What condition, instrument reading, equipment disability, etc. defines a serious emergency with a immediate threat to the off-site population. Actual fuel damage or the imminent threat of fuel damage is usually in this category. | What condition, instrument reading, equipment disability, etc. defines a serious emergency with a potential threat to the off-site population. The possibility of fuel damage is usually in this category. | What condition, instrument reading, equipment disability, etc causes a serious threat to the on-site personnel or to the on-site equipment. No off-site threat would be likely. | What condition, instrument reading, equipment disability, etc. causes concern with unknown consequences, but no obvious immediate radiological threat. This may be a threat to the on-site staff or to on-site facilities, such as a fire, but at a lesser level than Facility Emergency |

# Classifications, Graphically



# Tools to Determine Emergency Class

## Table A1– Critical Safety System Functions

- Failure to shutdown
- Inadequate core cooling
- Loss of AC or DC power sources
- Loss or degraded control of safety systems
- Major risk of or confirmed reactor core damage

# Tools to Determine Emergency Class
## Table A1– Loss of Fission Product Barriers

- Major risk of or confirmed reactor core damage
- High I-131 in pool
- Containment or confinement barrier damaged

# Tools to Determine Emergency Class
## Table A1 – Radiation Events

- **Excessive effluent release**
- **High radiation level in control room or other areas requiring continuous access**
- **High radiation level in areas requiring occasional occupancy**
- **Unplanned increase radiation levels in facility**
- **High ambient dose rates beyond the site boundary**

# Tools to Determine Emergency Class

## Table A1 - External and other events

- Security events (intruder or terrorist attack)
- Fire or explosion affecting reactor
- Toxic or flammable gases
- Major natural disaster
- Loss of communication
- Radioactive material control
- Irradiated fuel abnormality
- Experimental equipment abnormality

# Additions to Table A1

- Review potential emergency situations at your reactor
- If not on the suggested table, add the entry conditions and severity levels
- Adapt the suggested items to fit your situation
- Try it with the following two entry conditions

# Example EAL Table entry

| For the following entry conditions: | Declare a General Emergency if: | Declare a Site Area Emergency if: | Declare a Facility Emergency if: | Declare an Alert if: |
|---|---|---|---|---|
| Inadequate core cooling – Pool/tank level[1], such as pool or tank leakage greater than capacity of make-up water system, inadvertent drainage of pool/tank | Pool/tank water level is, or is projected to be, below top of active fuel for greater than *[insert site specific time period to cause release of fission products from fuel elements]* minutes. | | Pool/tank water level is or is projected to be below top of active fuel. | Pool/tank water level decreasing over a longer time period than expected while systems are responding as designed. |

[1] Inadequate core cooling is characterized by two kinds of entry conditions – Pool/tank water level and decay heat removal capability.

# Example EAL Table entry

| For the following entry conditions: | Declare a General Emergency if: | Declare a Site Area Emergency if: | Declare a Facility Emergency if: | Declare an Alert if: |
|---|---|---|---|---|
| Inadequate core cooling[1] – Loss of decay heat removal capability, such as failure of primary or secondary circulating pumps, failure of heat exchangers or valves required for decay heat removal, fuel channel blockage, loss of emergency core cooling system | Absence of ability to transfer decay heat to the environment for [*site-specific time for fuel temperature to exceed design values with only ambient losses available for decay heat removal]*<br>and<br>*Abnormal* increases *(100 - 1000x) in multiple radiation monitors*<br>or<br>other indications of imminent or actual core damage[2] | | Actual or projected long term failure of the ability to remove decay heat to the environment potentially affecting the ability to protect the core | Unavailability of normal system for decay heat removal |

[1] Inadequate core cooling is characterized by two kinds of entry conditions – Pool/tank water level and decay heat removal capability.

[2] Consideration of containment boundary status might be considered as further additional criteria

# Work Session Examples and Problems

- Let us classify an event at a particular research reactor
- This is a 10 MW(th) pool type reactor, sited at a Nuclear Research Centre, used for neutron physics experimentation and production of radioisotopes
- During irradiation of a capsule filed with tellurium dioxide the capsule ruptures and an large quantity of iodine-131 is released to the facility

# Solving Problems Using Table A1

- The symptoms of the event are:
  - High primary coolant I-131 concentration, at 70X reactor technical specifications
  - High radiation levels (15 mSv/h) for uncertain duration in areas requiring occasional occupancy to maintain and control safety systems
  - Damage to experimental assembly with potential for personnel overexposure in the facility

# Classification Using Table A1 (Cont'd)

- **Looking at Table A1 one concludes that the appropriate emergency class is:**

**SITE AREA EMERGENCY**

# Summary

- **Four different classes of unusual events on a reactor facility which should be declared**
- **Knowledge of the IAEA EPR-RESEARCH REACTOR classification table and the use of it during regular training**

# Where to Get More Information

- IAEA Methods for Developing Arrangements for Response to a Nuclear and Radiological Emergency, EPR-METHOD 2003
- IAEA, Emergency Classification – Table A.1 from EPR-RESEARCH REACTOR

# Emergency Preparedness and Response

# Urgent Protective Actions

## Seminar

# Introduction

- In the event of an emergency, protective actions may need to be taken to control the radiation exposures of members of the public or to on-site personnel

- The purpose of this lesson is to present background and guidance on major protective actions

# Content

- Exposure pathways
- Protection strategy
- Urgent protective actions
- Operational Intervention Levels
- Protection of Emergency Workers
- Summary

# Objectives of Emergency Response

- Mitigate the consequences at the source
- Reduce the risk of serious deterministic health effects (deaths)
  - Keep acute dose below health effects threshold
- Reasonably reduce the risk of stochastic effects (cancers)
  - Do more good than harm
  - Act according to international guidance

## Generic criteria for external acute doses for which protective actions are to be undertaken to avoid severe deterministic effects – (<10 h exposure)

- **Protective and other response actions are to be undertaken under any circumstances**
  - **Red marrow - 1 Gy**
  - **Tissue - 25 Gy at 0.5 cm**
  - **Fetus - 0.1 Gy**
  - **Skin – 10 Gy to 100 cm$^2$**

# Generic criteria for internal acute doses for which protective actions are to be undertaken to avoid severe deterministic effects – (30 d exposure)

- **Protective other response actions are to be undertaken under any circumstances**
  - **Red Marrow**
    - **0.2 Gy for radionuclides with Z ≥ 90**
    - **2.0 Gy for radionuclides with Z < 90**
  - **Thyroid – 2 Gy**
  - **Lung - 30 Gy**
  - **Colon – 20 Gy**
  - **Fetus – 0.1 Gy, entire gestation**

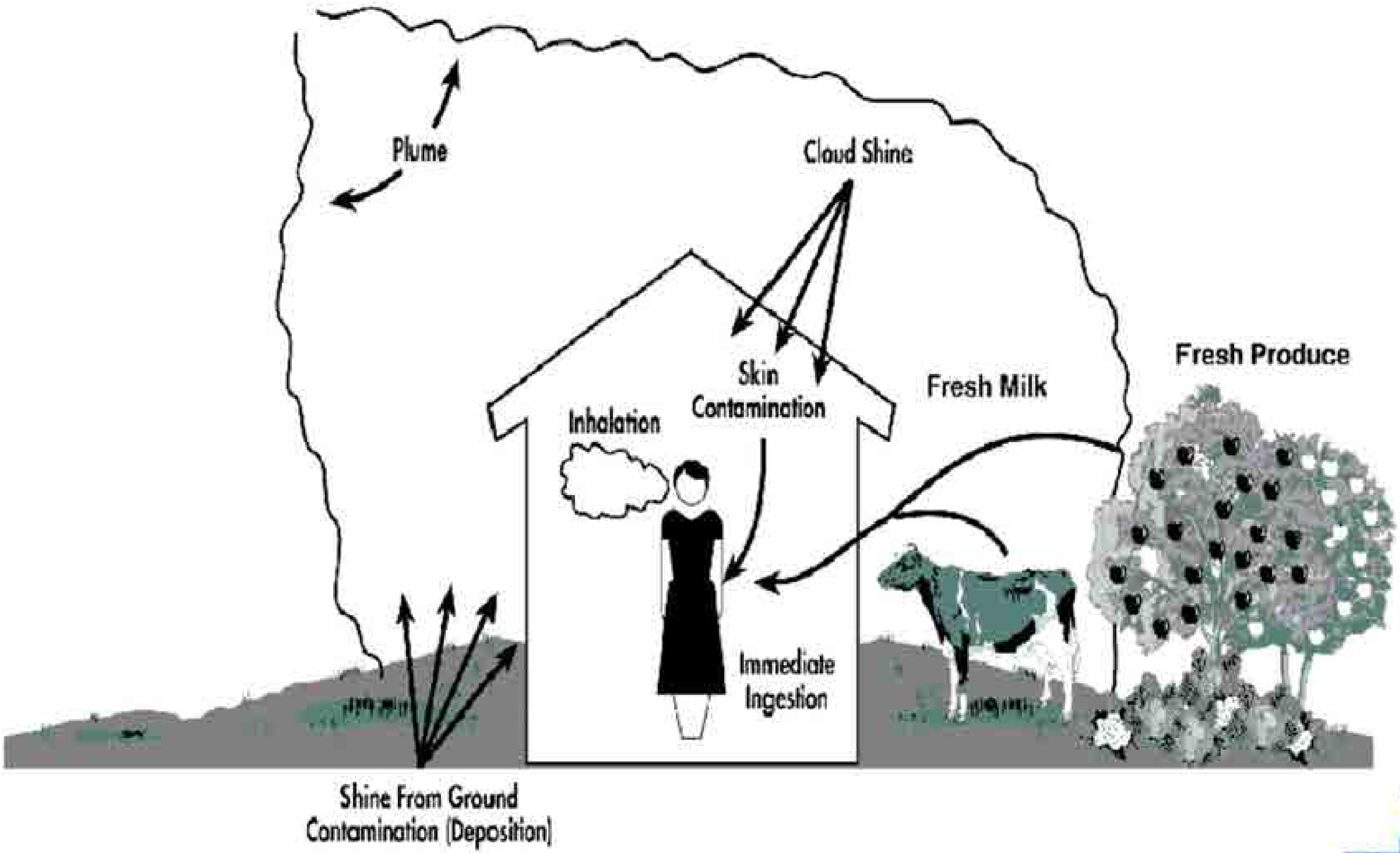
## Generic Criteria for Protective Actions to Reduce the Risk of Stochastic Health Effects

- Take urgent protective action when projected dose exceeds the following generic criteria
  - Equivalent dose to thyroid - 50 mSv in the first 7 days
  - Effective Dose - 100 mSv in the first 7 days
  - Equivalent dose to fetus - 100 mSv in the first 7 days

## Generic Criteria for Protective Actions to Reduce the Risk of Stochastic Health Effects

- **Take longer term medical actions to detect and effectively treat radiation-induced health effects**
  - **Effective Dose - 100 mSv in a month**
  - **Equivalent dose to fetus - 100 mSv during gestation period**
- **Temporary relocation, replacement food, milk and water**
  - **Effective Dose - 100 mSv per annum**

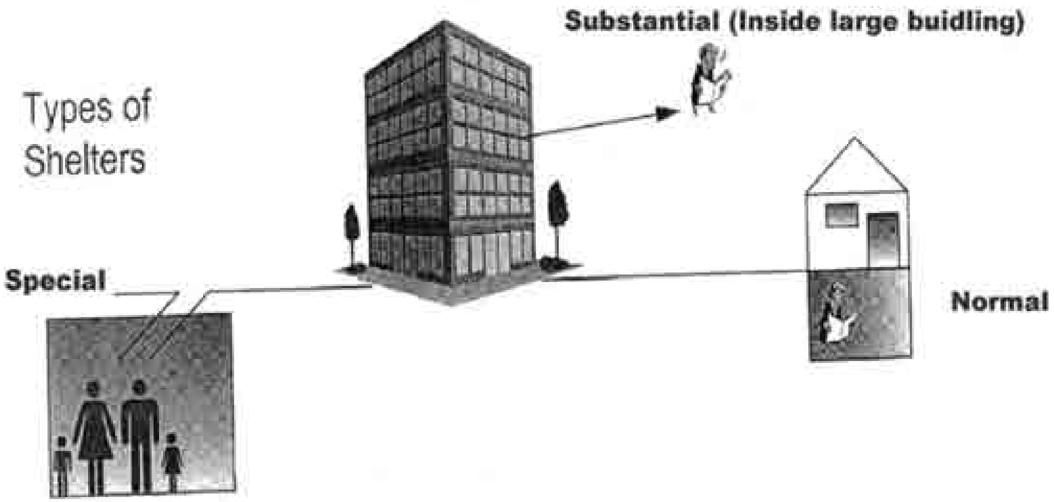
# IMPORTANT EARLY DOSE PATHWAYS FOR REACTOR ACCIDENTS



# Pathways, Phases, and Protective Actions

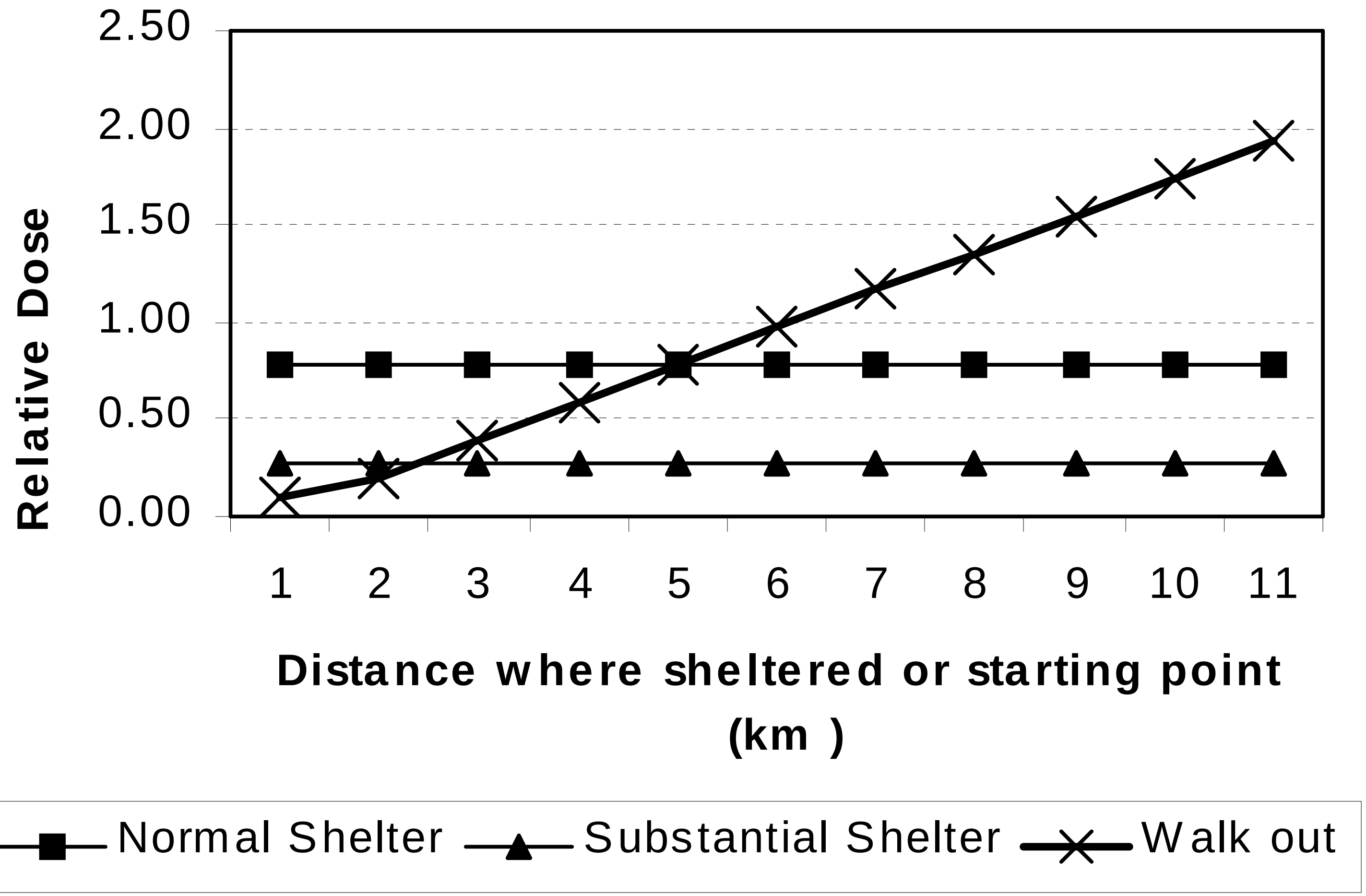
| PATHWAYS | PHASES | PROTECTIVE ACTIONS |
|---|---|---|
| Cloud Shine | URGENT | Sheltering<br>Evacuation<br>Control of Access |
| Plume Inhalation | URGENT | Sheltering<br>Use of Potassium Iodide<br>Evacuation<br>Respiratory Protection<br>Control of Access |
| Skin Contamination | URGENT | Sheltering<br>Evacuation<br>Decontamination of Persons |
| Short Term Ground Shine | URGENT | Evacuation<br>Relocation<br>Decontamination of Land and Property |
| Immediate Ingestion | URGENT | Food and Water Controls |
| Long Term Ingestion | LONG TERM | Food and Water Controls |
| Long Term Ground Shine and Inhalation of Resuspended Activity | LONG TERM | Relocation<br>Decontamination of Land and Property<br>Restricted Use |

# Types of Shelters and Effectiveness



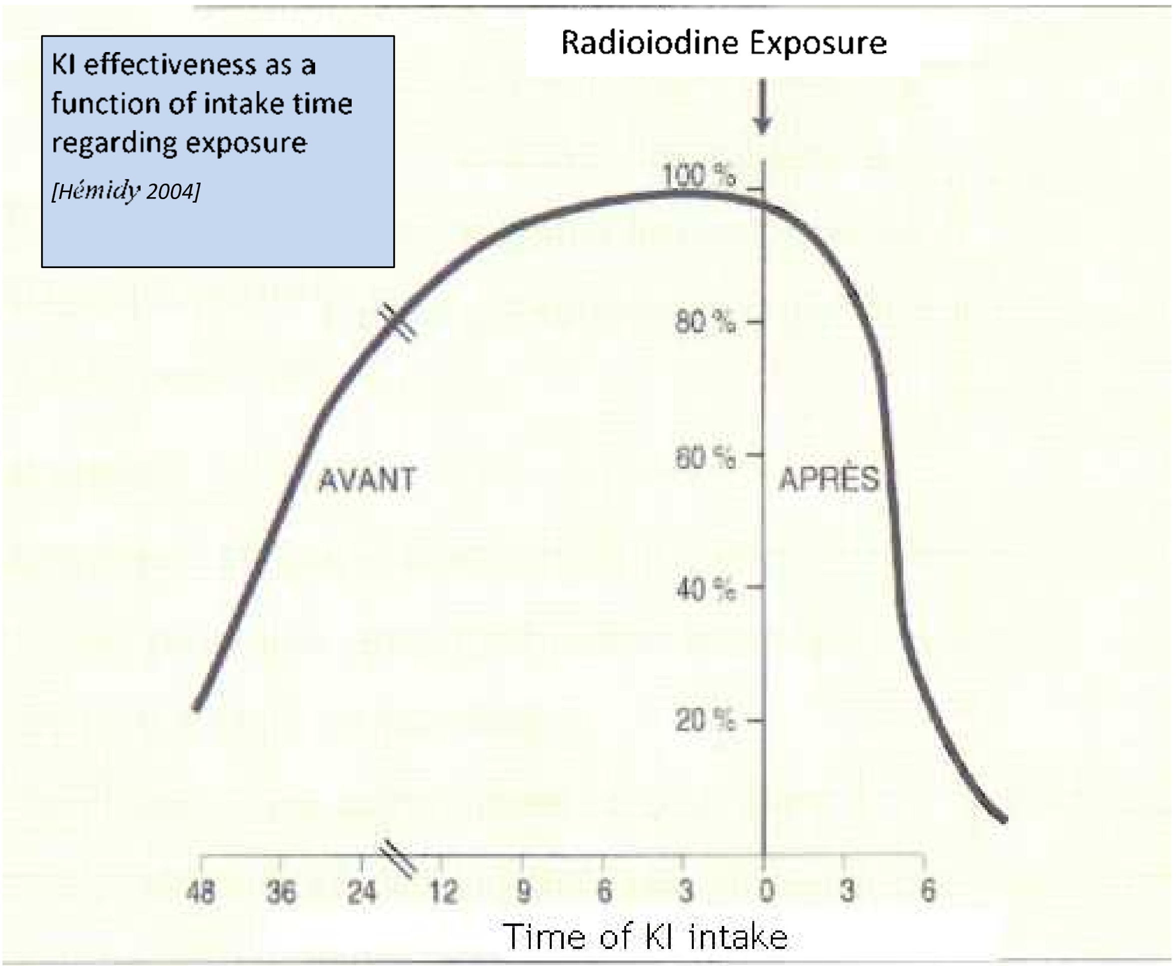

| | Normal | Substantial | Special |
|---|---|---|---|
| **Cloud shine** | 0.4 - 0.9 | 0.1 - 0.2 | > 0.001 |
| **Ground shine** | 0.01 - 0.1 | 0.005 - 0.01 | > 0.0001 |
| **Inhalation** | 0.3 - 0.5 | 0.3 - 0.5 | > 0.001 |

# Effectiveness of Sheltering and Evacuation in Plume



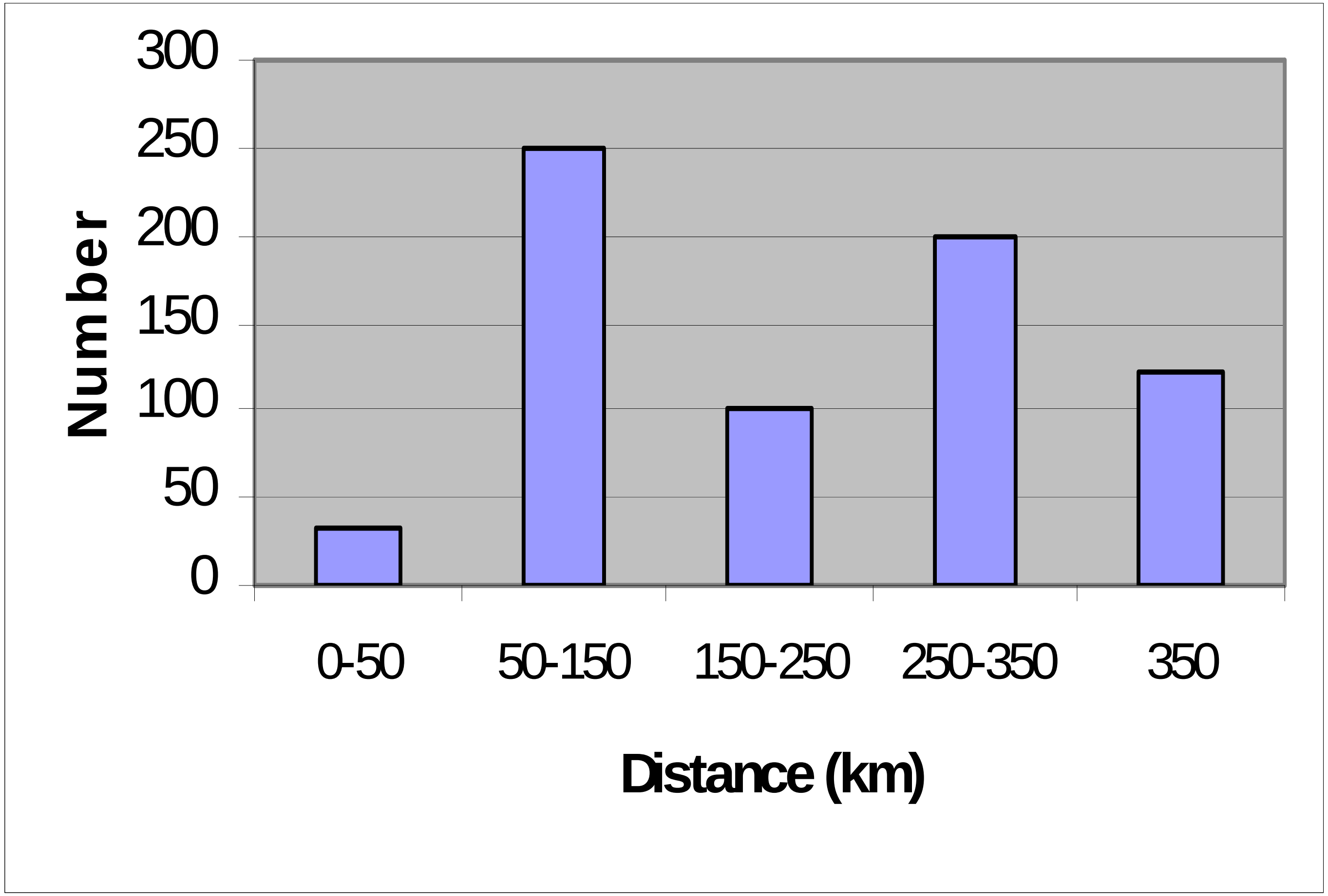
# Effectiveness of Thyroid Blocking with Time

100 Mg of Iodine - 130 Mg of KI

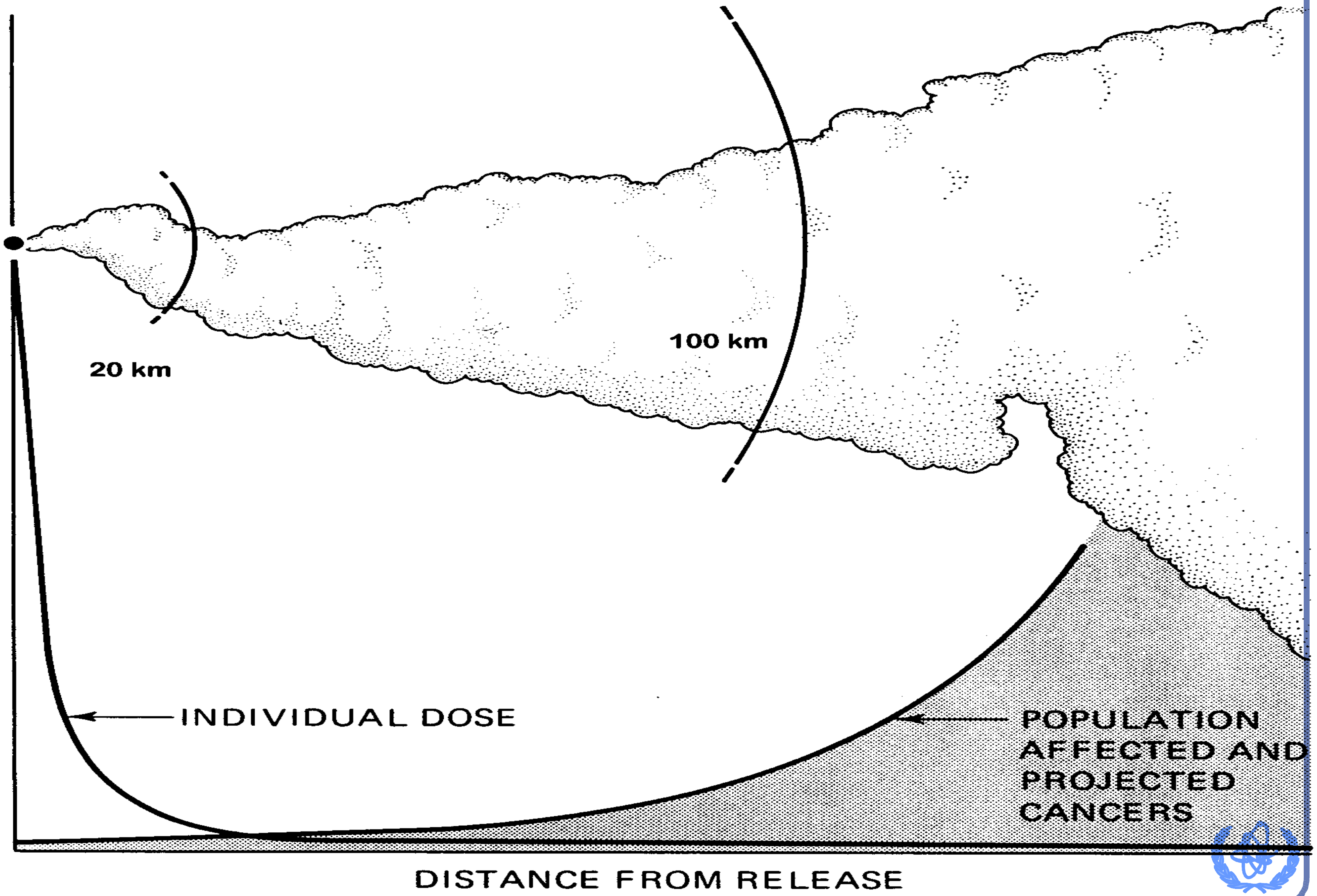



Hémidy PY. Intérêt de la prophylaxie par l'iode stable en situation accidentelle (in French). 22nd ATSR Congress Management of a Radiological Emergency Situation October 2004. Grenoble, France

# Total Number of Thyroid Cancers in Belarus Among Those 0-18 Years Old at the Time of Chernobyl Accident



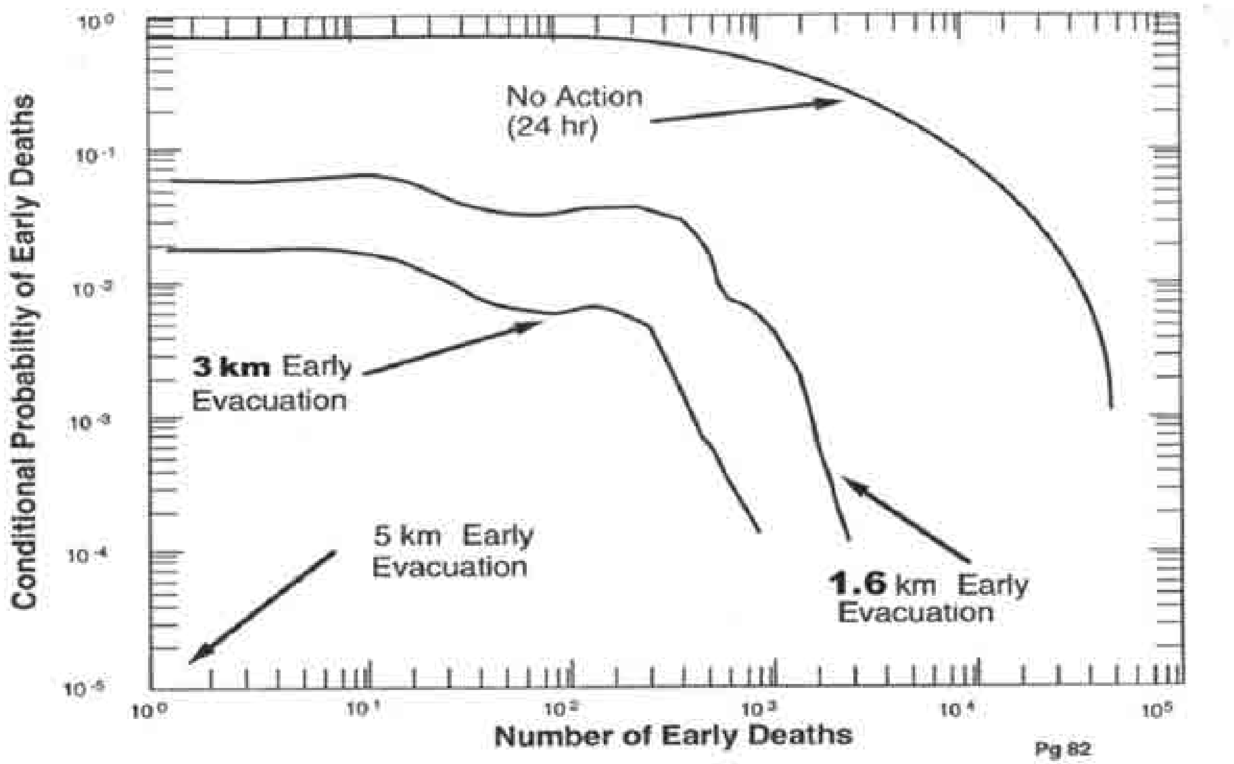
# MOST CANCERS WILL BE MORE THAN 10km FORM THE SITE



# The Basis Protective Action Strategy for a Reactor Emergency

- For area where early deaths are possible with a few hours
  - Implement sub. shelter or evacuate to reduce this risk - when dangerous condition detected.
- For area where urgent protective actions may be warranted in accordance with the generic criteria
  - Shelter and conduct prompt monitoring to determine if evacuation is warranted.
- Give thyroid blocking near the facility
- Restrict locally produced food consumption

# Probabilities of Fatalities Assuming Largest Power Reactor (3000 Mw(th)) Emergency




**Evacuation at time of the release to 5 km followed by evacuation of hot spots in 4 - 6 hours *PREVENTS* early deaths**

# Public Monitoring and Decontamination

- **Skin contamination could contribute to deterministic effects - on-site**
- **Public should be monitored**
- **Should not delay evacuation**
- **Screening or monitoring a sample is only practical method**
- **Instruct people to shower and change clothes as soon as possible**

# Protective Action Strategy to Reduce Public Risk for Core Damage Accidents

- Before or shortly after release - based on facility conditions
  - Evacuation or substantial sheltering near the facility (PAZ)
  - Take thyroid blocking on-site and near the facility
- After a release
  - Prompt monitoring to locate areas requiring further protective actions (UPZ).
  - Restrict consumption of locally grown food (UPZ)
  - Monitoring to locate where food restrictions and relocation is warranted (UPZ and beyond)

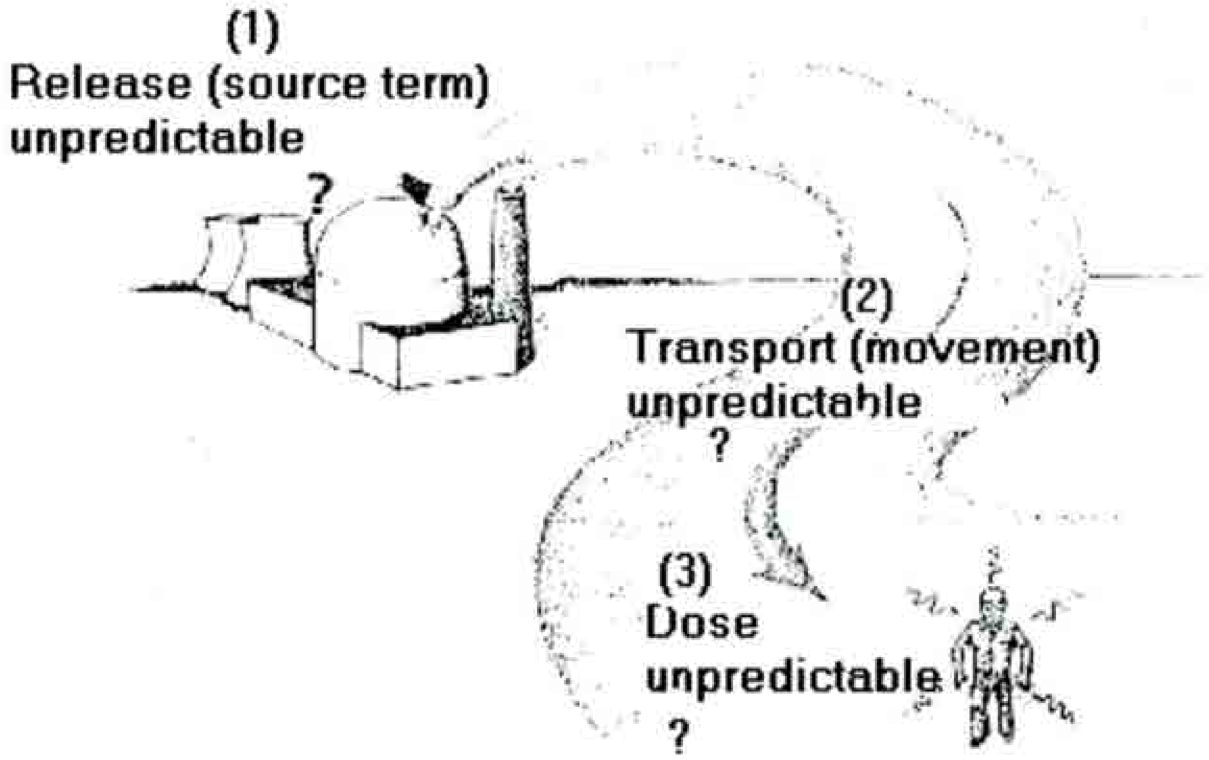
# Psychological Considerations

- Evacuations are common - people do not panic!
- Travel during evacuations is safer than normal travel
- Some people will act on their own and not follow instructions
- There will be better compliance with advice if trust is maintained by:
  - an ongoing information programme
  - clear and simple advice during the emergency.
  - consistent advice and assessment (one official information point)
  - using international guidance

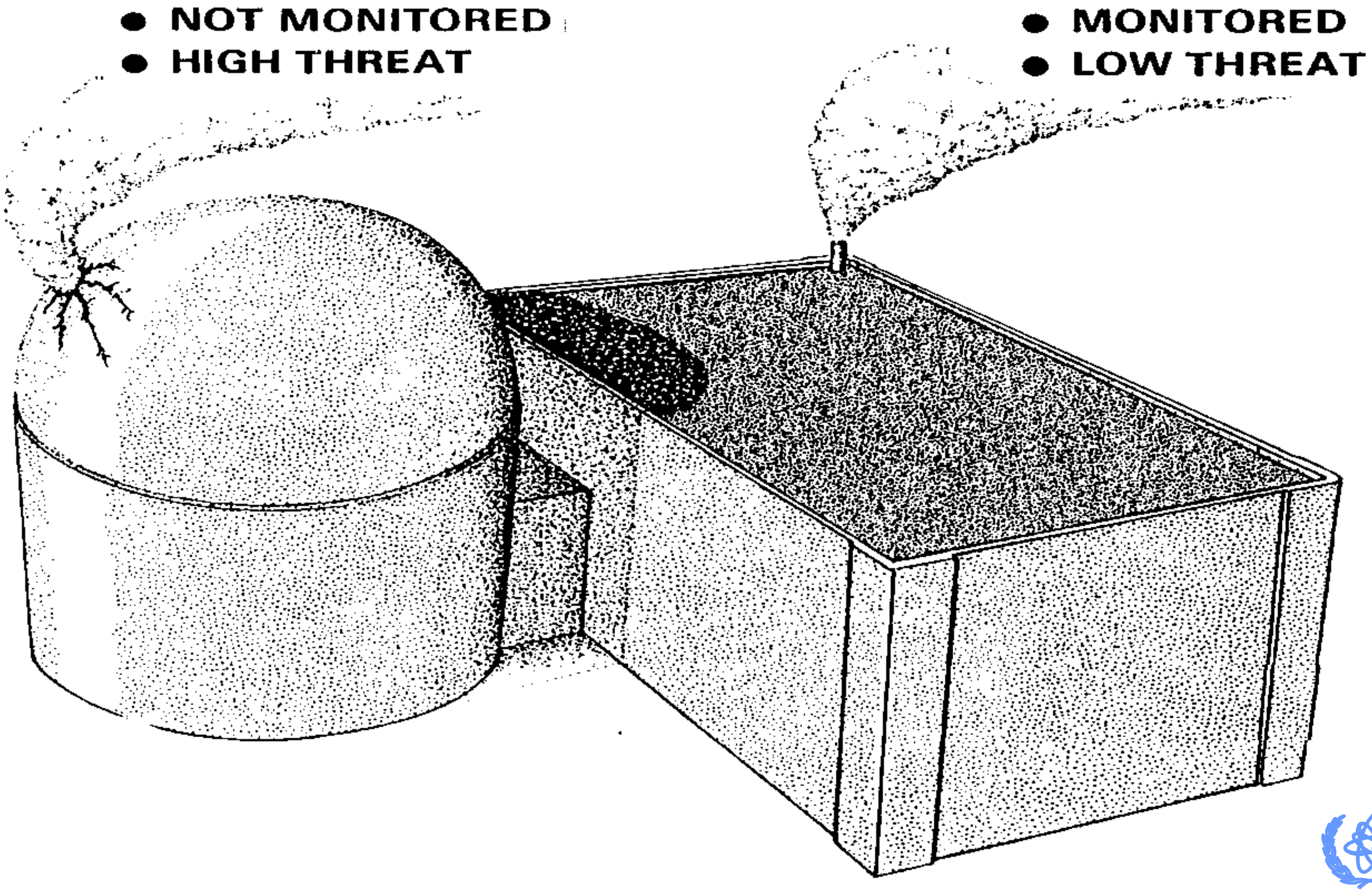
# Psychological Health Effects

- Expected after nuclear emergency
- At Chernobyl some actions did more harm than good
- Psychological effects must be considered in making decisions
- Do not take protective actions for political reasons

# DOSE PROJECTION TOO LATE AND TOO UNCERTAIN AS BASIS FOR PROTECTIVE ACTIONS

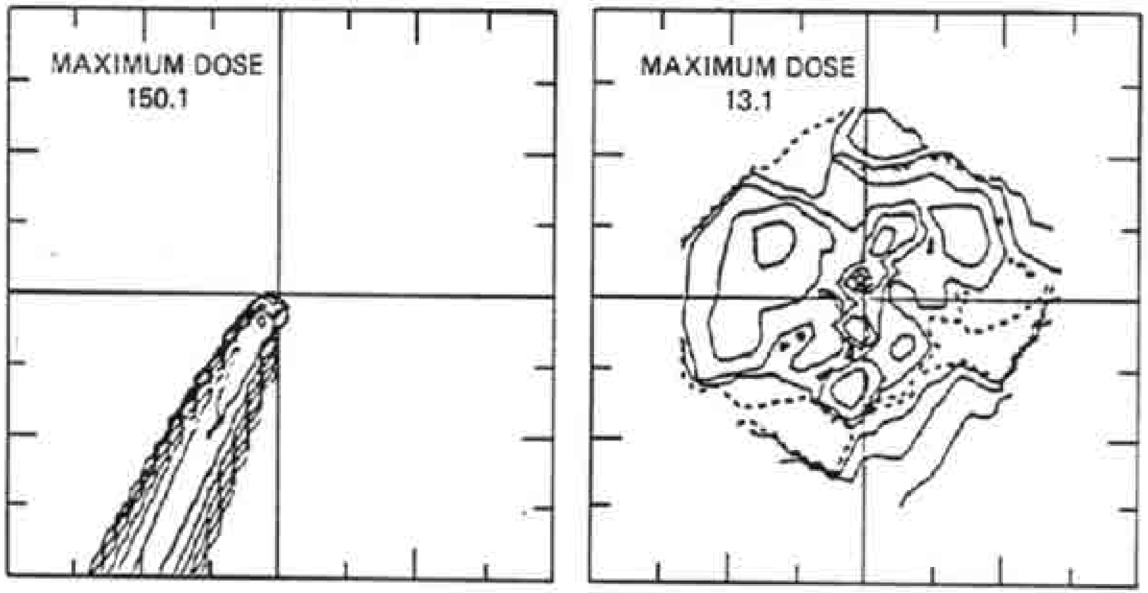


# A Major Release Most Likely Will Not Be Monitored



# Dose Projection Model

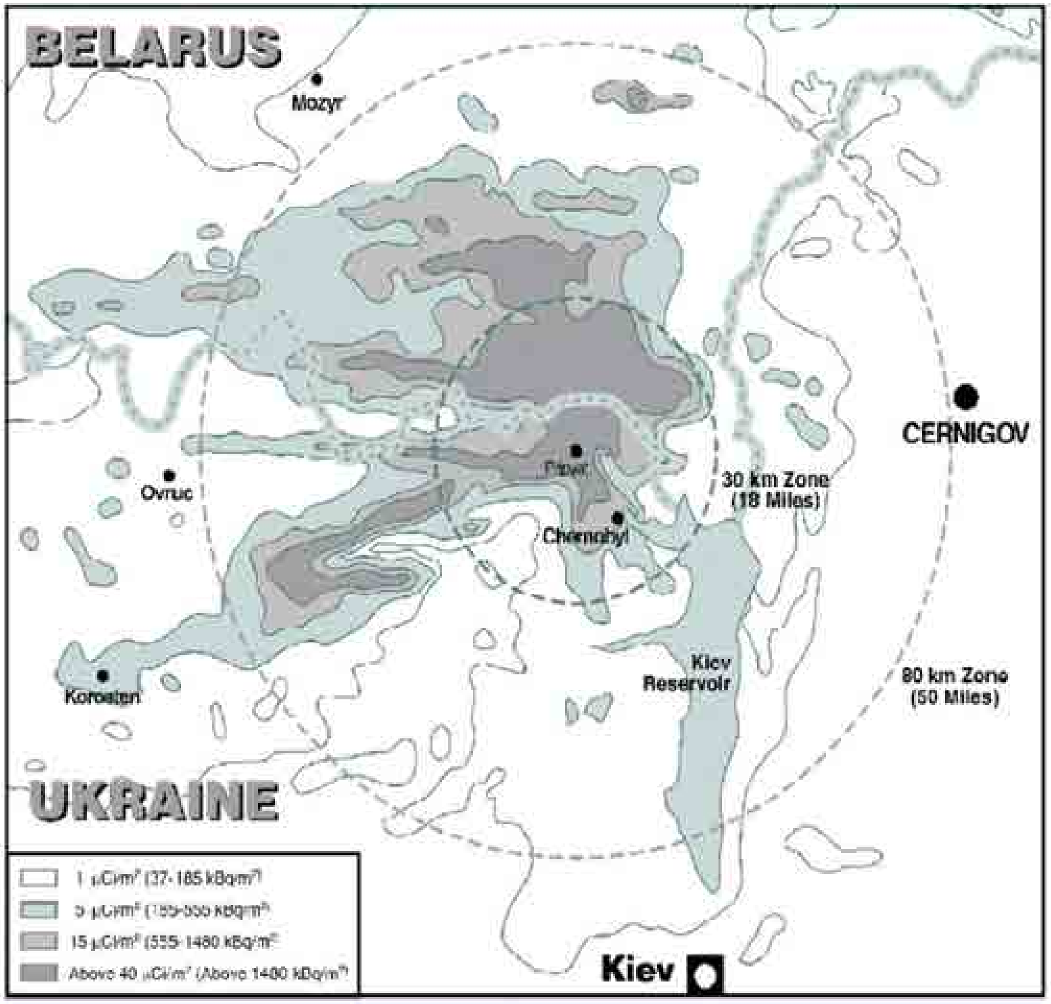
- **Models may not accurately project plume movement**
  **Do not rely on them for protective action**



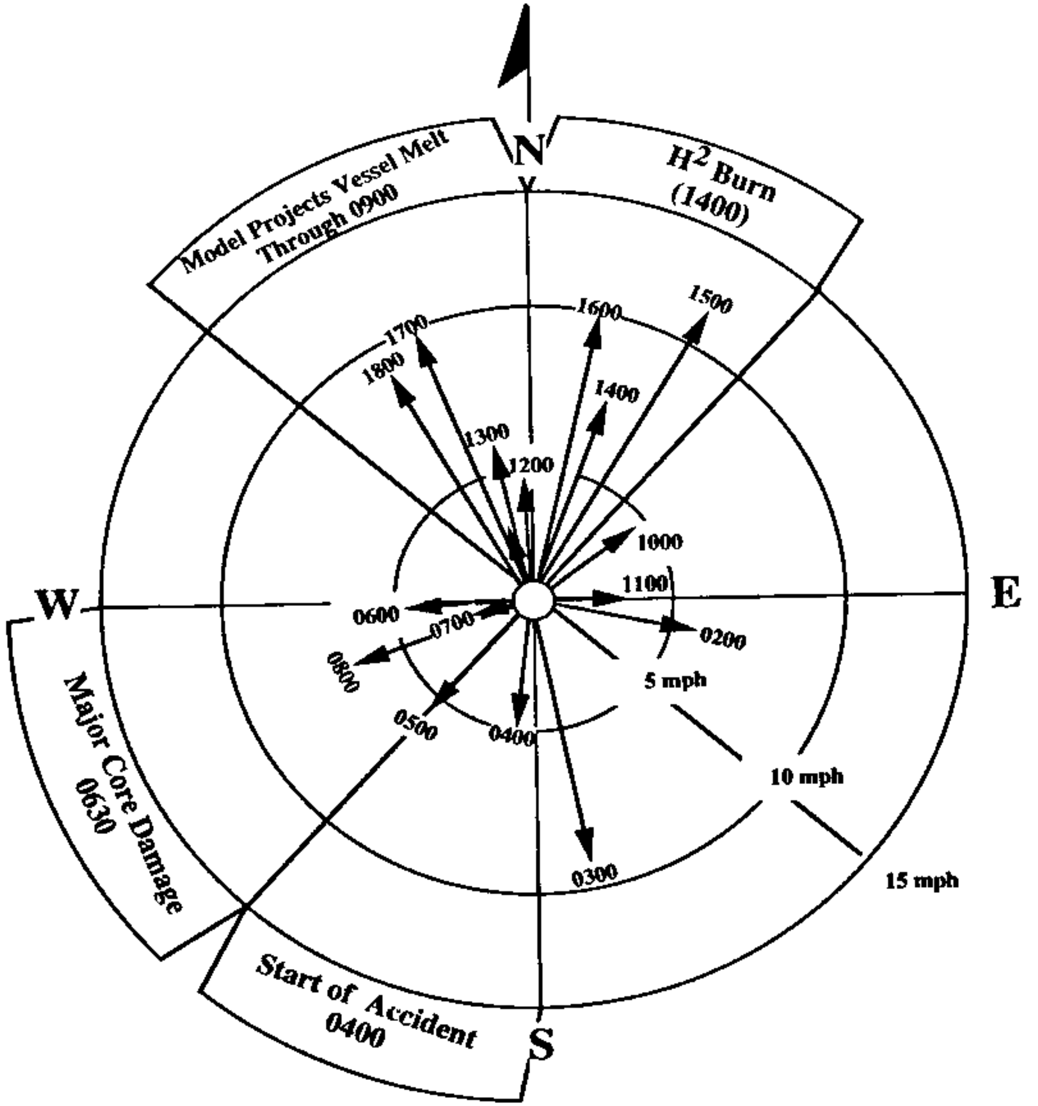

**Projection** **Actual**

**BE CAREFUL!**

# Expect All Directions to Be Affected by a Long Duration Release



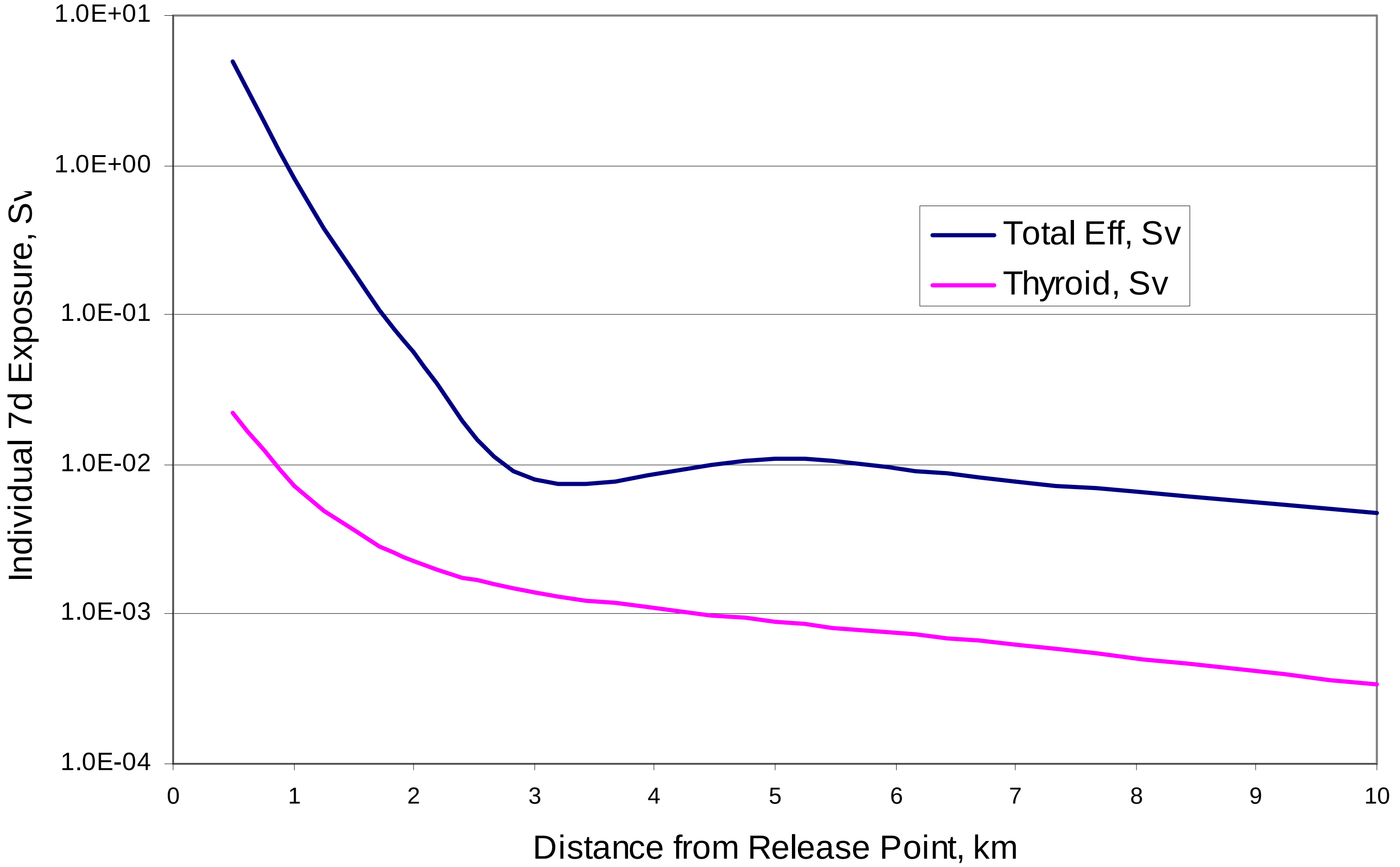
# Wind Direction During TMI



# Develop an Emergency Classification System

- Basis for fast coordinated national and regional action
  - Activation and notification
  - Protective action before a release
  - Notification of nearby countries if potential release
- Based on
  - Risk of core damage
    - Critical safety system
    - Barriers (core damage indication)
  - Environmental monitoring

# Severe Emergency at 100 Mw Research Reactor



# Protective Actions by Emergency Class – before env. monitoring results

| Protective Action | Class | |
|---|---|---|
| | Site Area Emergency | General Emergency |
| Evacuate or shelter non-essential personnel on-site | yes | yes |
| Provide responders with radiation protection | yes | yes |
| Prepare the public | yes | |
| Evacuate or shelter PAZ (Threat Category I only) | | yes |
| Take thyroid blocking in PAZ and UPZ | | yes |
| Monitor UPZ and take action where OILs are exceeded | Consider sheltering | yes |
| Restrict fresh food and milk | | yes |
| Notify nearby countries | | yes |
| Record names of exposed for follow up | | yes |

# After the Start of Release Revise Protective Based on Environmental Measurements

- IAEA Recommended Guidance from GSG-2
  - Operational Intervention Levels (OIL)
- Generic Criteria for
  - Urgent actions (e.g., evacuation, KI)
  - Long-term actions (e.g., relocation)
  - Food restrictions
- For dose that can be prevented by action
- Intended to do more good than harm
- Taking actions at much lower levels could do more harm than good

## The Generic Criteria Can Not Be Used Directly During Emergency

- **Not directly readable on instrument**
- **Develop operational intervention levels (OIL) as part of planning**
- **OIL readable on instruments used**
- **OIL used during emergency to make decisions**
- **IAEA has developed suggested default OILs**
- **Revise defaults during emergency (carefully)**

# Gamma Dose Rate Measurements in Environment

- Most important environmental monitoring
- Easy to measure with simple instrument and little training
- Can use to decide where to:
  - evacuate
  - shelter
  - give thyroid blocking
  - relocate

# Default Gamma Dose Rate OILs

**≥1.0 mSv/h ( 100 mR/h) - Evacuate**

**≥ 0.1 mSv/h (10 mR/h) - Relocate**

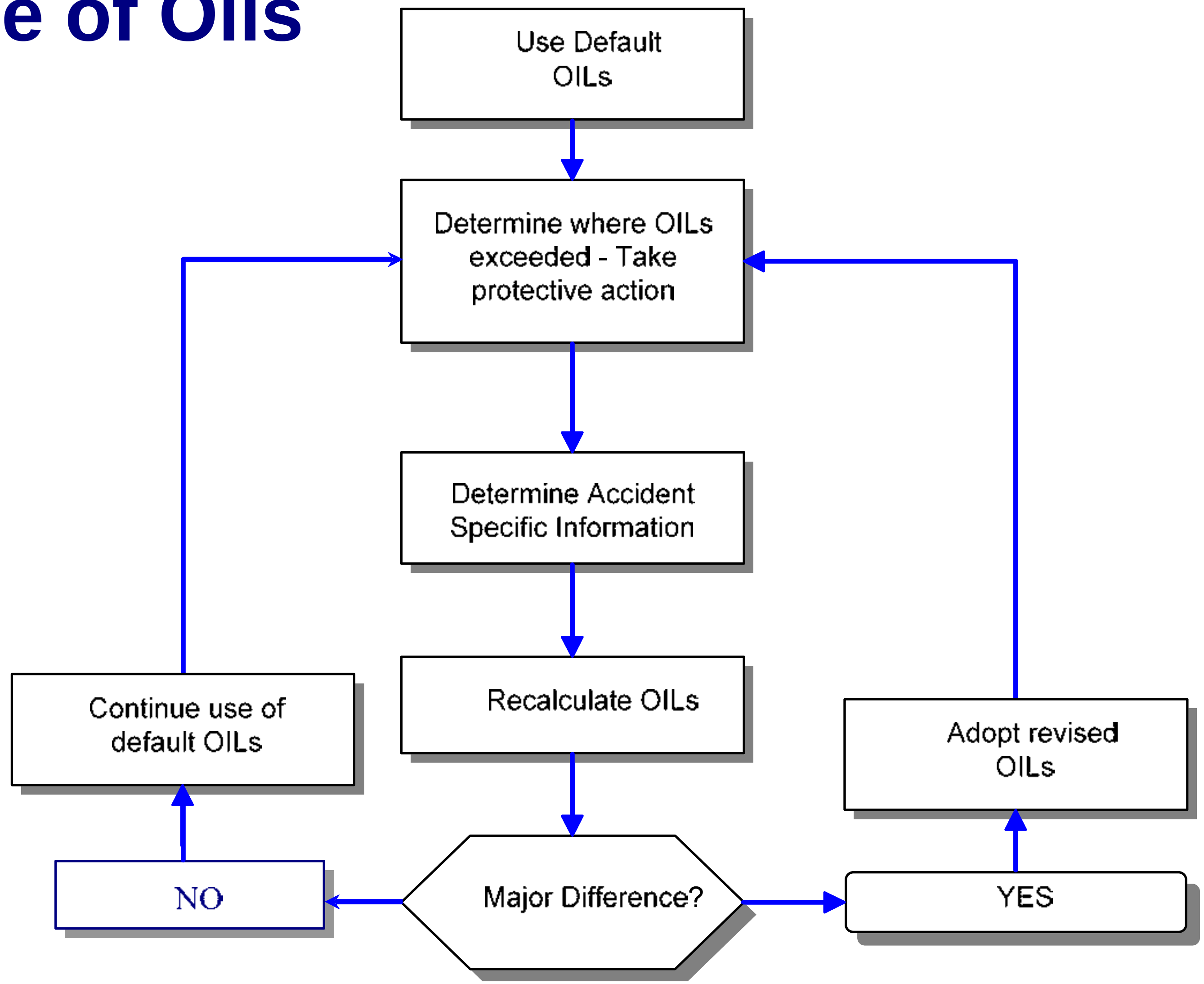
**≥ 1.0 µSv/h (100µR/h) - Restrict local food**
**Thyroid blocking**

**0.1 µSv/h (10µR/h) - Typical Background**

# Operational Intervention Levels

- **Contamination**
  - **Gamma at 10 cm from skin: 1μSv/h**
  - **Beta at 4 cm from skin: 1000 cps**
  - **Alpha at 1.5 cm from skin: 50 cps**
- **Screening food, water, milk**
  - **100 Bq/kg gross beta, or**
  - **5 Bq/kg gross alpha**

# Use of Oils


Use Default
OILs
Determine where OILs
exceeded - Take
protective action
Determine Accident
Specific Information
Recalculate OILs
Continue use of
default OILs
Adopt revised
OILs
NO
Major Difference?
YES

# Emergency Workers

**31 received lethal doses at Chernobyl (early deaths)**

- On-site personnel and off-site fire brigade
- Inhalation, external and skin contamination all important sources of dose
- Did not monitor their dose
- Were unaware of the dose rates where they worked
- Were not trained
- Did not have adequate protective equipment

# Emergency Workers (cont'd)

- Emergency workers of several categories will be or could be exposed to radiation
- Protection of workers should be based on the principles of GSG-2
- There may be that some workers are required to save lives of others
- The workers will most probably be the facility personnel and some first responders

# Emergency Workers (cont'd)

- **Any workers called upon to take emergency action that could approach the thresholds for deterministic effects should be volunteers**
- **The volunteers must be informed of the risks**
- **The emergency workers should be appropriately trained and have knowledge in radiation protection**

## Guidance Values for Limiting Exposure of Emergency Workers

- **Emergency worker exposure guidance, expressed as integrated external gamma dose during :**
  - **Life saving action**
  - **Prevent severe deterministic effects**
  - **Prevent the development of catastrophic conditions**

**<500 mSv**

# Guidance Values for Limiting Exposure of Emergency Workers (Cont'd)

- **Emergency worker exposure guidance, expressed as integrated external gamma dose to :**
  - **Avert a large collective dose**

**<100 mSv**

# Guidance Values for Limiting Exposure of Emergency Workers (Cont'd)

- Emergency worker exposure guidance, expressed as integrated external gamma dose to :
  - longer term recovery operations
  - Work not directly connected with an emergency

  **Occupational exposure guidance**

  **(max of 50 mSv/y, 5 yr average of 20 mSv/y)**

# In Summary
## First Hour of a Severe Reactor Emergency

- **Event detected by control room (0:00)**
- **Classified and emergency is declared (+ 5 min)**
- **Off-site officials notified (+ 15 min)**
- **Off-site officials decide on action (+ 30 min.)**
- **Sirens sound and the public turns on radio (+45 min)**
- **Radio message advises public to take action (+45 min)**
- **Public starts to take action (+ 60 min)**
- **Near-by countries notified (+60 minutes**
- **Extensive environmental monitoring begun**
- **Additional actions taken at levels consistent with International guidance**

# Where to Get Addition Information

- IAEA GSG-2 for the intervention criteria
- IAEA EPR-METHOD 2003 for general guidance
- IAEA EPR-RESEARCH REACTORS for response procedures for research reactors
- IAEA TECDOC-1092 for technical procedures for monitoring

## Emergency Preparedness and Response

# Instructing, Warning and Informing the Public

### Seminar

# Introduction

- **Communication with the media and the public is an essential part of emergency response preparedness plans**
- **The objectives of this lesson are to present and explain principles and basic ways of communication with the media and the public in an emergency**

# Content

- Why inform the public?
- How to communicate with the public
- Basic communication principles
- Working with the media
  - Media outlets
  - Media operationsThe media interview
  - Media Briefing/Interview Planning Worksheet
  - The press release/news statements
- Benefits of good media communications
- Summary

# Background

- People fear what they don’t understand
- Few understand radiation, and most distrust authorities
- Honest, accurate, and timely information builds trust

# Effective Communications

- **The importance of effective communications with the media cannot be overlooked**

- **In any significant emergency, media interest will be high**
- **News is a 24 hour activity**

# Why Inform the Public?

- Provide correct information to public
- Ensure the appropriate public response


- Maintain credibility
- Responders can focus on response
- Reduce the psychological impact

# How to Communicate With the Public

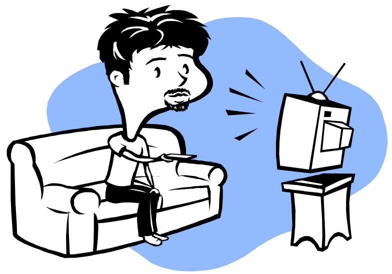
- Directly
  - Through public warning systems
  - Through community spokespersons
  - Through public audiences
- Indirectly
  - Through the media

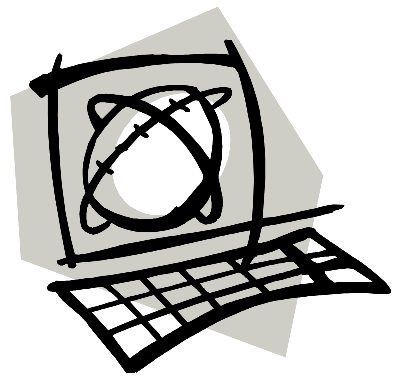
# Public Warning Systems

- Sirens with loud speakers
  - Expensive to build and maintain
  - Impact on real estate
- Direct telephone warning systems
  - Expensive and difficult to maintain
- Mobile loud hailers (Fire trucks, Police)
  - Cheap
  - Not always effective

# Media Communications

- **Like it or not, the media is the most effective way to communicate with the public**



# Working With the Media

**To communicate effectively with the media, you need to understand how the media works!**

# Media Operations

- **Media expectations/needs**
  - **Facts the media wants to know**
    - **Who, what, when , where, why, how?**
  - **Access to Emergency Manager and On-scene Controller near the emergency site**
  - **Production deadlines**

# Golden Rules of Media Relations

- You cannot control the media... Do not try!!
- Integrate the media into the plans
- Educate the media
- Journalists want facts, not public relations
- The media can be a tool to communicate with the public
- Bridge the technical gap
- Designate a single credible spokesperson for each level
- Coordinate media relations through a joint media centre if possible
- Monitor the media and correct rumours

# Golden Rules of Media Relations

- You cannot control the media... Do not try!!
- Bridge the technical gap
- Designate a single credible spokesperson for each level
- Monitor the media and correct rumours

# Fundamental Principles of Communications

- Less can be more
- Have trained communications experts at the executive level
- Communication must be on-going and predictable
- The foundation of trust is openness
- Use terms that are simple and easy to understand

# Communication With the Media and the Public

- When and What Form
  - On-going media effort as part of preparedness program
  - General information leaflets with terms, radiation units, emergency arrangements, and putting risks in perspective
  - Background information on radiation uses and emergency plans for use in media briefings

# Communication With the Media and the Public (Cont'd)

- **Information releases should first of all "Deliver a message"**

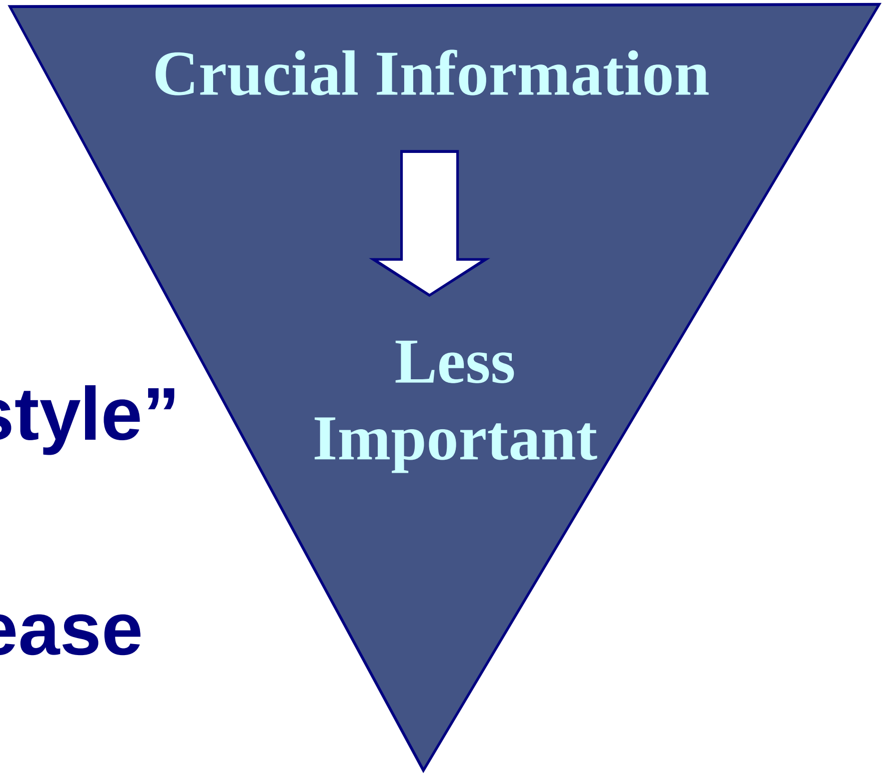
- **Identifying/designating individuals authorized as spokespersons**

# Communications With the Media and the Public (Cont'd)

- Information must be coordinated and approved before release in briefings, interviews, or press releases
- Designated media gathering point
- Joint Information Center and Emergency Public Information Center may be required for large scale accidents

# The Press Release/News Statement

- **Content**
- **Format**
- **"Inverted pyramid style"**
- **When to write a release**

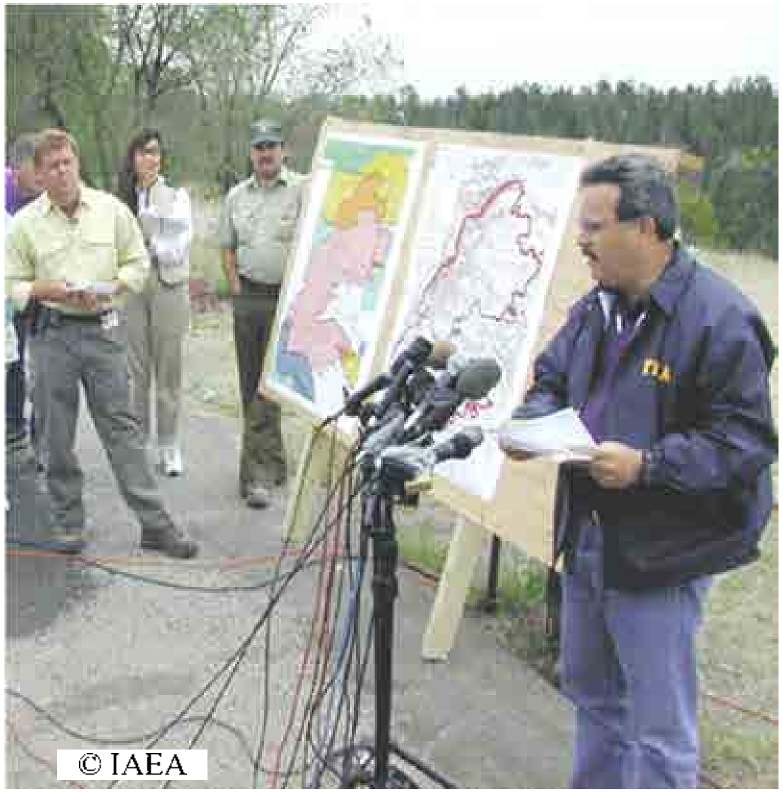


# On-scene Media Operations (Cont'd)

- On-scene Controller must establish media boundaries
- Must not interfere with response operations
- Establish "rules of engagement"
- Monitor the media

# On-scene Media Operations (Cont'd)

- Access to scene
- Designated media area
- "Pool coverage" arrangement
- Information technology
- Visiting dignitaries/officials



# The Media Interview

- Types of interviews
  - Live vs. taped
  - Print
  - Broadcast
  - General vs. investigative
  - Ambush vs. prearranged
  - Office vs. on scene

# Interviews - Unwritten Rules

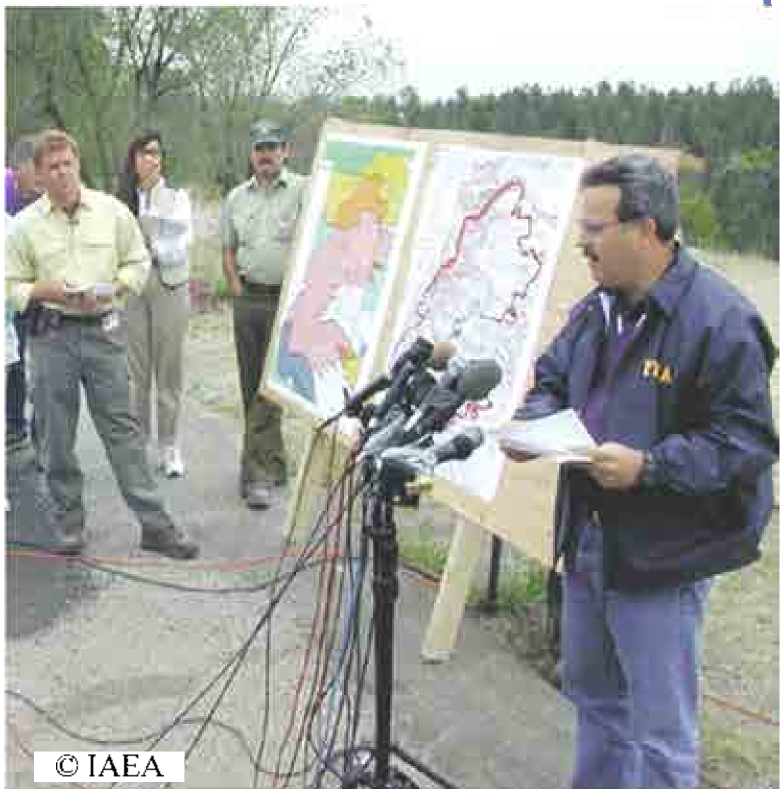
- Every thing you say is on the record
- You are entitled to polite behavior
- Journalists must identify themselves, their employer, and the subject of the interview.
- You can control to a certain extent where the interview takes place
- You should know if others will be present, who they are, and if there will be others interviewed, as well as the interview order.
- You are entitled to know if the interview will be taped, if it will be edited
- If you need an interpreter, bring your own

# General Interview Guidelines

- **Ten rules of communication during an interview**
  - **Be yourself**
  - **Be comfortable and confident**
  - **Be honest**
  - **Be brief**
  - **Be human**
  - **Be personal**
  - **Be prepared, positive, and consistent**
  - **Be attentive**
  - **Be energetic**
  - **Be committed and sincere**

# Media Briefing/interview Planner Worksheet

- **Date/time/place**
- **Audience**
- **Anticipated questions/responses**
- **Opening statement/introduction**




**Be Prepared!**

# Media Briefing / Interview Planner Worksheet

- **Key messages**
- **Supporting facts**
- **Sound bites**
- **Summary statement/conclusion**
- **Visual aids/handouts**

**Be Prepared!**

# Benefits of Good Media Communications

- Response focused on *real* issues as opposed to *perceived* ones
- Better appreciation of the response effort
- Better control over public protective actions
  - Less overreaction
- The emergency will be shorter-lived!

# Summary

- **Communicating with the public is an essential part of emergency response**
- **Use the media to communicate with the public**
- **Know the mass media and work with it**
- **Coordinate media relations**
- **Good media communications will enhance your emergency response**

# Where to Get More Information

- IAEA-TECDOC-1076
- IAEA-EPR-METHOD 2003
- IAEA-EPR-FIRST RESPONDERS 2006
- Your own Media Relations office

IAEA Training Course for Research Reactor Emergency Response

## Emergency Preparedness and Response

# Action Guides and Response Priorities

**Seminar**

# Introduction

- An Emergency Response Team is required to make decisions, to initiate and control response actions and to evaluate information for further actions
- The purpose of this lesson is to present a suitable organization for that Team and discuss the response priorities

# Content

- Emergency Response Team Organization
- Responsibilities of Team members
- Additional Team members
- Priority of response actions
- Suggested timing of response actions
- Summary

# Objectives of Emergency Response

- **Safety objective – protect individuals, society and the environment**
- **Radiation Protection objective - Mitigate the radiological consequences of any emergency**
- **Protection objective - prevent the occurrence of deterministic health effects in individuals and reasonably reduce the risk of stochastic effects**
- **Technical Safety objective – take all reasonably practical measures to prevent accidents and to mitigate their consequences; ensure that for all probable accidents the radiological consequences would be minor**

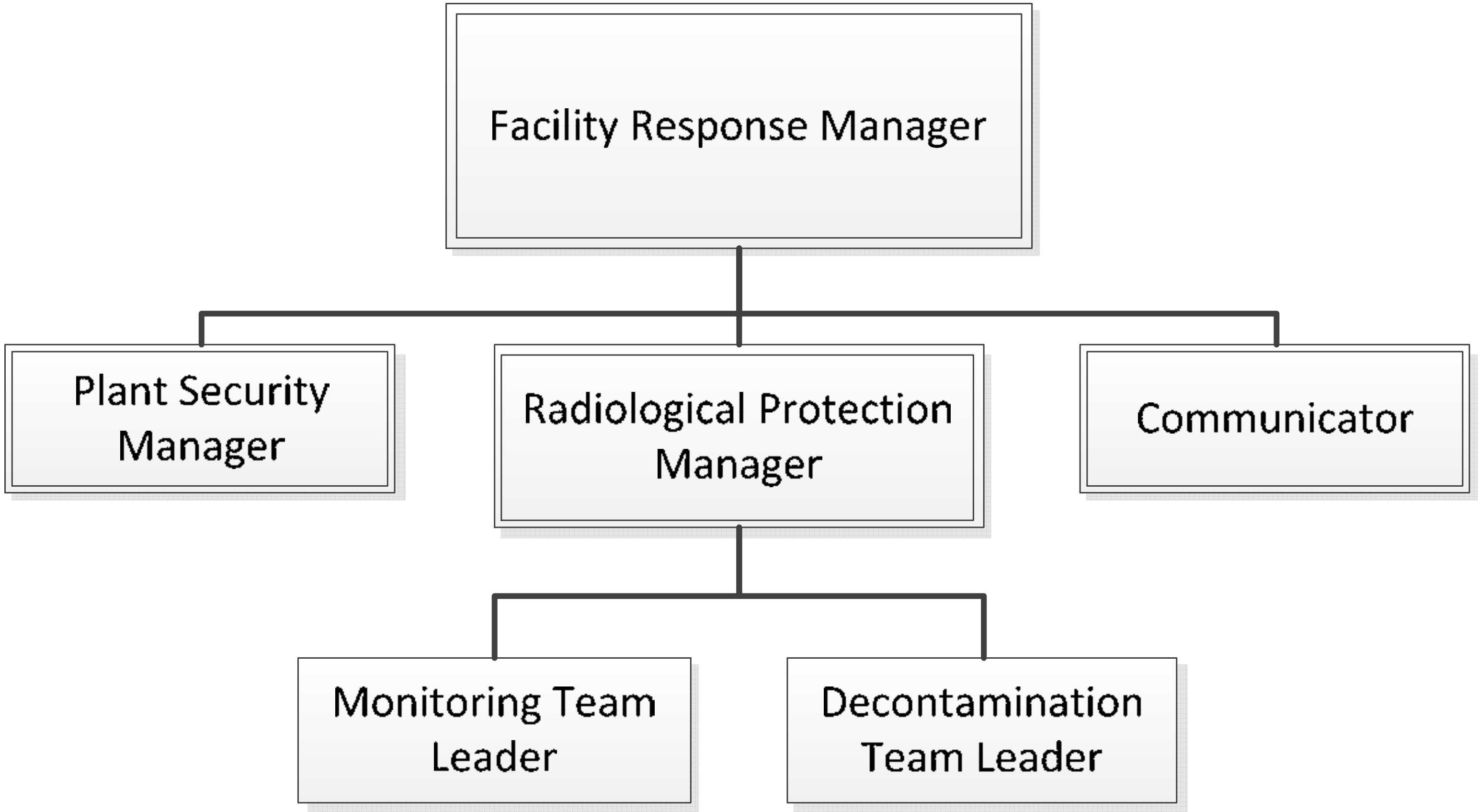
# Radiological Protection Objectives

- Mitigate the emergency at its source
- Reduce the risk of serious deterministic health effects (deaths)
  - Keep acute dose below health effects threshold
- Reasonably reduce the risk of stochastic effects (cancers)
  - Do more good than harm
  - Act according to international guidance

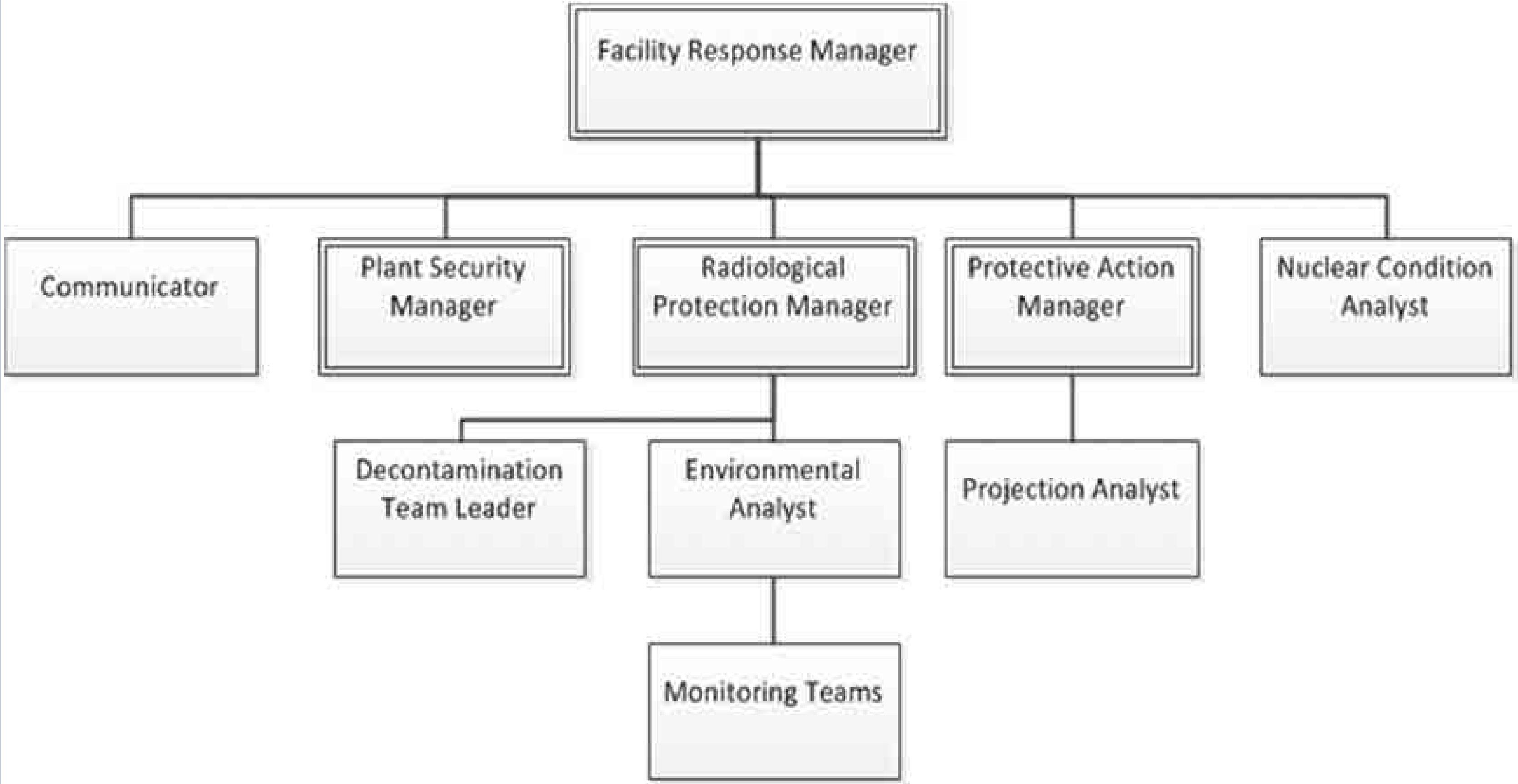
# EPR-RESEARCH REACTOR Provides

- Action Guides for emergency team
  - Recognize, Classify, Notify, Mitigate Consequences
- Decision model for classification
- Information Tables
- Data organizing tools (worksheets)
- Some additional information
  - Public statements
  - Other Emergency Plan elements
  - Minimum equipment

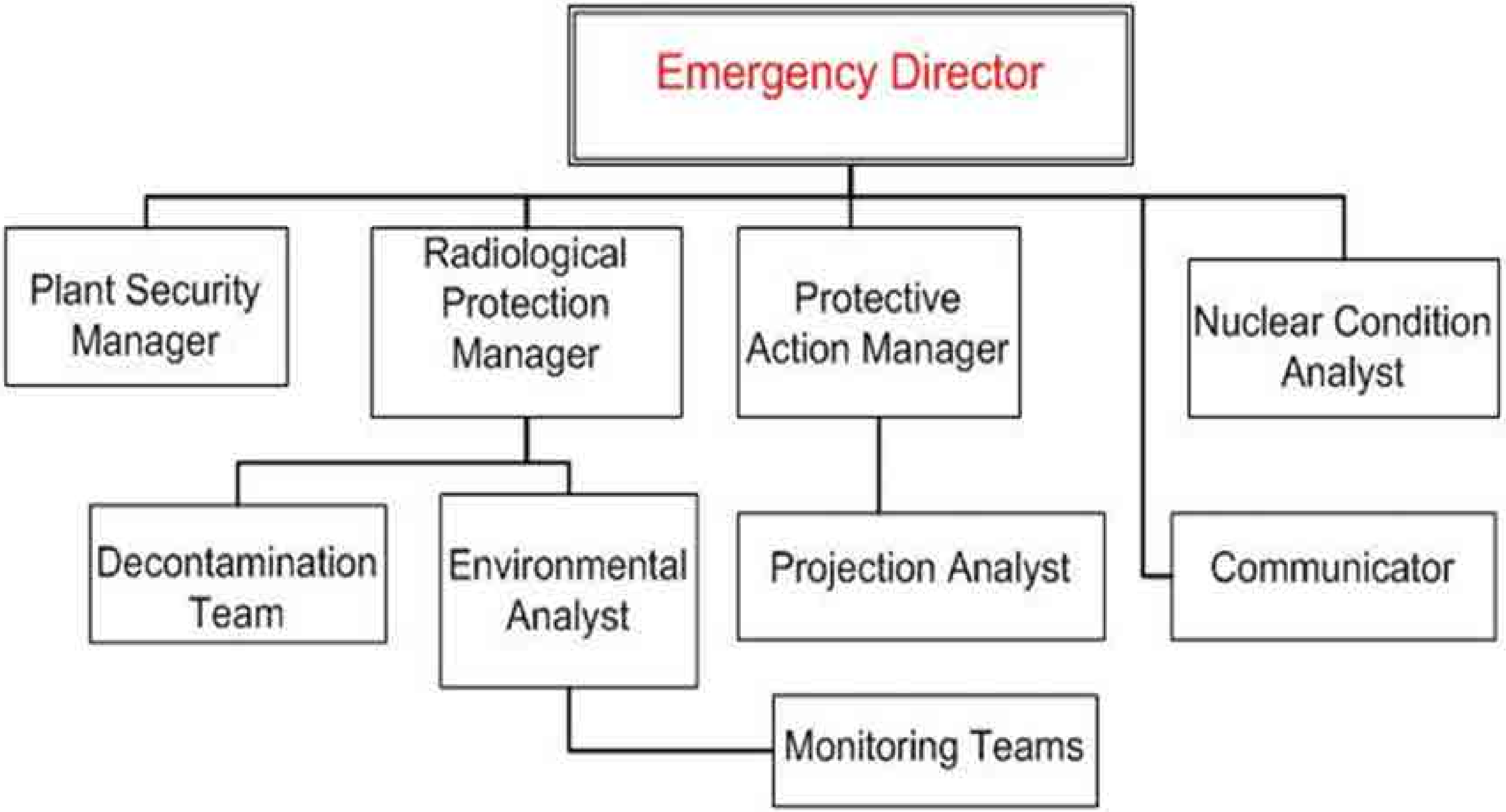
# Emergency Response Team for Threat Category III



# Emergency Response Team (ERT) for Threat Category II



# Emergency Response Team (ERT) for Threat Category II



# Facility Response Manager

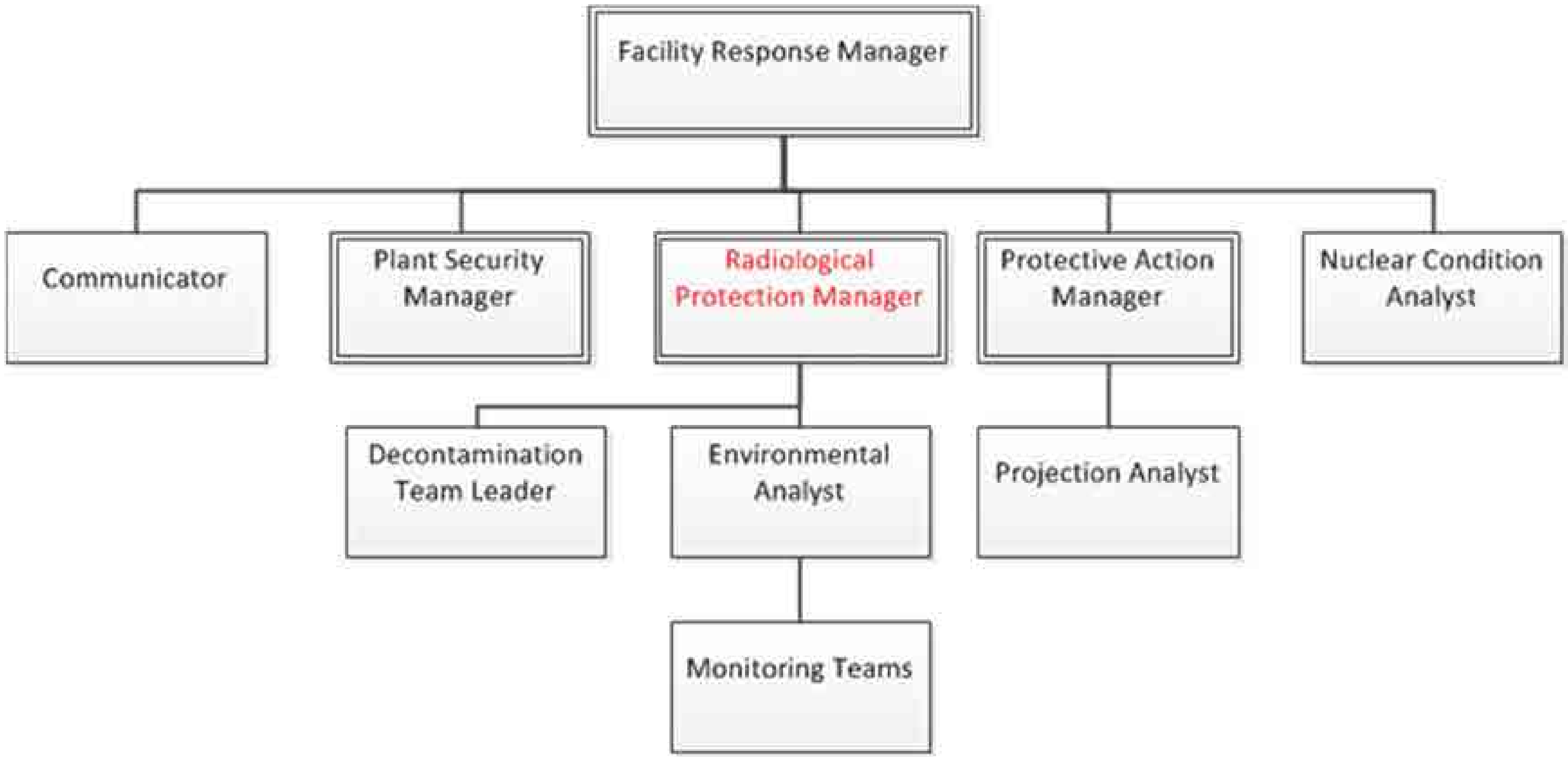
- **Leads the response team and carries the overall responsibility for the response**
- **Specifically responsible for:**
  - **Concurring with the emergency class**
  - **Approving off-site notifications**
  - **Approving news releases**
  - **Confirming all individuals accounted for and medical treatment initiated**

# Emergency Response Team (ERT) for Threat Category II

# Plant Security Manager

- Coordinates Security Plan actions with the emergency response
- Controls access to and from the site
- Coordinates with local security organizations if their response is needed

# Emergency Response Team (ERT) for Threat Category II



# Radiological Protection Manager

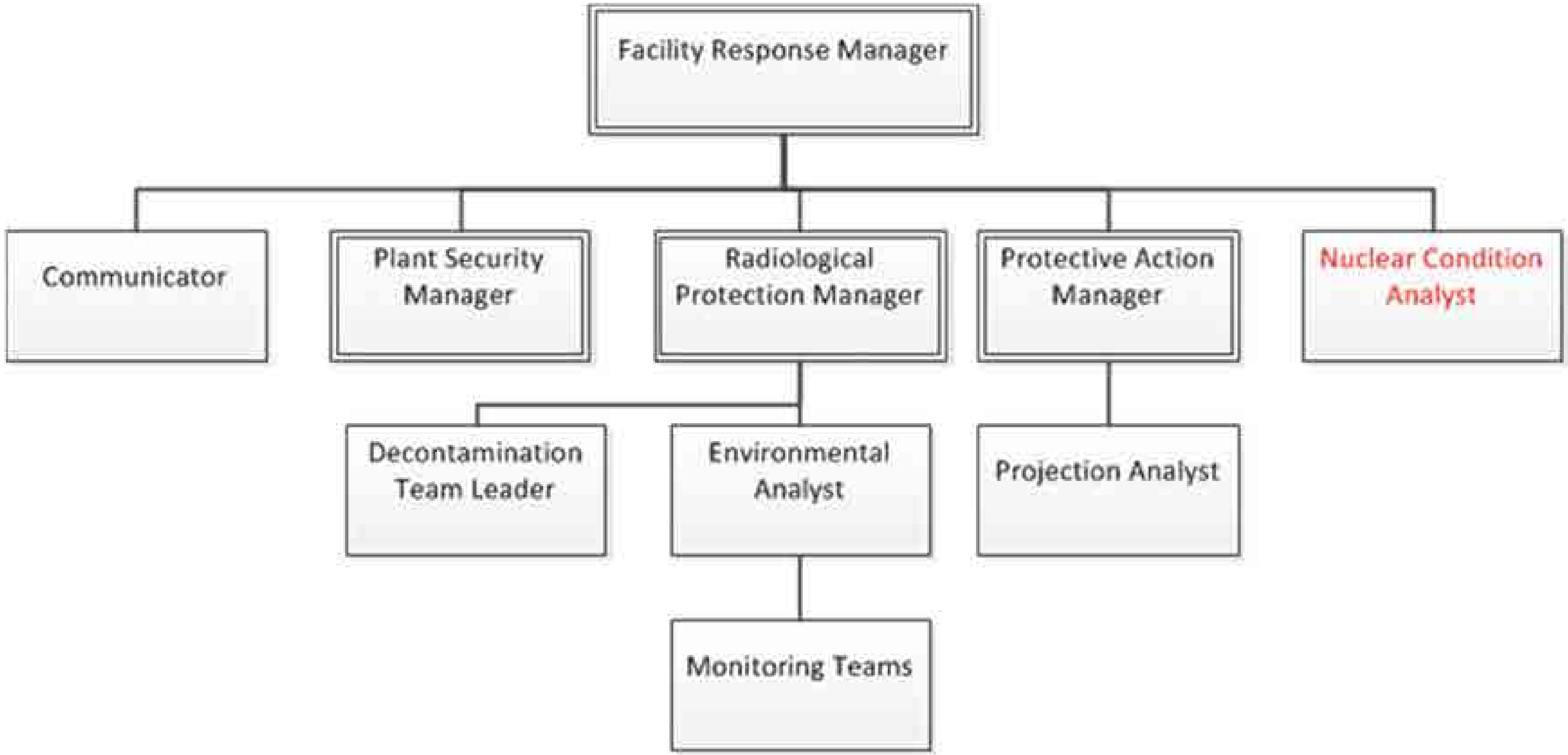
- Prepare a monitoring plan to determine the scope of the radiological threats
- Assess environmental monitoring results and advise when OILs are exceeded
- Determine need for medical assistance from off-site
- Authorizes exceeding occupational exposure limits
- Authorize departures from the facility

# Emergency Response Team (ERT) for Threat Category II

# Protective Action Manager

- Recommends urgent and long-term protective actions
  - based on emergency class
  - based on environmental monitoring data
- Recommends revised OILs when appropriate
- Proposes changes to the environmental monitoring plan

# Emergency Response Team (ERT) for Threat Category II



# Nuclear Condition Analyst

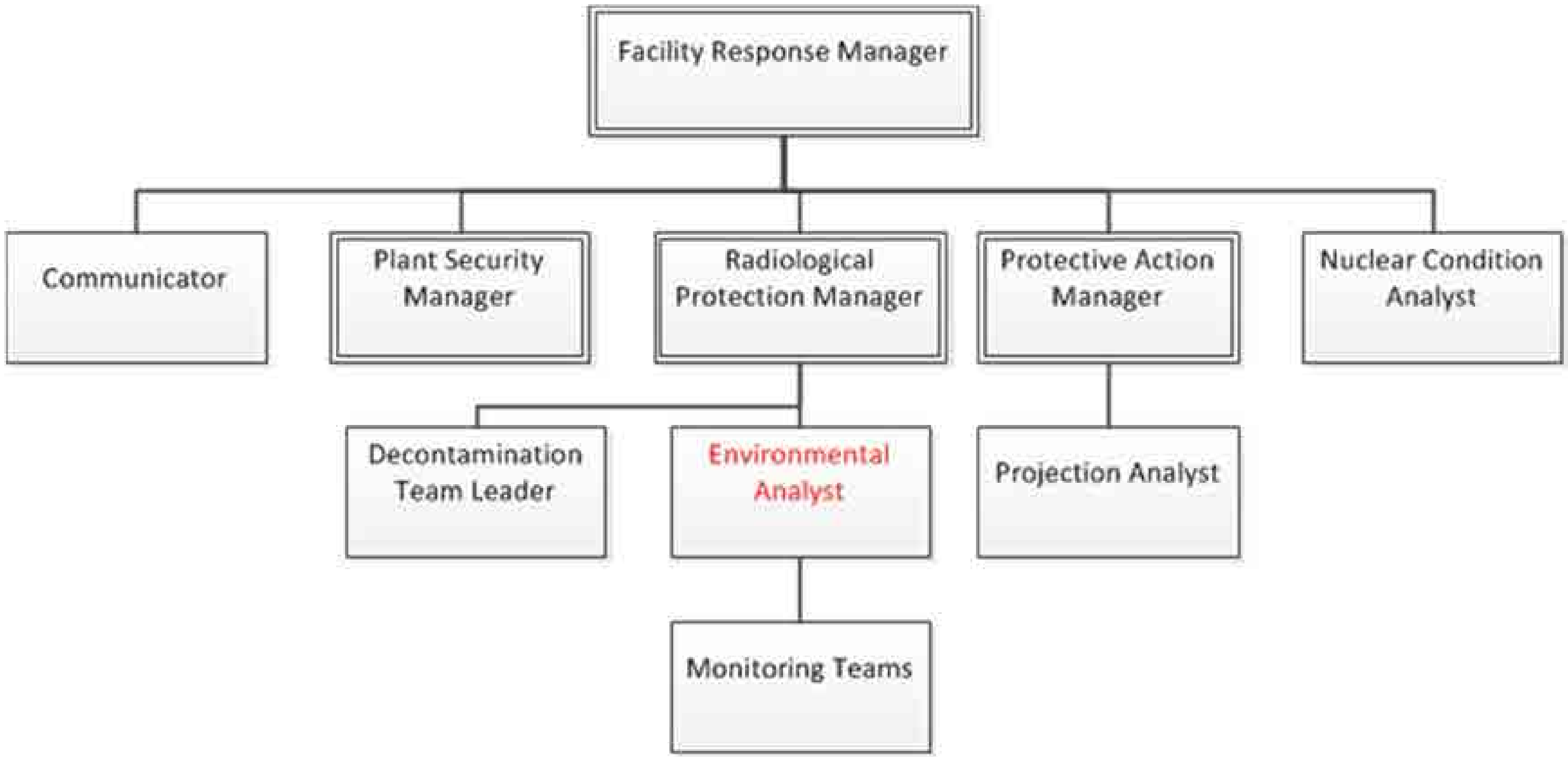
- Determines emergency class using the classification table
- Monitors reactor and facility condition to verify no change to emergency class
- Facility technical advisor to the Facility Response Manager
- At larger reactors could be a team of several technical experts

# Emergency Response Team (ERT) for Threat Category II

# Communicator

- Notifies on-site and off-site of the emergency with Facility Response Manager approval
- Prepares news releases for Facility Response Manager approval
- Maintains communication with off-site
- Contacts off duty personnel for additional personnel resources

# Emergency Response Team (ERT) for Threat Category II



# Environmental Analyst

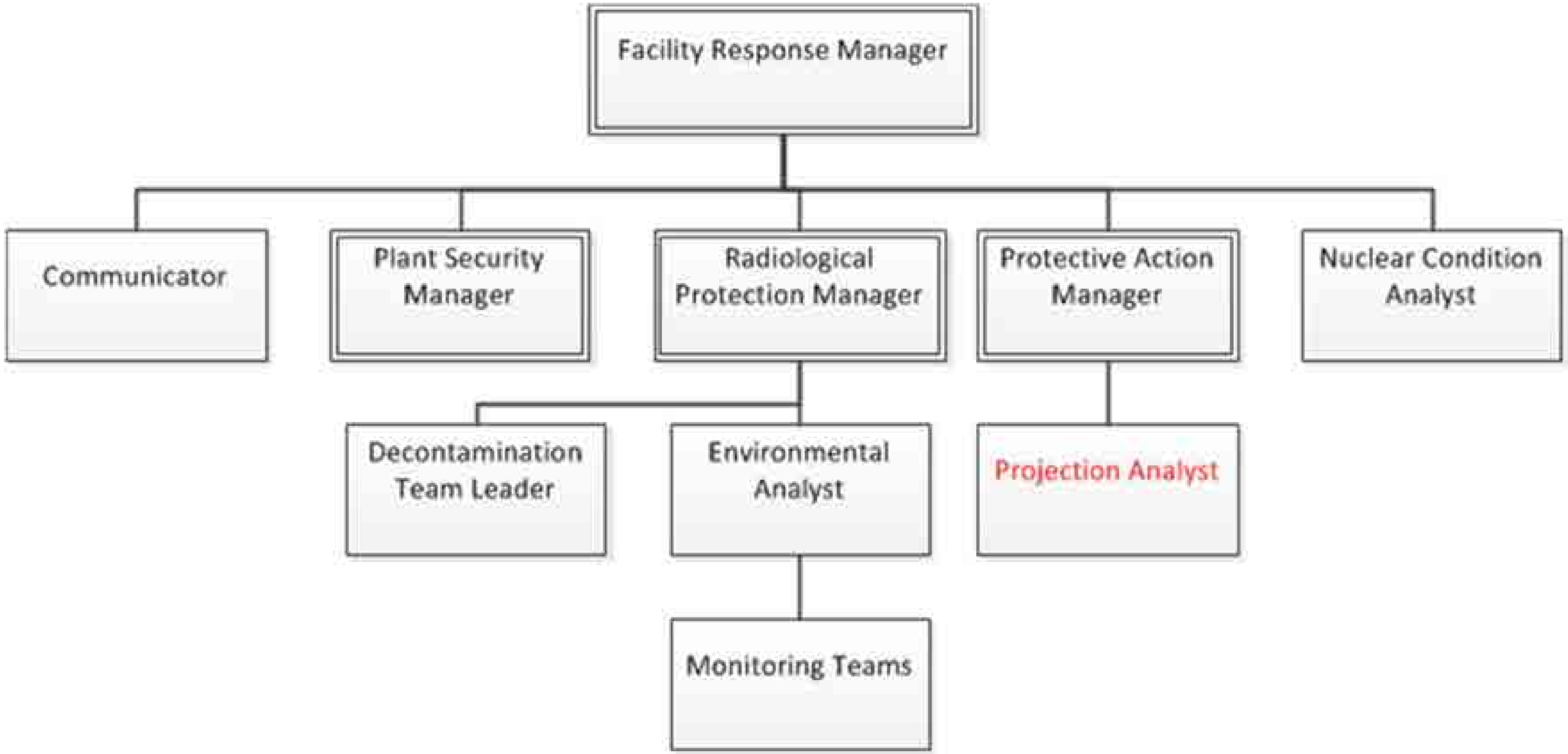
- **Implements the environmental monitoring plan**
- **Reports environmental monitoring results**
- **Suggests revisions to the environmental monitoring plan**
- **Ensures Monitoring Teams are properly equipped and protected**

# Emergency Response Team (ERT) for Threat Category II

# Decontamination Team Leader

- Assess contamination and injuries to site personnel
- Assess contaminated areas on the site
- Decontaminates where required
- May provide escort of contaminated and injured individuals to hospital

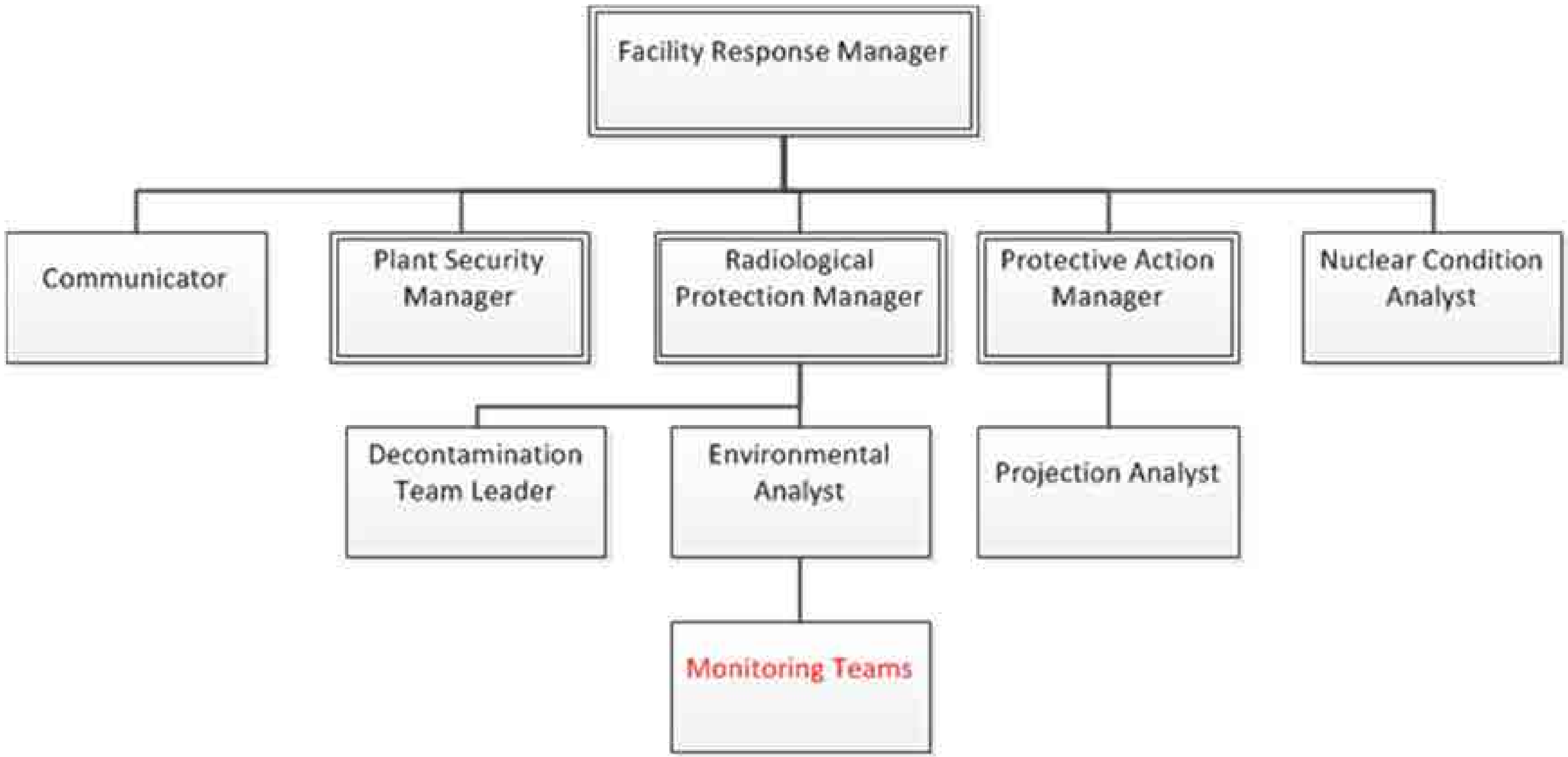
# Emergency Response Team (ERT) for Threat Category II



# Projection Analyst

- Reviews environmental monitoring results and projects to more distant sectors
- Recommends additional monitoring based on projections
- May use computer models to assist the projections
- Evaluates if default OILs could be revised

# Emergency Response Team (ERT) for Threat Category II



# Monitoring Teams

- Performs environmental monitoring
- Alerts the facility when OILs exceeded
- Monitoring could include different types of teams
  - Deposition sampling
  - Airborne sampling
  - Vegetation sampling

# Additional Response Team Positions

- Incident Commander – controls off-site responders such as fire brigade
- Logistics – extended response, arranges for additional supplies
- Safety Manager
- Others, as the facility determines

# Immediate Actions

- Recognition of an emergency causes two different sets of response actions
  - Reactor operating staff initiates the appropriate Emergency Operating Procedure
  - Emergency Response Team initiates the appropriate emergency response procedures

# Immediate Actions – Emergency Response

- **IAEA standards: always a person at the facility:**
  - **able and authorized to classify the emergency without consultation,**
  - **able and authorized to notify the appropriate off-site notification point, and**
  - **able to provide sufficient information for an effective off-site response**

# Emergency Response Priorities

- Classify the emergency – within 15 minutes of recognition
- Notify on-site personnel and facility management– within 15 minutes of classification
- Notify off-site authorities – within 15 minutes of classification for SAE and GE, within 1 hour for A or FE
- Recommend on-site protective actions – complete within 60 minutes after classification

# Emergency Response Priorities (cont.)

- Activate on-site Emergency Response Team – complete within 2 hours
- Obtain support of off-site emergency services – expected within 30 minutes after classification, or as need is identified
- Develop environmental monitoring plan – within 30 minutes after classification
- Deploy on-site environmental monitoring teams – within 30 minutes after classification, complete within 1 hour

# Emergency Response Priorities (cont.)

- **Recommend off-site urgent protective actions – within 30 minutes after classification, if required**
- **Initiate off-site environmental monitoring – within 1 hour after classification**
- **Assess environmental monitoring results and revise monitoring plan**
- **Review urgent protective actions – as monitoring data becomes available**

# Emergency Response Priorities (cont.)

- **Project off-site radiological consequences – commence within 1 hour of obtaining on-site environmental monitoring data**

# Summary

- Responsibilities of the Emergency Response Team
- Suggested response team organization
- Response priorities
- Questions and further discussion?

# Additional Information

- **IAEA EPR-RESEARCH REACTOR**
- **IAEA EPR-FIRST RESPONDERS 2006**
- **IAEA EPR-METHOD 2003**

**IAEA Training Course for Research Reactor Emergency Response**

# Emergency Preparedness and Response

# Medical Management Overview

## Seminar

# Introduction

- **Objectives of the emergency response:**
  - **To reduce the risk or mitigate the consequences of the emergency at its source**
  - **To prevent or reduce deterministic health effects**
  - **Reasonably reduce the risk of stochastic effects**

# Objectives of Emergency Medical Preparedness and Response

- To perform treatment of life threatening injuries
- To implement actions needed to meet general objectives of emergency response
- To participate in training, drills, and exercises to update and enhance basic knowledge and skills necessary to meet general objectives of emergency response

# Fact

**Each member of emergency response organization needs to understand the basics of radiology to meet the objectives efficiently**

# Content

- Ionising radiation and human
- Health effects of radiation: description, examples
- Medical aspects of radiological accidents
- Psychological aspects of radiological accidents
- Medical response as a part of the overall emergency preparedness and response
- Infrastructure and functional requirements for medical preparedness
- Summary

# Overview

**Radiation causes ionisation of:**

**ATOMS**

**which will affect**

**MOLECULES**

**which may affect**

**CELLS**

**which may affect**

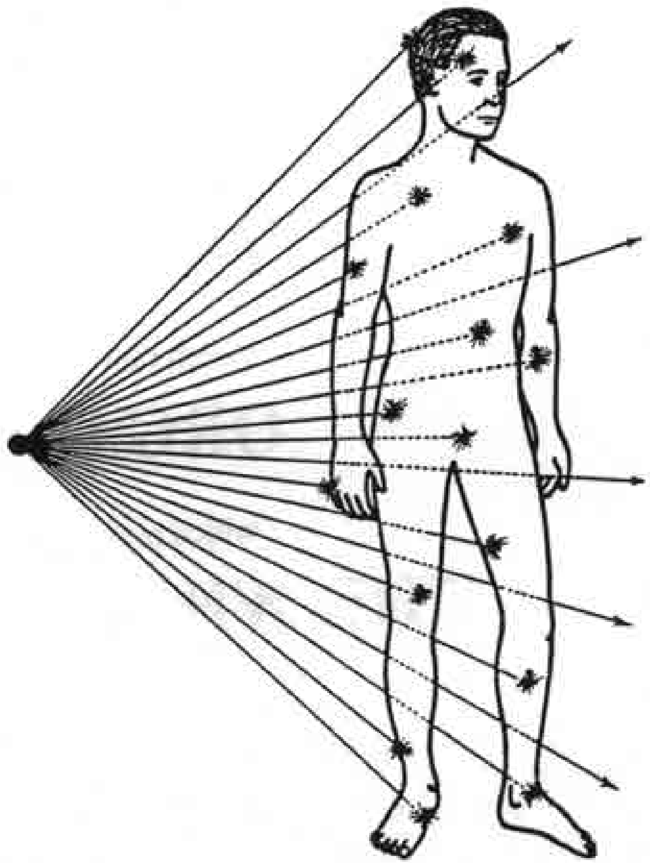
**TISSUES**

**which may affect**

**ORGANS**

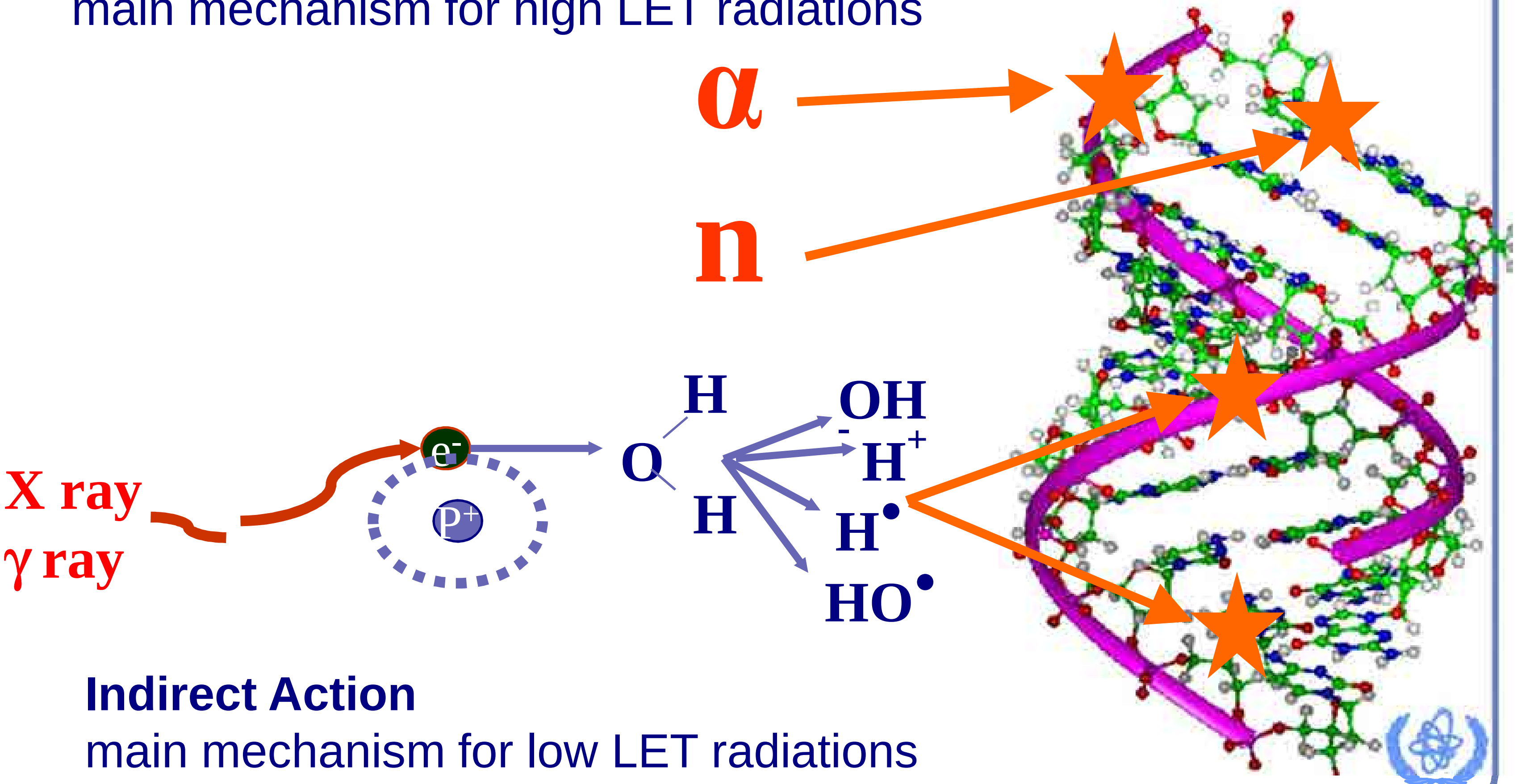
**which may affect**

**THE WHOLE BODY**



# Direct and Indirect Action of Ionising Radiation on DNA

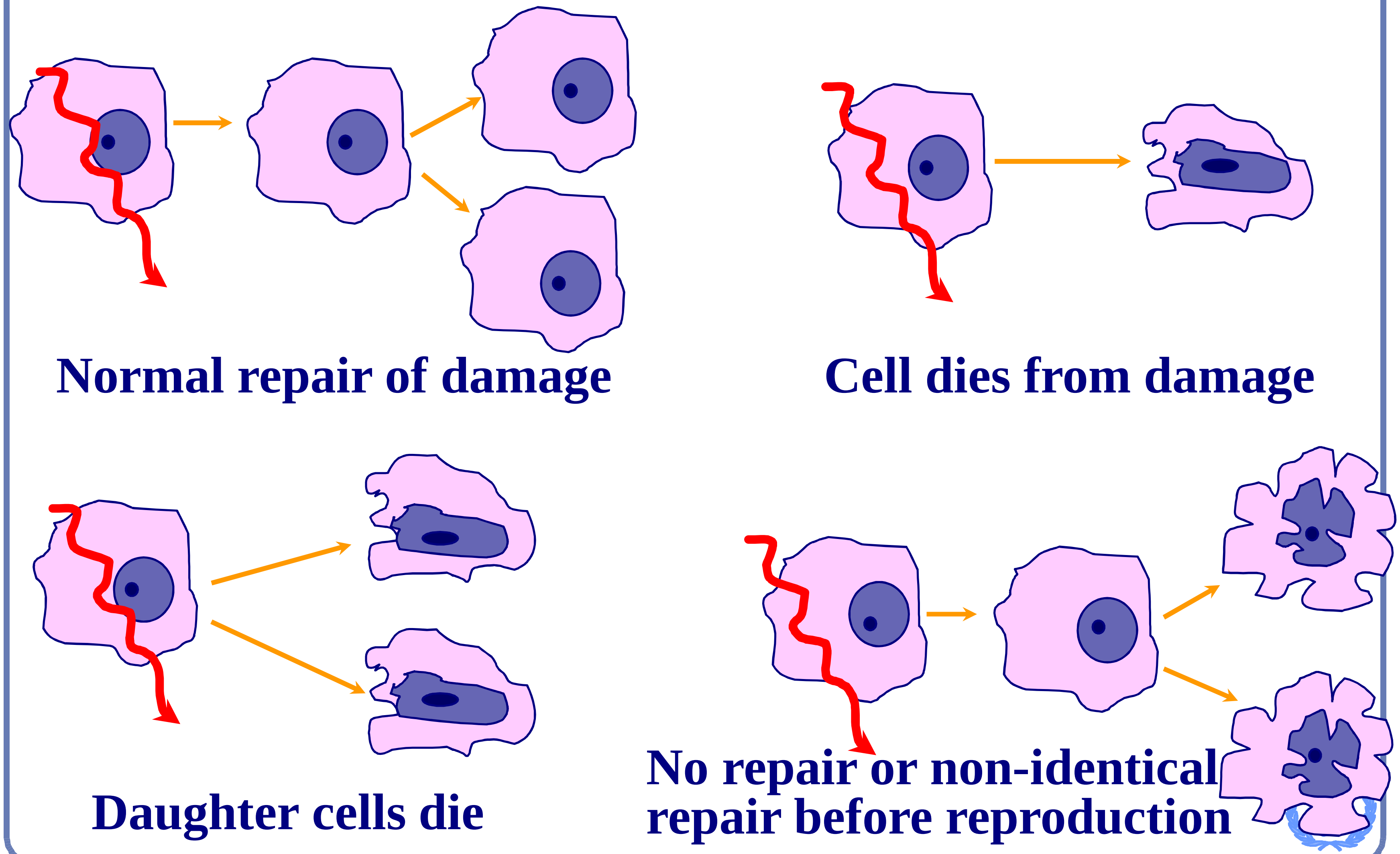
**Direct Action**
main mechanism for high LET radiations




**Indirect Action**
main mechanism for low LET radiations

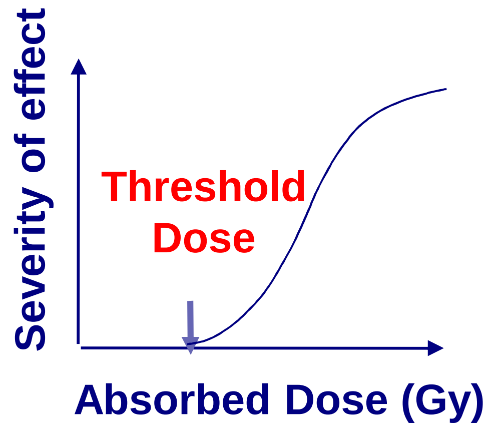
# Ionising Radiation and Human

## Cellular Level



# Ionising Radiation and Human
## Deterministic Effects

- **A cell that has been hit may destroy itself or may be destroyed while dividing**
- **Cell killing is not equal to health effect**
- **Only massive cell killing leads to health effects**
- **Massive cell killing can occur only after high doses**
- **These are called deterministic effects**



# Deterministic Health Effects

## Description, Examples

- **Early appearance (days to weeks, excl. cataract)**
- **Existence of dose threshold, specific for particular effect**
- **Below dose thresholds - no effect**
- **Above threshold the severity depends on level of radiation dose**


# Deterministic Health Effects
## Description, Examples (cont'd)

- Dose response curve is sigmoid
- At high dose and dose rates
  - Dose rate has a profound influence on effects
- Some deterministic effects have characteristics that distinguish them from similar effects due to other causes, which may help to identify the affected individuals
- The occurrence of the initial event has sometimes been detected by the unexpected appearance of deterministic effects
- Need specialized treatment

# Deterministic Health Effects

## Threshold of Occurrence

| Organ or tissue | Dose in less than 2 days [Gy] | Deterministic effects | |
|---|---|---|---|
| | | Type of effect | Time of occurrence |
| Whole body (bone marrow) | 1* | Death | 1 – 2 months |
| Skin | 3 | Erythema | 1 – 3 weeks |
| Thyroid | 5 | Hypothyroidism | 1st – several years |
| Lens of the eye | 2 | Cataract | 6 months - several years |
| Gonads | 3 | Permanent sterility | weeks |
| Foetus | 0.1 | Birth defects | - |

* Without medical care

# Deterministic Effects After Chernobyl

- **Very high doses on-site**
- **134 cases of acute radiation syndrome among responders (fire fighters and recovery operation workers)**
  - **28 died in 1986 from a combination of high external doses of gamma radiation and skin burns due to beta radiation**
  - **17 died in 1987-2004 from various causes, not all linked to radiation**
- **No cases of acute radiation syndrome have been recorded among the general public**

# Ionising Radiation and Human

## Stochastic Effects

- If the cell is not killed but the genome is changed, it may give rise to a mutated cell clone
- From one of these cells through the chain of possible several mutations after many years the first cancer cell can appear
- If any cell, capable of dividing, is hit by radiation, a cancer may arise
- If a gamete is hit and the genome is changed and this particular gamete will start a pregnancy, the child may carry a genetic disease
- Cancer and hereditary effects are the stochastic effects of radiation

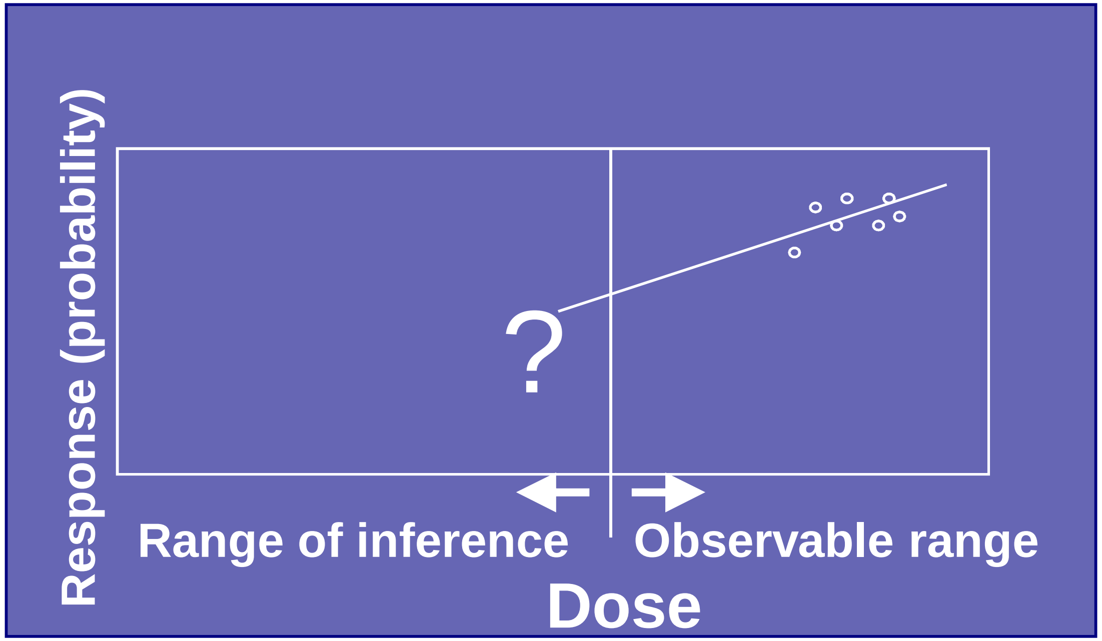
# Stochastic Health Effects

- A radiation-induced health effect, occurring without a threshold level of dose, whose probability is proportional to the dose and whose severity is independent of the dose
- Stochastic health effects:
  - Radiation-induced cancers
  - Hereditary effects
- Late appearance (years)
- Latency period:
  - Several years for cancer
  - Hundreds of years for hereditary effects

# Stochastic Health Effects

## Description, Examples

- Dose response is believed to be more or less linear
- Dose rate may have a slight effects on risk
- Indistinguishable from ‘spontaneous’ cancers
- Seen only in epidemiological studies
- Normal treatment



# Radiation Induced Cancer

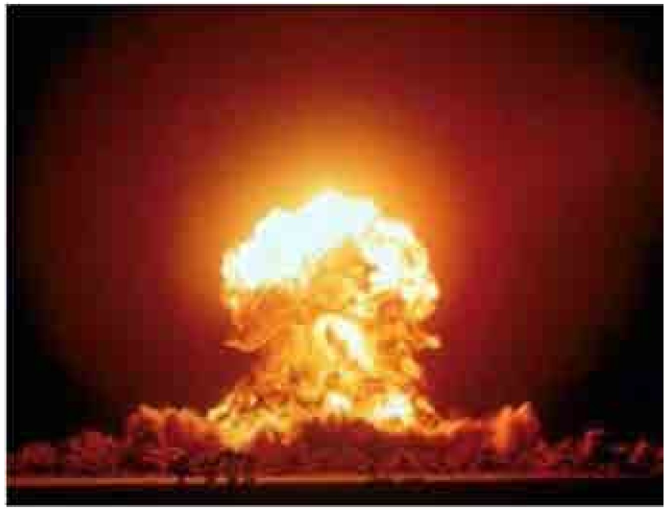
- **Cancer – the main possible health effect of public exposure**
- **Excess risk as a probability of radiation induced cancer**

# Sources of Data on Stochastic Health Effects

- Occupational exposure
  - Early radiologist and medical physicists
  - Radium-dial painters
  - U-miners, nuclear industry workers
- Patients irradiated for medical reasons
- A-bomb survivors
- Overexposure due to nuclear weapons test
- Overexposure due to emergencies

# Life Span Study (LSS) Solid Cancer Mortality

- **47 years of follow-up (1950-1997)**
- **Observed: 9,335 fatal cases of solid cancer**
- **Expected: ~8,895 fatal cases of solid cancer**
  - **i.e. ~440 cancers (5%) attributable to radiation**

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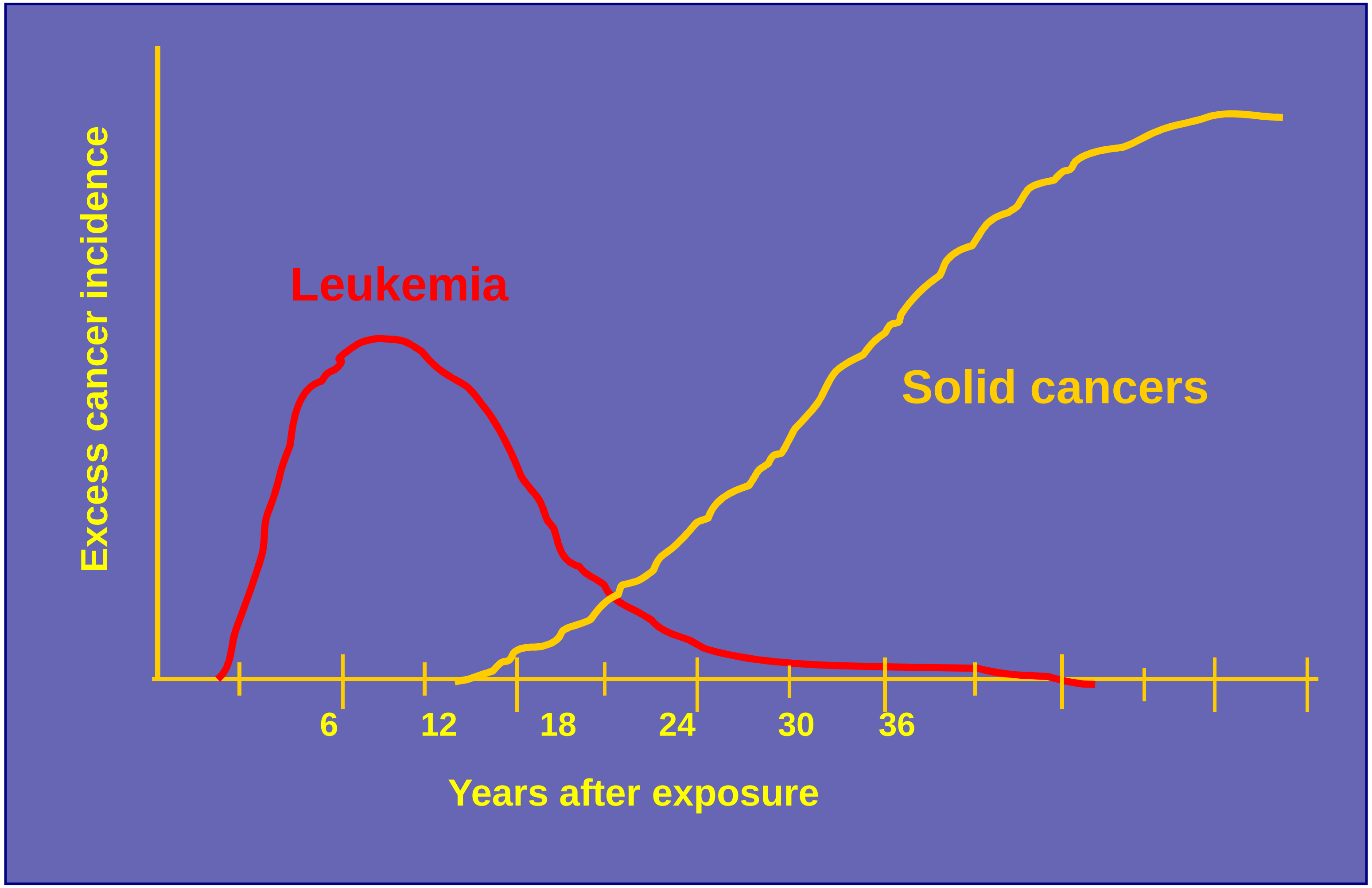
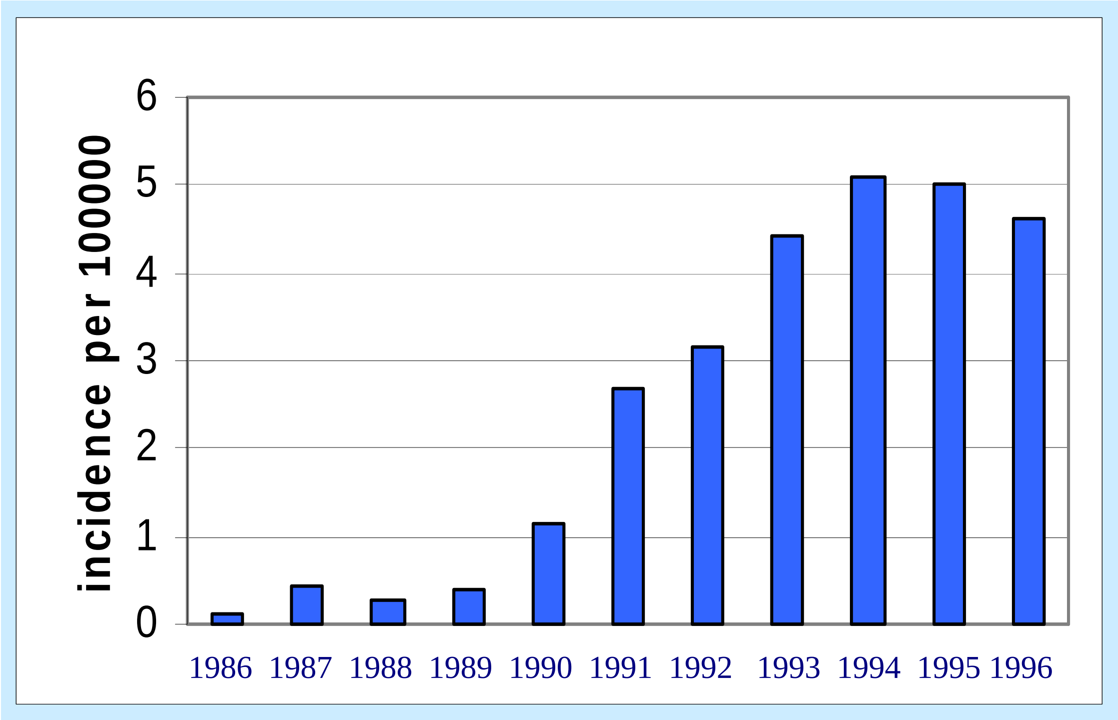
# Excess Cancer Incidence



# Thyroid Cancer Incidence Rate




**Thyroid cancer incidence rate among children of Belarus exposed to radiation due to the Chernobyl accident**

# Risk Coefficients
## Stochastic Effects

- **ICRP: cancer mortality in a whole population exposed at low dose rate**
  - **5.5% per man-Sv**

- **ICRP: risk for genetic diseases in the offspring of an exposed population**
  - **0.2% per man-Sv, all future generations counted together**

# Common Risks

- **Another way of looking at risk, the Relative Risk of 1 in a million chances of dying of common activities in our society**
  - **Smoking 1.4 cigarettes (lung cancer)**
  - **Eating 40 tablespoons of peanut butter**
  - **Spending 2 days in New York City (air pollution)**
  - **Driving 40 miles in a car (accident)**
  - **Flying 2500 miles in a jet (accident)**
  - **Canoeing for 6 minutes**
  - **Receiving 0.10 mSv of radiation (cancer)**

# Medical Aspects

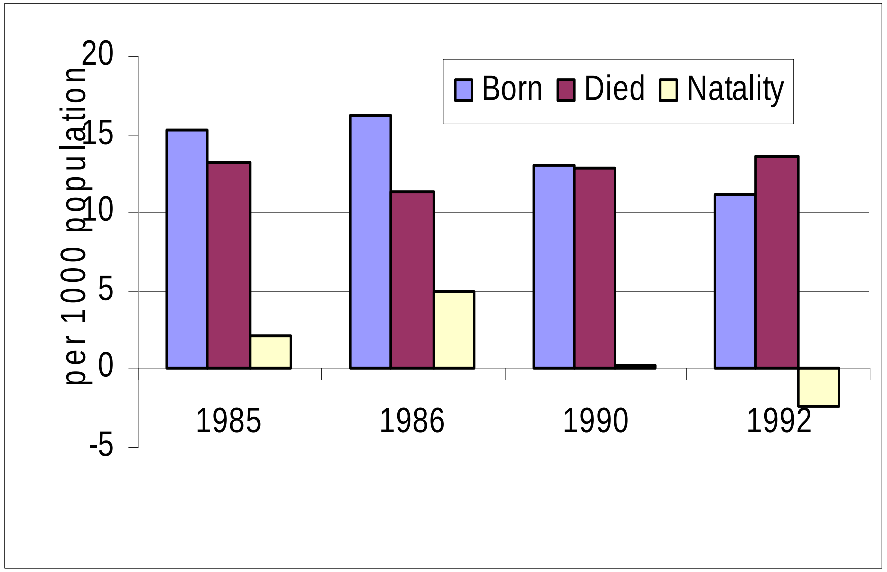
| Accident | Critical organ | Major source of dose |
|---|---|---|
| Reactors (power, research, ship) | Whole body (bone marrow)<br>Skin<br>Thyroid | Gamma<br>Beta<br>Radioiodine |
| Spent reactor fuel storage or reprocessing | Whole body (bone marrow) | Gamma |
| Industrial and medical gamma sources (sealed) | Whole body (bone marrow)<br>Skin | Gamma<br>Gamma |
| Industrial and medical gamma sources (damaged, unsealed) | Whole body (bone marrow)<br>Skin | Gamma<br>Beta |
| Pu - weapons damage or manufacture | Lung | Alpha |

# Medical Consequences

- Public health effects directly related to radiation exposure
  - Deterministic
  - Stochastic
- Public health effects indirectly related to radiation exposure
  - Caused by the emergency
  - Caused by the intervention

# Indirect Health Effects

- **Caused by the accident**
  - **Psychological**
  - **Voluntary abortions**
  - **Demographical Effects**




**Demographic data for region of Russia contaminated due to Chernobyl accident**

# Indirect Health Effects (cont'd)

- **Caused by the intervention**
  - **Psychological**
  - **Consequences of inappropriate medical care**
  - **Consequences of restriction of food products**
  - **Side effects of iodine prophylaxis – very rare**

# Psychological Effects

- Psychological effects do not correlate with real exposure but with subjective perception of risk
- Psychological effects cover
  - Psychic suffering
  - Changes in risk perception
  - Modification in individual and social behavior
- Modification factors:
  - Demographic
  - Perceptual
  - Sociological

# Psychological Effects (Cont'd)

- Major accidents showed that affected people
  - Believe in the threat to their health
  - Doubt what has been reported about emergency and resulted doses
  - Modification in their life style
  - Have somatic complains
  - Increased substance abuse (alcohol, tranquilizers, sleeping pills)

# Psychological Effects (Cont'd)

- Any psychological stress had general health effects
- Stress symptoms
  - Anxiety, depression
  - Disturbed sleep, headache, nausea
  - Loss of appetite, fatigue, apathy
  - Aggression, suicidal acting, drug and alcohol abuse
  - Stress symptoms may mimic somatic disease
  - Diffuse pain anywhere may be due to stress

# How to Reduce Psychological Effects

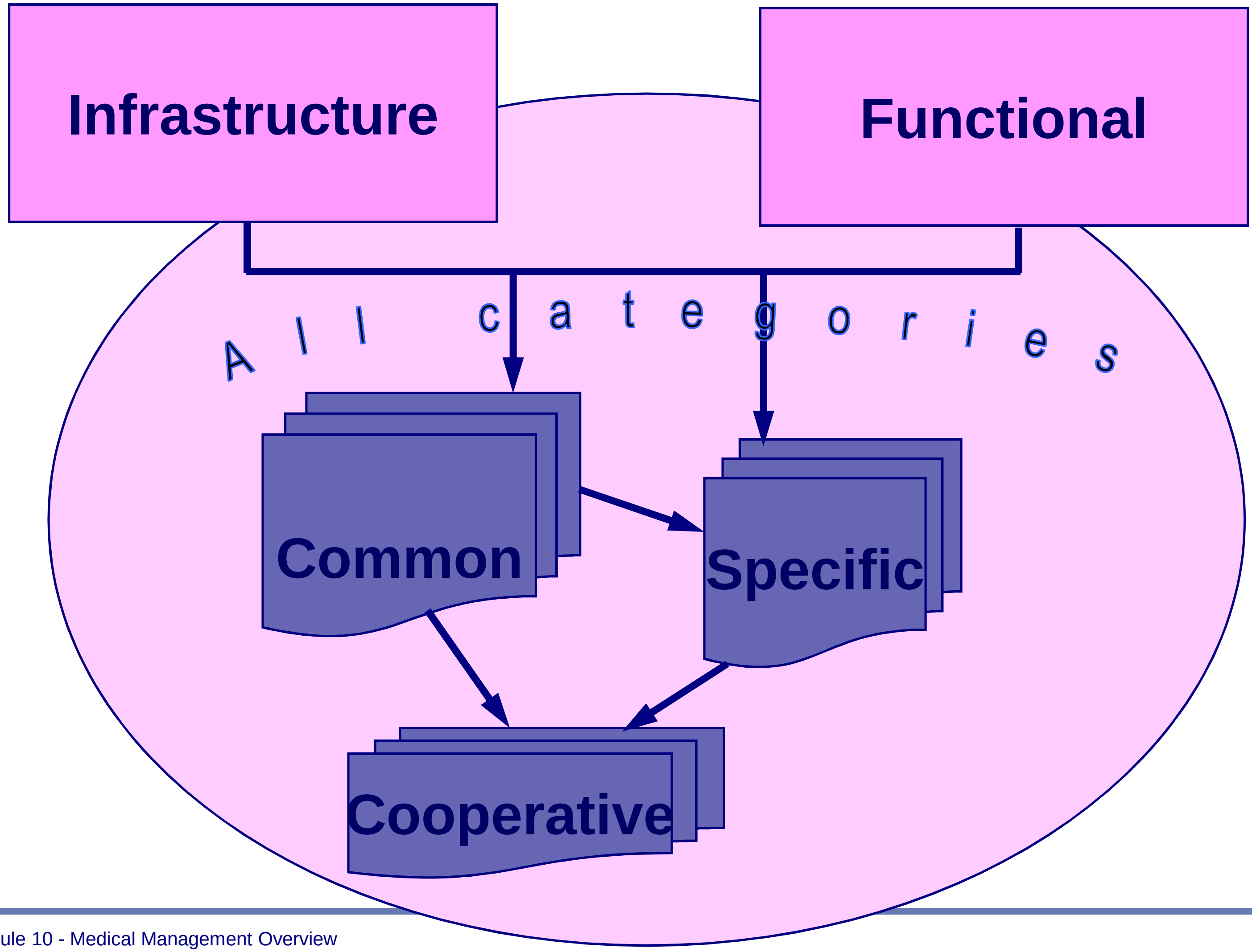
- **Have an ongoing information program**
- **Give clear, simple and timely advice**
- **Consistent advice and assessment (one official point)**
- **Use international guidance**
- **Ensure protective actions are justified**
- **Correct false information**
- **Consider education and counselling**

# Requirements for Medical Preparedness

- **Infrastructure**
  - **Must be in place to ensure that the functional requirements of a response can be performed when needed**

- **Functional**
  - **Should be fulfilled to achieve the response objectives**

# Requirements for Emergency Preparedness and Response



# Requirements (Cont'd)

- Infrastructure
  - Authority
  - Organization
  - Co-ordination
  - Plans and Procedures
  - Logistical Support and Facilities
  - Training, Drills and Exercises
  - Quality Assurance and Program Maintenance

# Requirements (Cont'd)

- Functional
  - Identification, notification and activation
  - Emergency source management
  - Urgent protective actions
  - Issuing instructions and warnings to the public
  - Protection of emergency workers
  - Assessment of the initial phase
  - Management of emergency operations

# Requirements (Cont'd)
## Functional

- Medical management
- Informing the public
- Agricultural countermeasures, countermeasures against ingestion and longer-term protective actions
- Mitigation of non-radiological consequences
- Recovery

# Medical Assistance

- **Provide immediate on-site first aid**
- **Decontamination of injured persons**
- **Transport and initially treat a limited number individuals from the site**
- **Treat highly exposed persons**
- **Treat radiation exposure among the public**

# Summary

- This lecture presented overview of medical management
- The following topics were covered in the lecture: health effect of radiation, direct and indirect effects of radiation exposure, objectives and requirements for emergency medical preparedness and response
- Comments are welcomed

# Where to Get More Information

- UNSCEAR, Sources and Effects of Ionizing Radiation, 2000 Report to the General Assembly with Scientific Annexes, United Nations, New York (2000)
- IAEA EPR-MEDICAL
- IAEA EPR-METHOD 2003
- Medical management of radiological casualties. Handbook. Ed. D. Jarrett., AFRRI, Bethesda, MD, 1999
- Module 11 of the current Workshop

# Emergency Preparedness and Response

# On-scene Emergency Medical Response

## Seminar

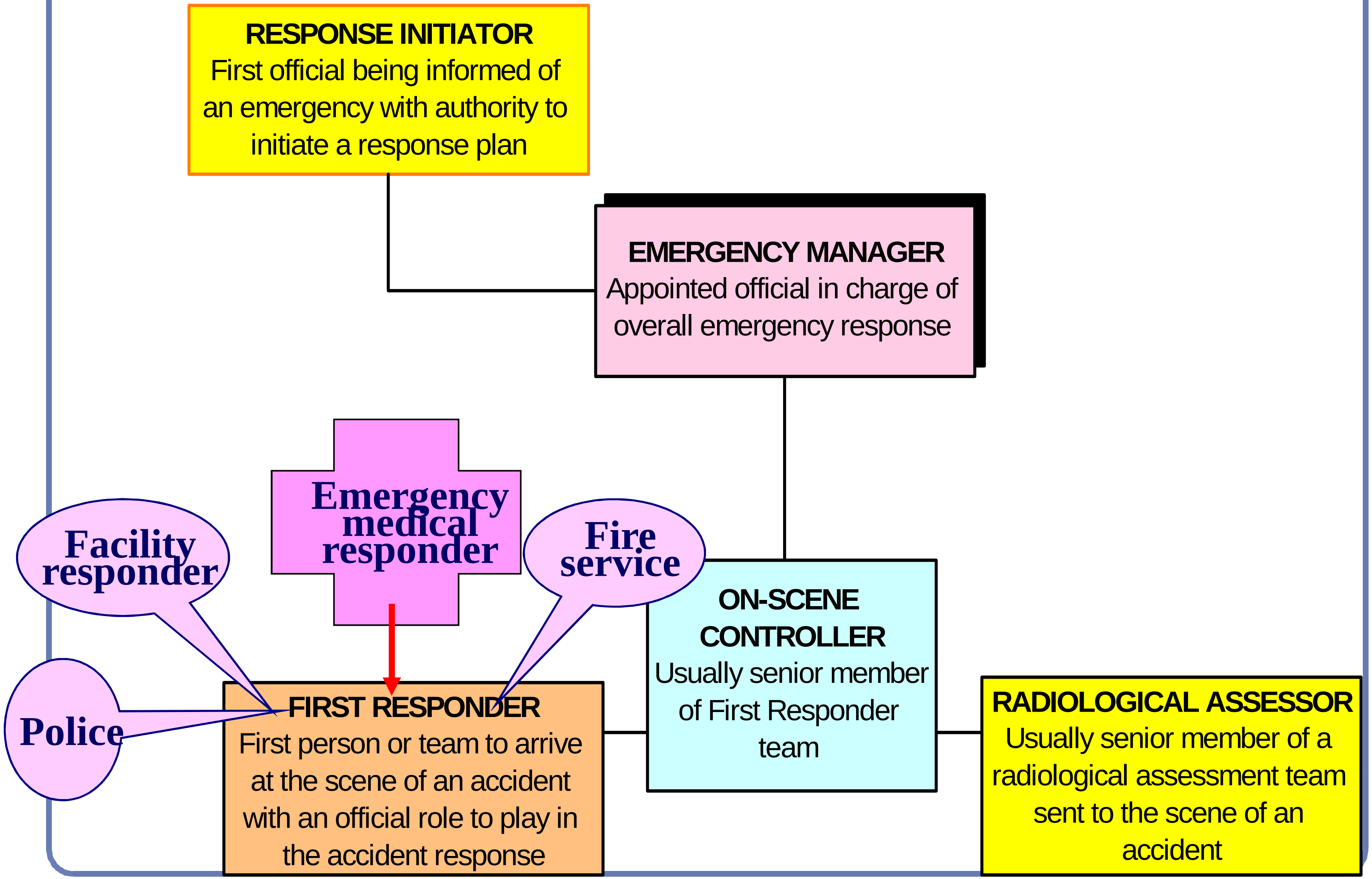
# Introduction

- Basics principles of medical handling of exposed persons can be divided into:
  - General methods of handling
  - Specific methods due to specificity of the possible health effects of radiation and contamination
- Medical handling:
  - On-site
  - Off-site

# Content

- Emergency medical response as a part of the overall response organization
- Role and tasks of the Emergency Medical Responders on scene
- Basic steps for contaminated casualty handling
- Basic steps in decontamination
- Summary

# Generic Response Organisation



# General Rules to On-site Management of Radiation Injures

- **Perform medical triage of injured victims**
- **Give conventional first aid**
- **Perform radiological triage of injured victims**
- **Manage personal contamination**
- **Manage radiation injuries**

# Role and Tasks

## Accept Your Role, Protect Yourself

- **Implement Procedure C4 (IAEA-TECDOC-1162)**
- **Step 1**
  - **If you are first at the scene assume the role of the On-scene Controller until relieved**
  - **If not, get briefing by the On-scene Controller**
- **Step 2:**
  - **If you have personal dosimeters wear them**
  - **Wear protective clothing as required**

# Role and Tasks

## Search and Rescue

- **Step 3**
  - **Perform search and rescue for injured persons as soon as possible**
  - **Assess and treat life-threatening injuries immediately**
  - **Perform routine emergency care during extrication procedures**

# Search and Rescue
## Step 3 (cont'd)

- **Remove injured persons from the hazard area as soon as possible**
- **If necessary, request additional medical help**

# Role and tasks

## Radiological Triage

- **Step 4**
  - **Perform radiological triage and isolate contaminated person(s)**
  - **Remove all contaminated clothing unless medically contraindicated**
  - **Isolate (bag and secure) clothing, shoes, and personal belongings**
  - **Cover wounds with sterile dressings and prepare injured persons for transport to the hospital**
  - **Transport in a manner suitable to prevent further contamination of the patient, the ambulance, and attending personnel**

# Role and Tasks
## Establish Contacts

- **Step 5**
  - **Establish contact with the police to obtain names and addresses of the involved population for further interview(s)**
- **Step 6**
  - **Inform the receiving hospital about the nature of the conventional injuries and any known or suspected exposure or contamination with radioactive materials**
  - **Identify the radioactive materials if known, if not, request help from Radiological Assessor**

# Role and Tasks

## Checking contamination

- **Step 7**
  - **Perform personal and equipment contamination check using procedures in IAEA- TECDOC-1092 or request assistance from the Radiological Assessor**
  - **When the medical conditions do not require urgent hospitalisation DO NOT leave the scene of an emergency without being checked for possible personal contamination**

# Step 7 (Cont'd)

- **DO NOT take any equipment out of the scene area prior to being checked for possible contamination**
- **If you have to leave the scene urgently then contamination control procedures should be performed as soon as reasonable**

# Life Saving and First Aid
## Other Response Teams

- **If persons involved in the emergency appear to be injured, use standard methods for medical first aid**

**DO NOT DELAY LIFE SAVING ACTIONS DUE TO THE PRESENCE OF RADIATION!**

  - **Remove the injured persons from the hazard area as soon as possible**
  - **Notify Emergency Medical Responders and inform them that the victim may be contaminated with radioactive material**

# Radioactive Contamination

- Radioactive contamination – radioactive materials (gases, liquids, solids) released into the environment
  - Contamination of environment
  - Contamination of objects
  - Contamination of people – personal contamination
- Personal contamination can be
  - External
  - Internal
  - Combined

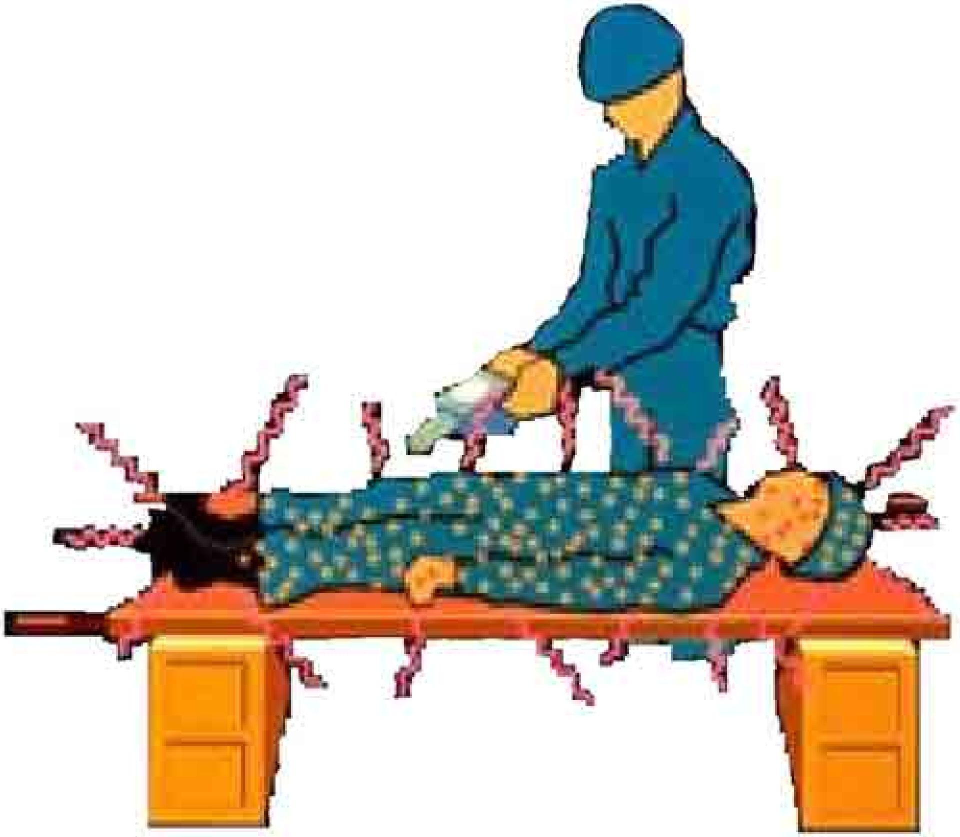
# Contamination of the Victims

## General Consideration

- Severe external contamination unlikely in the public
- Slight contamination may be widespread
- Fear of contamination could be widespread even more
- Most people are less contaminated than they fear

# Radiological Triage
## Frisking Technique

# Radiological Survey of the Injured Person on the Stretcher



# Operational Intervention Levels

## Skin and Clothing

| Contaminant | OIL |
|---|---|
| General gamma emitters<br>Beta emitters | 1 μSv/h or<br>1000 cps |
| Alpha emitters | 50 cps |

**Trying to measure these levels will take several minutes with a typical hand held probe. In case of urgency multiply the levels by a factor of 10 backing this up by instructions to change clothing for known clean kit followed by hand washing and washing of hair**

# Decontamination Procedures

- **Life saving measures first**
- **Use warm water, soap, or ordinary detergent, soft brush, plastic sheet, tape towel, sheet**
- **Remove entire clothing and place in plastic bag**
- **Identify contaminated areas, mark clearly, and cover until decontamination takes place**
- **Start decontamination from the wound, when present, and move on to the highest contaminated areas**

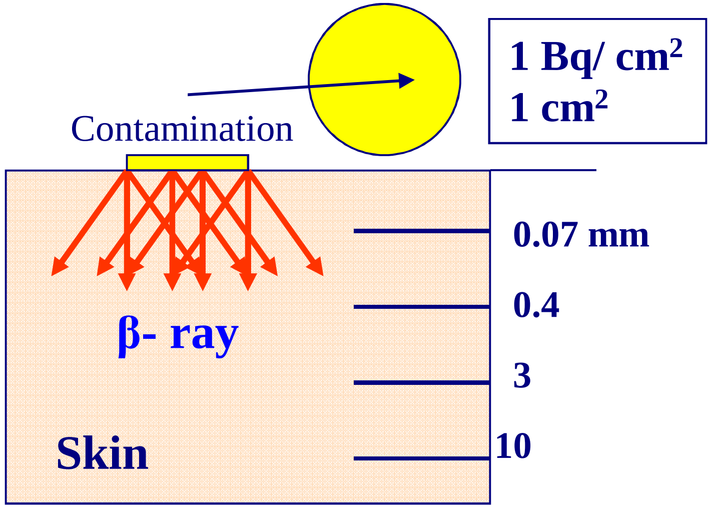
# Medical management
## Contaminated Victims

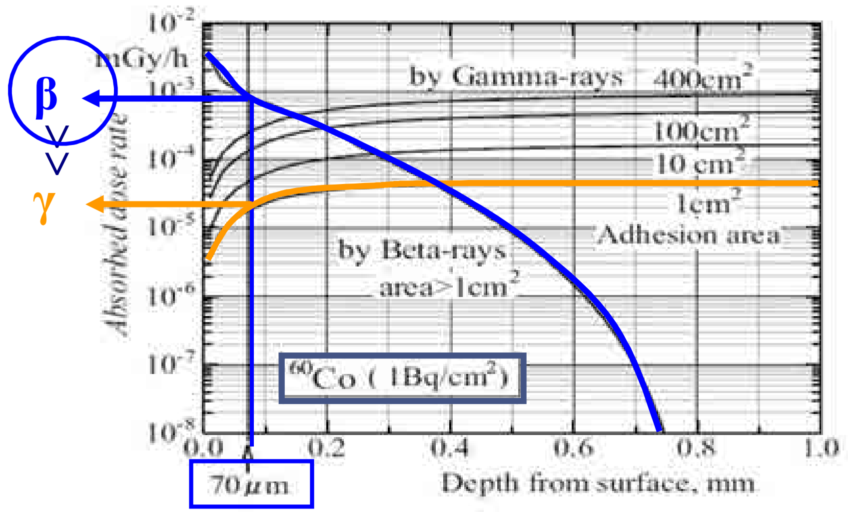
- In all cases and at any step of medical aid, the first priority in the care of the patients is to attend to the most severe life-threatening injuries
- Perform decontamination after stabilization
  - The presence of potential radioactive contamination should not deter the nature or rapidity of medical care
- All clothing should be removed using contamination control techniques

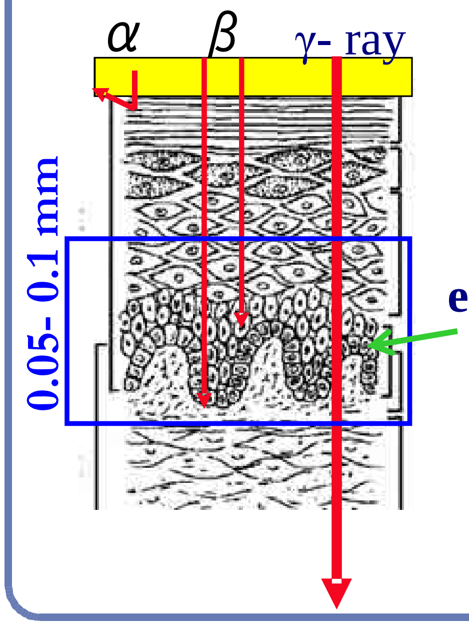
# Routes of Contamination
## Skin

- Skin may become contaminated if in contact with radioactive aerosols, liquids, or contaminated surfaces
- Radioactive materials may be intake to the body through ingestion or absorption from contaminated skin or wound
- Beta-emitting radionuclides can cause skin burns

# Absorbed dose rate on the skin




| | Skin | Lens | Organ | |
|---|---|---|---|---|
| Depth (mm) | 0.07 | 0.4 | 3 | 10 |
| $^{60}Co$ | 935 | 26.0 | | |
| $^{137}Cs$ | 1432 | 384 | | |
| $^{192}Ir$ | 1384 | 307 | | |

($nGy \cdot h^{-1} \cdot Bq^{-1} \cdot cm^2$)

**Levels of surface contamination** → **Skin absorbed dose / h**

**1 Bq / cm²** → **935 nGy / h**

# Skin Decontamination

- Purpose
  - To lower the risk of internal contamination of the victim, and to decreases the risk of skin beta burns
  - To prevent the spread of contamination
- General rule
  - Decontamination should be done by washing with water and soap or cleaning solutions but not to the extent that the skin is further damaged or abraded

# Skin Decontamination (Cont'd)

- After the person's clothing is removed, washing the person with detergent and water is 95% percent effective
- Keep in mind that the outermost layer of the skin is replaced every 12-15 days. Thus, contamination that is not removed and is not absorbed by the body will be sloughed within a few days
- If contamination is not removed by washing, wrap the contaminated area and, over time, sweating will decrease contamination

# Local Contamination

- Cover uncontaminated area with plastic sheet and tape edges
- Soak, gently scrub with soap, and rinse thoroughly
  - Repeat the cycle and observe changes in activity
  - One cycle should not last longer than about 2-3 min
  - Avoid vigorous scrubbing
  - A saline solution (for eyes) or mild bleach solution (for skin) may facilitate the process

# Summary

- This lecture presented materials about on-scene emergency medical response
- The main points important to note are:
  - First aid is an important task for Emergency Responders on the scene of the emergency
  - Tasks of Emergency Medical Responders should be coordinated with tasks of other responders
  - Contaminated casualty handling – way to decrease the contamination of victims and to prevent the spread of contamination
- Comments are welcomed

# Where to Get More Information

- IAEA-TECDOC-1162
- IAEA-TECDOC-1092
- IAEA - EPR-FIRST RESPONDERS 2006
- IAEA - EPR-MEDICAL
- Module 10 of the current Course

IAEA Training Course for Research Reactor Emergency Response

# Development of Response Capabilities

# Infrastructure and Functional Requirements

## Seminar

# Introduction

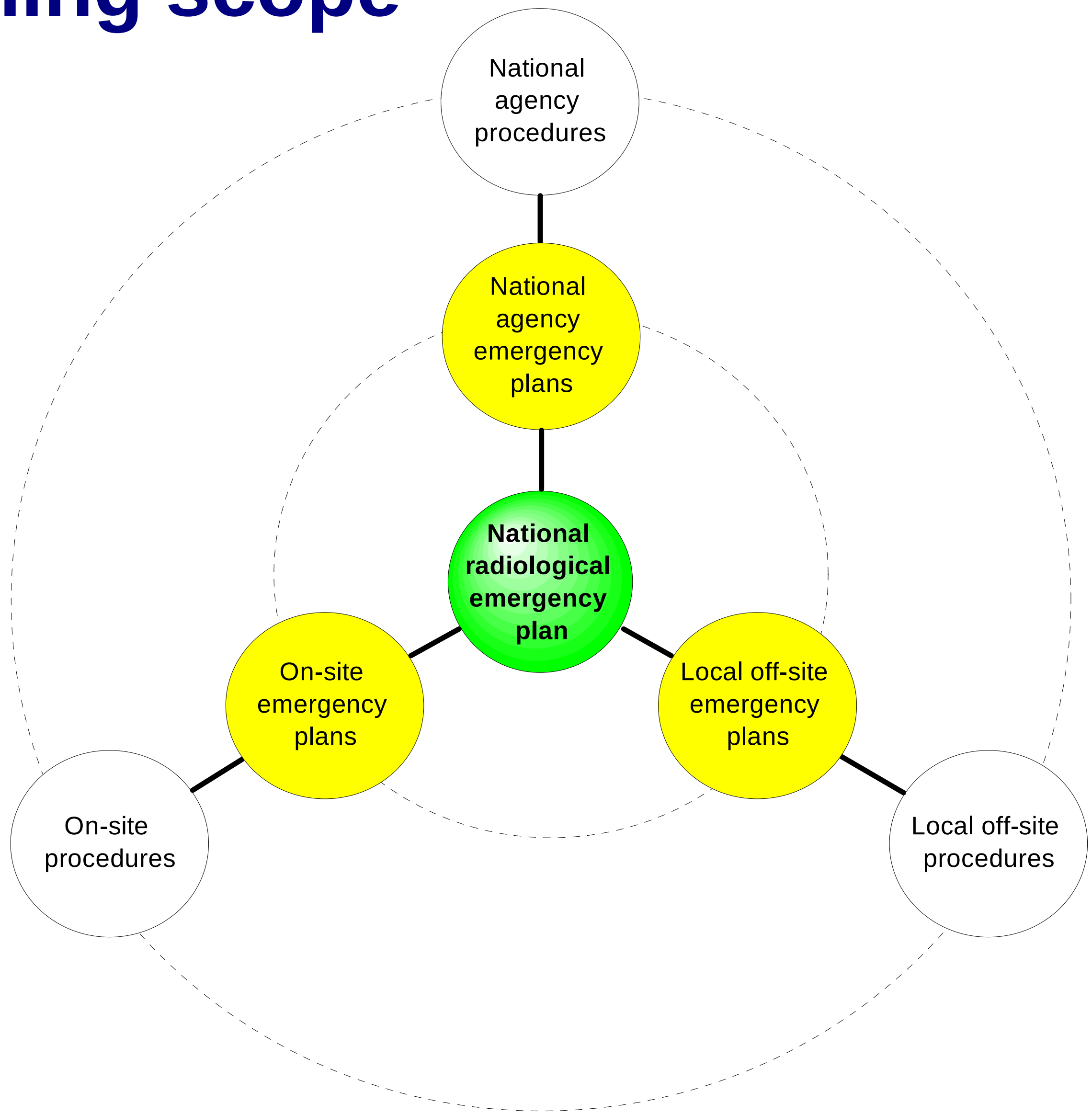
- Elements (requirements) for sound response preparedness are divided into infrastructure (preparedness) and functional (response) elements
- The module is explaining what the infrastructure and functional requirements contained in IAEA EPR-METHOD 2003 mean in practice in the content of research reactor emergency response preparedness

# Content

- Emergency planning scope
- What are infrastructure and functional elements?
- Infrastructure elements
- Functional elements
- Optimization in planning
- Summary

# What Is Included in Emergency Planning?

# Planning scope



# Common Planning Problems

- Who is responsible?
- No legal framework
- No teeth
- Lack of knowledge of risk
- Lack of resources
- Lack of organization
- Lack of co-ordination
- Training "for exercises"
- Public education
- Public information
- "Paper plans"

# What are Infrastructure Requirements?

- **The question is:**
  - **What do I need to have to be able to respond adequately**
- **The answer is:**
  - **The right infrastructure**

# What are infrastructure requirements?

- But... What must I be able to do?

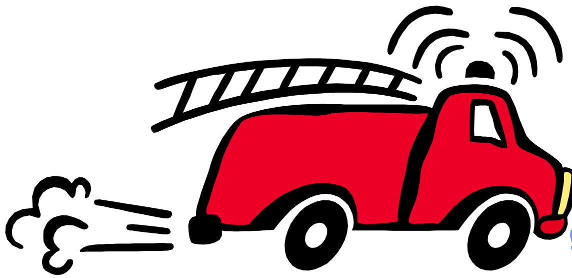
- That is described by the functional requirements
  - Also referred to as performance objectives

# What are infrastructure requirements?

**So...**

- **Infrastructure**
  - **What you need**
- **Functional**
  - **What you must be able to do**

**Clear?**

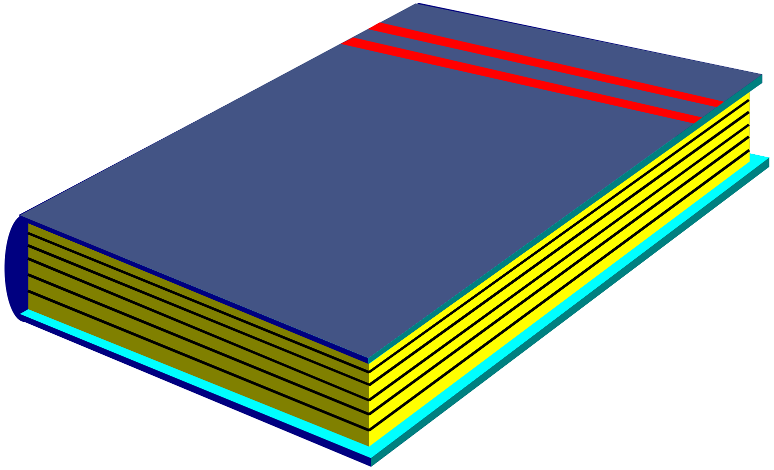


# Infrastructure Requirements
## Areas

- Legal
- Authority
- Agreements
- Organization
- Co-ordination
- Logistics
- Plans and procedures
- Classification system
- Training

# Legal Requirements

- Acts, statutes and jurisdictions
- Who is responsible for what?
  - facility, municipalities, regions, national
- Need a national policy



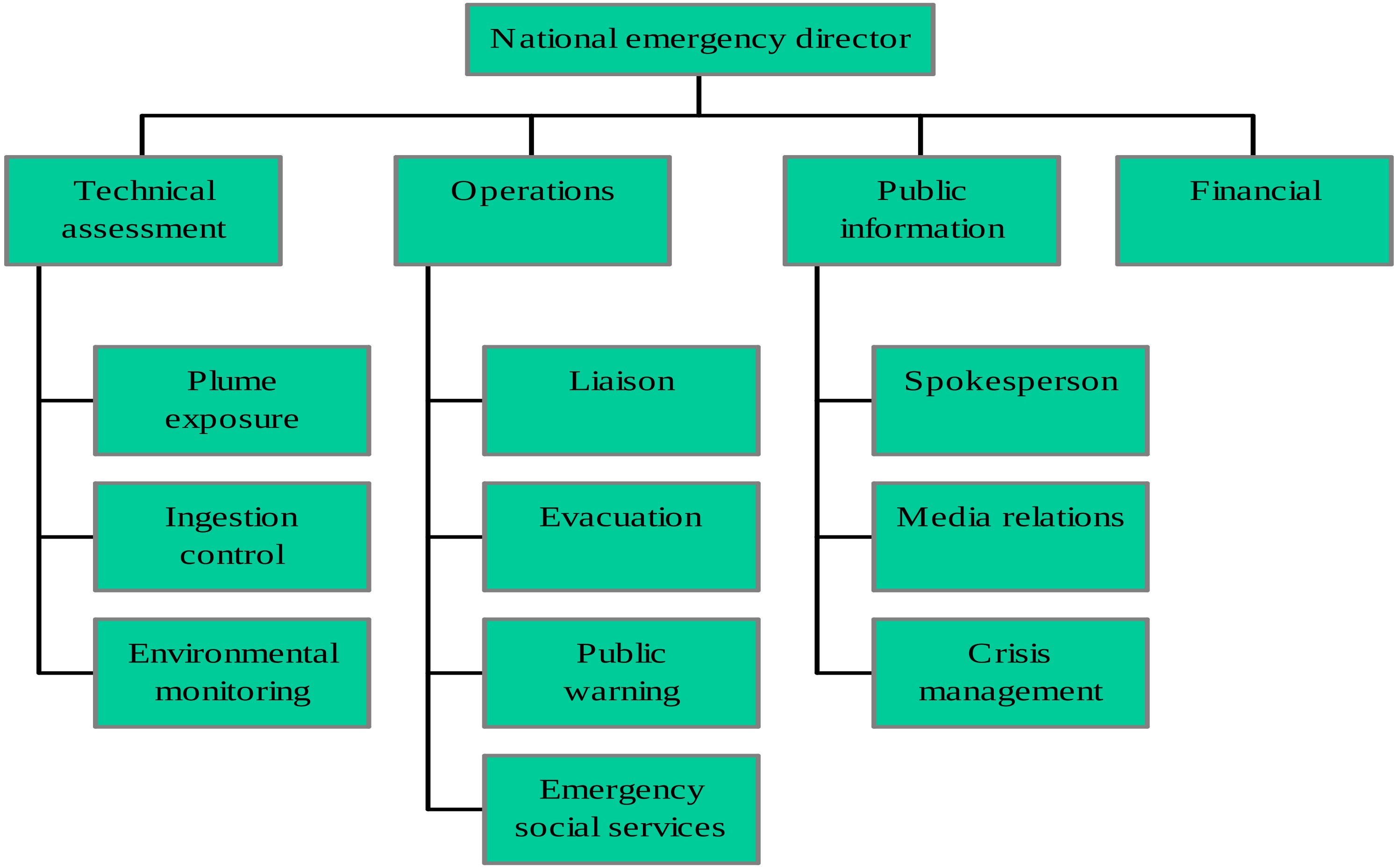
# Authority

- Typical problems:
  - who decides: local or national?
    - who decides protective actions?
  - who controls resources from ministries: ministry or national authority?
  - what if there is a disagreement on what to do?
  - who should be notified first?
  - who decides when to activate?

# Organization

- Block diagram
- Authorities and role of each block
- Concept of operations
- Integrate plans
- Assign staff

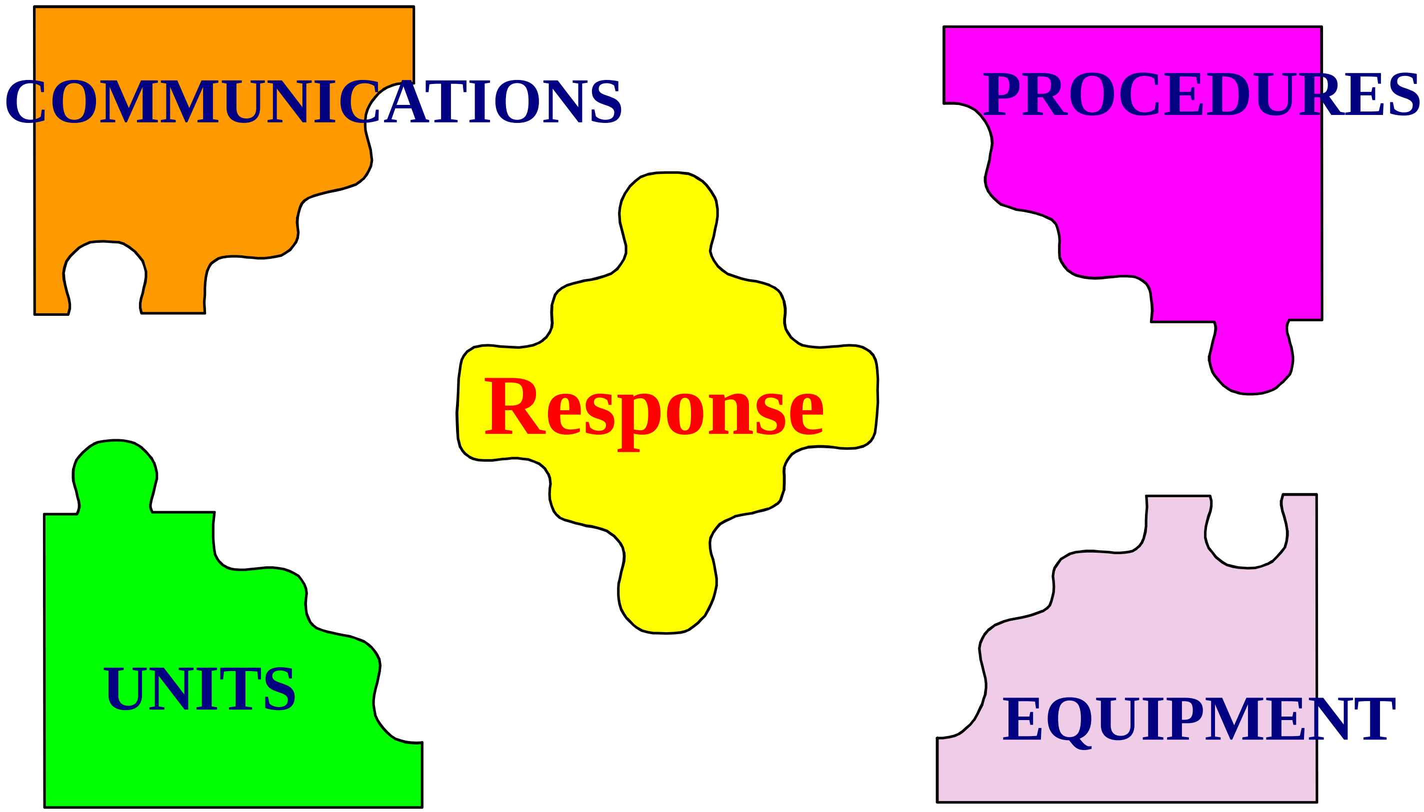
# Block Diagram - Example



# Agreements and Co-ordination

- **Several organizations have to co-operate**
  - **Hagersville tyre fire, Canada: over 200 organizations responded**
- **Some tasks require capabilities from more than one organization**
  - **example: food monitoring and control: ministries of agriculture, health, fisheries, environment, regulator**
- **Agreements must be in place**
  - **working together, units, methods, transfer of information**
- **Agreements in writing**

# Interoperability



# Transboundary Agreements

- If you are within the PAZ or UPZ of another country's reactor
- Provide for prompt notification to the local authorities
- Typical problem: you discover there has been an accident through environmental detection, which may be too late

# Logistics

- Needs analysis
- Facilities and equipment for all response functions
- Laboratories for sample analysis
- Survey and sampling teams
- Information management
- Communications systems

# Facilities and Equipment

- Emergency operations centres
- Locations (take into account radiological hazard)
- Monitoring equipment
- Transportation equipment
  - Response, evacuation, etc.
- Personnel protection
- KI pills
- Office supplies
- Communications equipment
- Staging
- Protection for personnel going to the site
- Inventory checks
- Calibration and maintenance
- Use same as routine equipment
- Quality assurance
- Provision for getting additional resources
  - National and international
- Medical
- Exposure control

# Plans and Procedures

- Response plan must be documented
- Procedures are developed
- Quality assurance
  - Correct set of plans in place
  - Same set of plans at all locations
- Review and modifications
  - from exercises
  - from organization changes

# Classification System

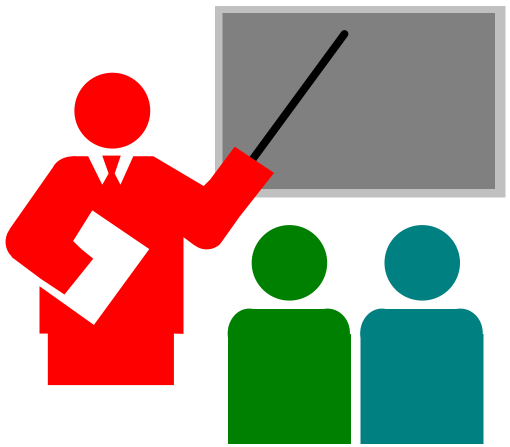
- Classification allows prompt assessment of the risk, before a release
- Classification must originate from the reasearch reactor facility
- Must be common
- Must trigger initial actions

# Classification system

- **Common problems**
  - **too complicated or not based on the system used in the station**
    - **leads to delays in classification**
  - **different system on-site and off-site**
    - **leads to confusion**
  - **not properly understood by all**
    - **leads to wrong actions**

# Training

- Training requirements for each position
- Training programme
- Training material
- Tests/exercises
- Feedback process



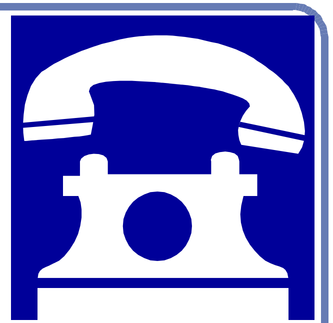
# Functional Requirements
## Areas

- Notification and activation
- Mitigation
- Urgent protective actions
- Longer term protective actions
- Emergency workers protection
- Public education
- Media relations
- Optimization

# Notification and Activation

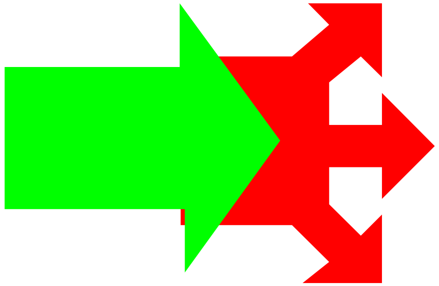
- Off-site notification protocol and message
- Procedures to relate classification to actions
- Means to activate critical staff 24 hrs/7 days
- Means to notify other countries

# Off-site Notification



- **Requirement for prompt notification (15-30 minutes)**
- **Contact points well defined and available 24hrs/7days**
- **Notification message pre-defined**
  - **information may be limited**
  - **be realistic in amount of information needed, as too much information may delay the notification**
- **Follow up information defined**

# Activate Key Staff 24/7



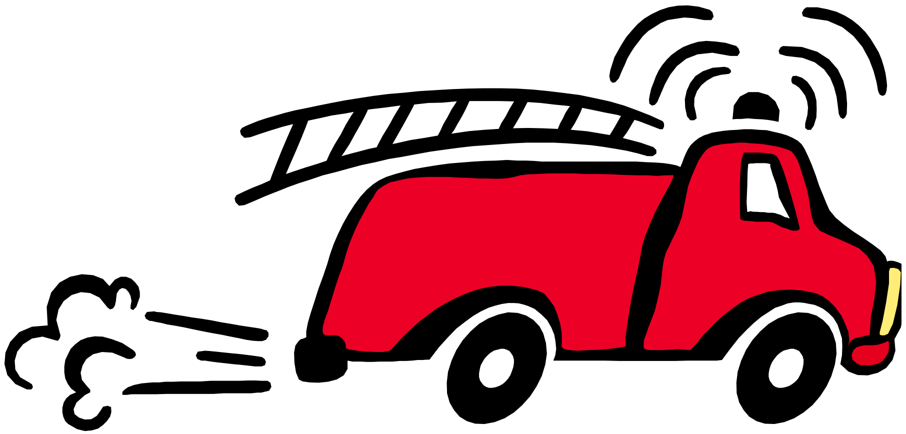
- Designate who activates whom:
  - Who is considered key staff?
- Communications:
  - Telephone, pager, cellular, others
  - List of numbers up to date
- Duty system or “depth” among staff
- Co-ordination of absences
- Fan out system should have built-in redundancy

# Notify Other Countries

- Nearby countries:
  - Prompt notification directly from the facility or promptly through approved channels
  - Contact point identified
  - Protocol identified, including format
  - Language issues taken into account
- Distant countries
  - IAEA and bilateral agreements

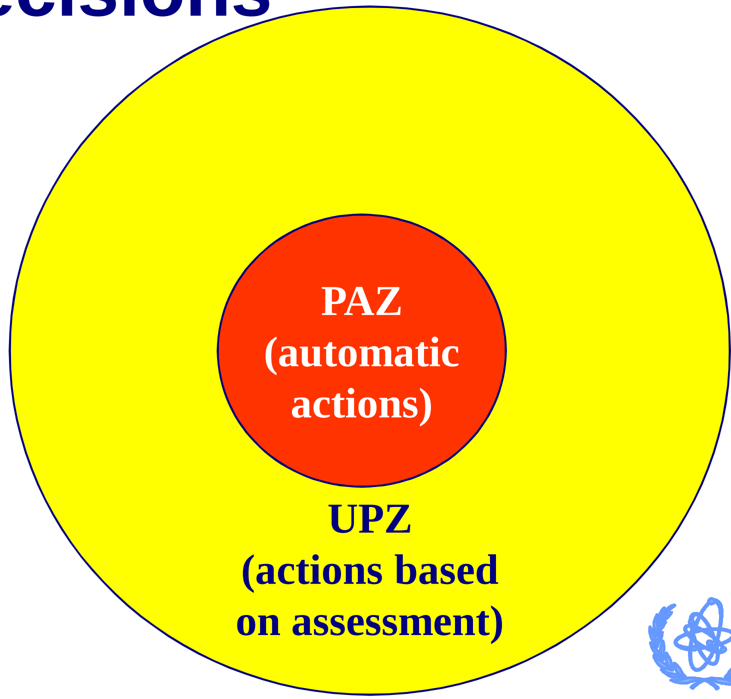
# Mitigation

- Plant emergency operating procedures
- Technical support
- Display critical information
- Damage control



# Urgent Protective Actions

- Establish PAZ and UPZ
- Decision-making procedures
- Means to implement decisions
  - Vehicles
  - Traffic control
  - Security
  - etc.



# Urgent Protective Actions

- Typical problems:
  - Politicians do what they want, regardless of what technical staff recommend
  - Several organizations, each with its own dose projection software, predict doses that vary by several orders of magnitude
  - The information is limited and/or misunderstood (TMI)

# Urgent Protective Actions

- Typical problems:
  - Not enough vehicles
  - Evacuation routes not well defined
  - Traffic jams
  - KI pills difficult to distribute
  - No access by incoming emergency vehicles
  - Special facilities: how to evacuate them, and where to bring them
  - Not everyone goes to reception centres

# Urgent Protective Actions

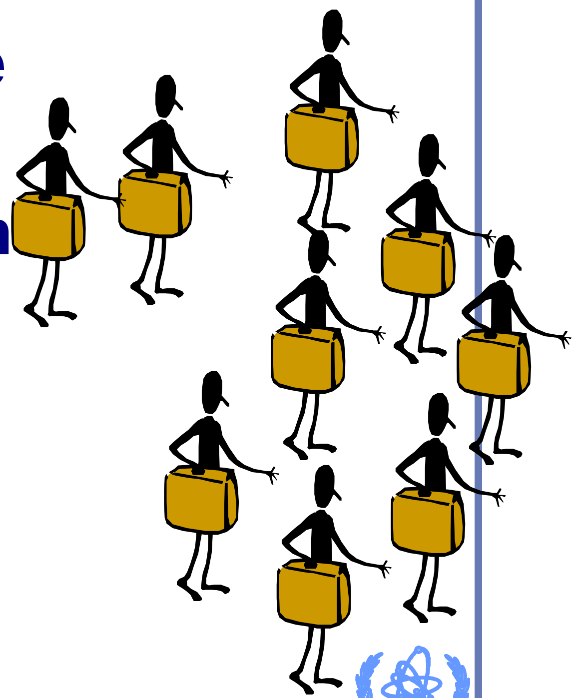
- Contamination monitoring creates bottle neck
- Spontaneous evacuation
- Evacuation under the plume vs sheltering and evacuation
- Security in the evacuated zone
- Levels to allow return
- Farm animals and pets

# Longer-term Protective Actions

- National levels for food control and relocation
- Develop sampling plan
- Identify laboratories and equipment

# Longer-term protective actions

- Restrict consumption of home-grown vegetables
- Restrict sales of farm produce
- Water restrictions
- Protection of water reservoirs, cattle
- Alternate feed
- Alternate supplies for the population
- Control of imports and exports
- Instructions
- Treatment
- Relocation, resettlement



# Longer-term Protective Actions

- Business resumption
  - Industry, government services
- Enforcement
- Variability of criteria based on availability of alternate supplies
- Financial compensation

# Emergency Worker Protection

- Measures should be in place to protect emergency workers, including first responders (e.G. Police, fire fighters)
- Dosimeters should be available
- Establish safe limits for dose
- Emergency workers should be trained

# Public Education

- Educate the public so they understand the risk and follow instructions
- Educate before an emergency, not after!
- Education should include:
  - Knowledge of activity and hazards
  - How they would be informed
  - What they should do

# Media Relations

- Have a good communications plan in place
- Train spokespersons
- Coordinate response agencies
- Designate facilities for media reception
- Media kits
- Access to professional media officers

# This is going to cost a lot, right?

# Not necessarily...

# Golden Rules of Optimization

- Use existing resources and systems
- If you do not have the resources, know where to find them
- Consolidate training with other courses
- Integrate planning with other emergency plans
- Bring planning up to speed and maintain it:
  - Preparedness cycle has high cost
- Exercise frequently
  - Well exercised plan better than pretty procedures
- People must "buy into" the plan

# Summary

- Emergency planning covers a broad scope of activities
- Infrastructure requirements describe what is needed to enable a good response
- Functional requirements describe the response that should be achieved
- Both are described in EPR-METHOD 2003
- Integration and consolidation of existing systems can reduce cost and enhance the state of preparedness

# Where to Get More Information

- **IAEA EPR-METHOD 2003**
- **IAEA EPR-RESEARCH REACTOR**

IAEA Training Course for Research Reactor Emergency Response

# Emergency Preparedness and Response

# Emergency Monitoring and Assessment

## Seminar

# Introduction

- **This lecture presents an overview of the IAEA technical publication *Generic procedures for monitoring in a nuclear or radiological emergency* (IAEA-TECDOC-1092) with modifications proposed in EPR-METHOD 2003 and EPR-RESEARCH REACTOR**

- **It covers strategy, manpower and equipment needed in environmental, source, personal and equipment monitoring during a nuclear or radiological emergency**

# Content

- Objectives of emergency monitoring
- Generic monitoring organization
- Emergency monitoring strategy
- Emergency staff
- Instrumentation
- Basic survey methods
- Quality assurance system
- Summary

# Overview

- One of the most important aspects of managing a radiological emergency is the ability to promptly and adequately assess the need for protective actions
- Protective action emergency management must make use of the key relevant information available
- Emergency monitoring is one of the main sources for obtaining the needed information

# Purpose

- **The primary purpose of emergency monitoring is to provide timely information on which decisions on protective actions can be confirmed or revised**
- **This requires detection of radioactive material, determination of its location and its nature**

# General Goal

- **To assist, confirm or revise decision-making regarding**

**WHETHER**

**WHEN**

**and**

**WHERE**

**to apply protective actions**

# General Objectives

- The objectives of emergency monitoring in general are:
  - To provide information for emergency classification
  - To help decision makers to assess the need for protective actions and interventions on the basis of operational intervention levels (OILs)
  - To assist in preventing the spread of contamination
  - To provide information for protection of emergency workers

# General Objectives – Cont'd

- **To provide accurate and timely data on the level and degree of hazards resulting from a radiological emergency**
- **To determine the extent and duration of the hazard**
- **To provide detail on the physical and chemical characteristics of the hazard and**
- **To confirm the efficiency of remedial measures such as decontamination procedures etc.**

# Generic Monitoring Organization

**Facility Response Manager**
Responsible for overall accident response

**Radiological Protection Manager**
Determine radiological conditions

**Environmental Analyst**
Manage field monitoring and sampling

**Sample Analyst**
Manage laboratory analysis

**Field teams**

**Laboratory teams**

# In a Reactor Accident

| Accident phase | Type of measurements and sampling |
| --- | --- |
| Initial environmental assessment | ➢ Ambient dose rates |
| During a release | ➢ Ambient dose rates<br>➢ Air sampling<br>➢ Isotope concentrations in air |
| After a release | ➢ Ambient dose rates from deposition<br>➢ Ground deposition concentrations<br>➢ Environmental sampling<br>➢ Isotope concentrations |

# Monitoring Priorities in a Research Reactor Accident (EPR-RESEARCH REACTOR)

| PRIORITY | OBJECTIVE | WHEN | WHERE |
|---|---|---|---|
| 1 | • Detect release<br>• Identify safe areas | • Immediate, repeat once an hour | • On-site, to boundary in all directions |
| 2 | • Determine where OIL-1 exceeded | • After classification<br>• During release | • Off-site, start downwind, survey in all directions |
| 3 | • Determine where OIL-2 exceeded | • During release | • Off-site, start where OIL-1 not exceeded |
| 4 | • Determine where OIL-3 exceeded | • During release | • Off-site, start where OIL-2 not exceeded |
| 5 | • Determine where OIL-6 exceeded | • After plume passage<br>• After release ends | • Off-site, start where OIL-3 not exceeded |
| 6 | • Determine where OIL-6 exceeded | • After plume passage<br>• After release ends | • Twice the distance from where OIL-3 no longer exceeded |

# Emergency Staff - General Guidance

- Use persons who are skilled and experienced
- Persons performing routine monitoring and sampling should receive specific training for non-routine and emergency monitoring and sampling
- Teams should be well trained and properly equipped with personal protective equipment and be acquainted with emergency exposure guidance

# Environmental Survey Team

- Environmental Survey Team should be technical personnel trained in:
  - radiation dose rate measurements
  - surface contamination measurements
- Team should be regularly exercised in emergency response scenarios

# Radionuclide Identification Team

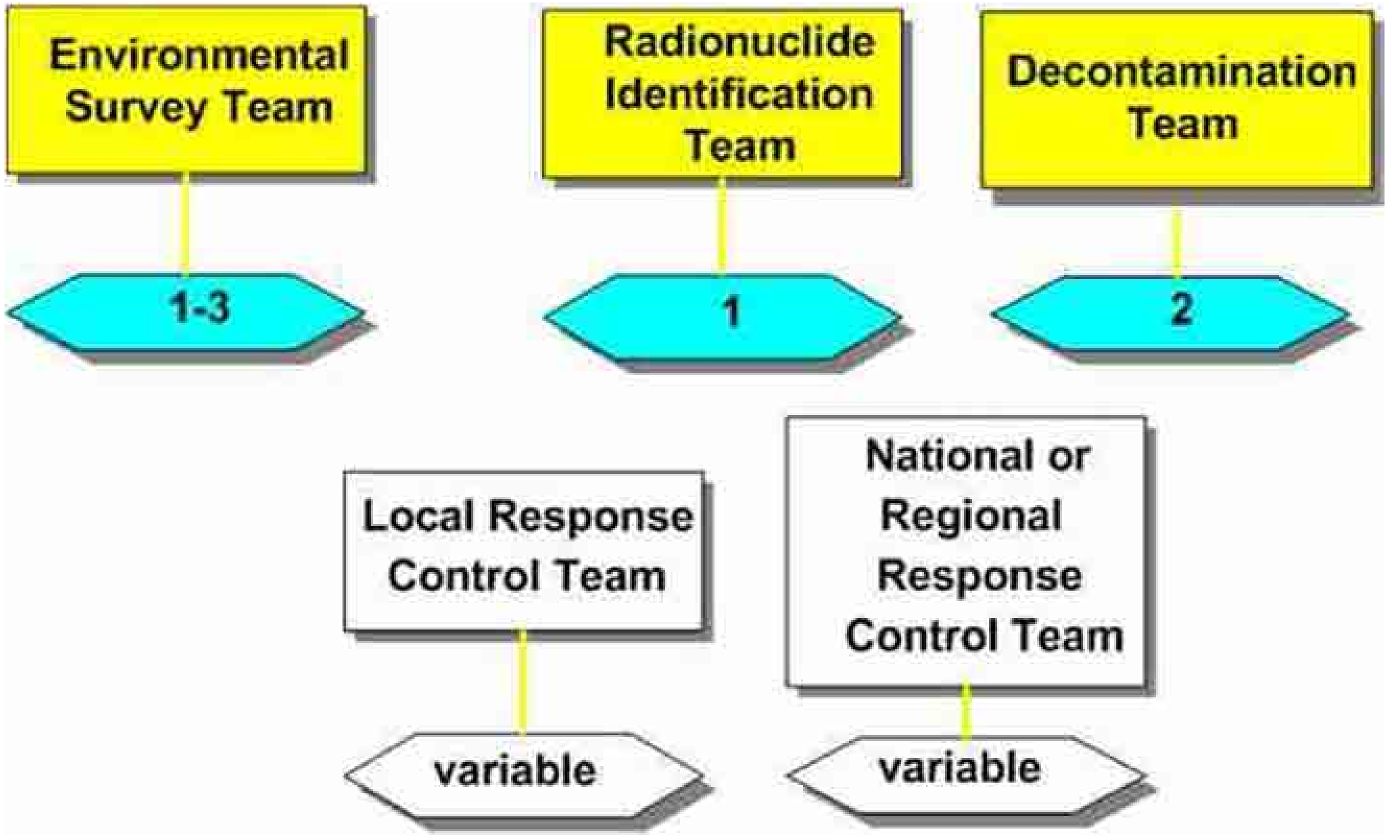
- **Team members need to be experienced environmental sampling personnel or personnel well instructed in correct sampling procedures for the particular types of sample required**

- **Teams may also need to be experienced in radiological assessment techniques to monitor their own safety and to provide field radiological data if requested to do so**

# Decontamination Team

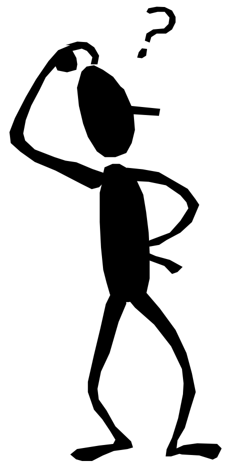
- **Members need to be skilled in the use of contamination monitors**
  - **To assess contamination**
  - **To prevent the spread of contamination**
  - **To monitor the efficiency of decontamination of people and surfaces**
- **All such persons should receive regular re-familiarization training in such techniques**

# Suggested Number of Teams for Research Reactor Accident Response



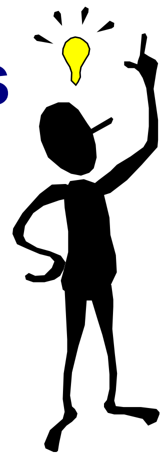
# Instrumentation - General Guidance

- **Choose appropriate equipment for the potential releases**



- **Properly calibrate equipment**

- **Maintain equipment readiness**
  - **batteries available**

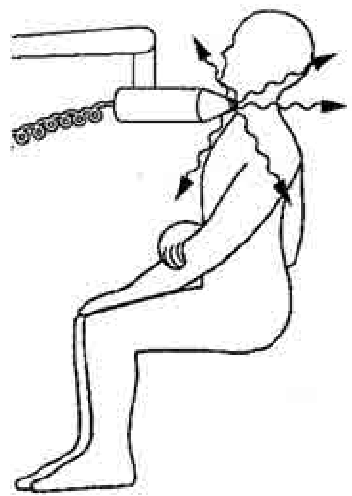


# Basic Survey Methods

- **Ground survey**
- **Personal monitoring and decontamination**
- **Sampling and sample analysis**

# Personal Monitoring

- To control personal exposure and contamination of response personnel and in particular field monitoring teams
- To monitor persons from the emergency area for skin and clothing contamination before, during and after decontamination
- To monitor thyroid for radioiodine uptake



# Sampling - General Guidance

- **Take representative samples to enable the level and extent of contamination of air, ground, water, foodstuffs, vegetation etc. to be accurately and rapidly determined**
- **Sampling techniques should be consistent between sampling teams**
- **Samples should be taken at locations representative for the area and where contamination is more likely rather than at the most accessible sampling sites**

# Confidence in the Monitoring Results

- Confidence in the monitoring results and international acceptability can be achieved only by implementing effective quality assurance system
- The system basically consists of
  - quality assurance (QA) programme
  - quality controls (QC) and
  - audits / appraisals

# Procedures

- **Measuring procedures**
- **Calibration procedures**
- **Evaluation procedures**
- **QA and QC procedures**

**What procedures???**

# Summary

- **Monitoring organization and emergency team protective guides should be adapted to reflect country specific system in emergency response**

# Where to Get More Information

- **IAEA TECDOC-1092**
- **IAEA EPR-METHOD 2003**
- **IAEA EPR-RESEARCH REACTOR**

IAEA Training Course for Research Reactor Emergency Response

# Emergency Preparedness and Response

# Non-radiological Safety at Research Reactors

## Seminar

# Introduction

- Non-radiological safety at a research reactor is concerned with events at non-nuclear components of the facility which can trigger a radiological emergency
- Basic knowledge on research reactor design is needed
- We all know very well: a nuclear reactor should be safe, safe and safe
- It should be useful and not very expensive

# Content

- Physical protection systems (PPS)
- Fire protection systems (FPS)
- Electric power supply systems (EPSS)
- Water flow safety systems
- Civil engineering issues
- Hazardous materials
- Summary

# Physical Protection Systems (PPS)

- **What the PPS is for?**
  - **To protect nuclear material from theft**
  - **To protect nuclear material from illicit use**
  - **To protect a nuclear facility from terrorist action**
  - **To protect a nuclear facility from an action of mentally abnormal person**

# Physical Protection System Structure

- Physical protection system hardness is suitable to:
  - Category of nuclear material to be protected
  - Susceptibility of a nuclear facility for an unauthorized entrance to the sensitive areas
  - Design basis threat (DBT)

# PPS Functions

- Intrusion detection with sensors, access control and assessment (CCTV)
- Adversary delay barriers: outer layers and inner layers
- Response forces and communication

# Fire Protection Systems (FPS)

- **Fire on reactor facility is a grave and dangerous event because**
  - **It can cause a cut-off or destroy the rector control system**
  - **It can damage the reactor cooling system**
  - **It can make impossible to access to important for the facility safety areas**

# Reactor FPS Objectives

- The following objective are achieved
  - To prevent fires from starting
  - To detect and extinguish quickly those fire which to start, thus limiting the damage
  - To prevent the spread of those fires which are not been extinguished, thus minimizing their effects on essential facility function

# FPS Structure

- Fire protection system consists of
  - Fire detection
  - Fire signalization
  - Extinguish installations and equipment
    - Stationary extinguish installation
    - Portable extinguish equipment
    - Auto-extinguish installation (sometimes)

# Fire Protection Vital Areas

- **Control room**
- **Reactor control system relay room**
- **Emergency electrical power system**
- **Uninterruptible power supply (UPS) equipment**
- **Special nuclear material vault**
- **High radioactivity reactor products**

# Electric Power Supply System (EPSS)

- Research reactor EPSS function is to make available of reliable power for essential functions as
  - Protection system
  - Instrumentation
  - Reactor core cooling
  - Lighting
  - Ventilation

# EPSS Structure

- A research reactor EPSS consists of
  - Major EPSS fed from central (national) grid usually by means of two independent power transmission lines, connected to different part o central system
  - Uninterruptible power supply system
  - Emergency electrical power system

# EPSS Structure (Cont'd)

- **Research reactor systems need different genders of electrical feeding**
  - **Alternating current (AC) low voltage, in Europe 380/220 V**
  - **AC various voltage to auxiliary circuits supply**
  - **Direct current (DC) from battery to emergency supply, to sensitive electronic and to UPS uses**
  - **DC  from converters to charge batteries**
  - **AC from diesel-generators to emergency supply**

# Emergecy EPSS

- It takes energy:
  - From batteries for some second up to some hours
  - From diesel-generators after its start-up
    - some seconds or a couple of minutes, up to the moment normal power supply is restored

# Water Flow Safety System

- **Reactor design protects the facility for abnormal situation as water flow caused by**
  - **Catastrophic rainfall**
  - **Flooding**
  - **Water supply and sewerage systems out of order**
  - **Fire extinguish action**

# Civil Engineering Issues

- An emergency situation can be caused by a partial or total destruction of the reactor building
- A serious destruction can be the resulted
  - Of an earth-quake or other circumstances outside of our control
  - Some flying object crash, for instance an aircraft

# Civil Engineering Damage

- Research reactor building structures can be also severly damaged by
  - Hurricane winds
  - Tornado striking facility
  - Explosion of a gas cylinder
  - Missile impact from whatever source

# Civil Engineering Protection Measures

- Solid construction of the reactor buildings
- Anti earth-quake building construction, if necessary
- Strict interdiction of aircrafts flying over the reactor site
- Considering in emergency planning

# Hazardous Materials

- In research reactor facility is vitally recommended to avoid or minimize the quantity of hazardous materials as
  - Strongly toxic substances
  - Explosives
  - Pressurized  cylinders with combustible gases

# Summary

- **Specification of emergency important non-radiological issues were discussed**
- **All these issues you have to consider also in your emergency plan**

# Where to Get More Information

- International Basic Safety Standards, IAEA Safety Ser. No. 115, available also in electronic record
- Preparation, Conduct and Evaluation of Exercises to Test Preparedness for a Nuclear or Radiological Emergency, EPR Exercise, 2006
- Safety requirements of research reactors, IAEA NS-R-4, 2005

# Development of a Response Capability

# Developing Emergency Response Capability

## Step-by-step Process

### Seminar

# Introduction

- The Chernobyl and Goiânia accidents resulted in a re-examination of many emergency planning principles and practices
- This lesson provides a practical step-by-step method for developing integrated operator, local and national radiation emergency response plans

# Content

- Basic concepts
  - Planning areas and zones
  - Planning levels and responsibilities
  - Emergency classes and conditions
  - Integrated planning concept
- Planning methodology
  - Ten tasks
- Summary

# Background

- The range of potential radiation accidents is enormous, ranging
  - From a major reactor accident
  - To accidents involving small amounts of radioactive material
- A minimum level of planning is appropriate in every country, even in those without any known radiological activities

# Background – Cont'd

- The response to radiation emergency is basically the same as the response to any accident involving hazardous material
- Planning on the basis of established principles of radiation protection and safety is essential
- Provisions should be developed to identify potential radiological hazards
- Radiological plans should be incorporated into plans for all types of hazardous materials

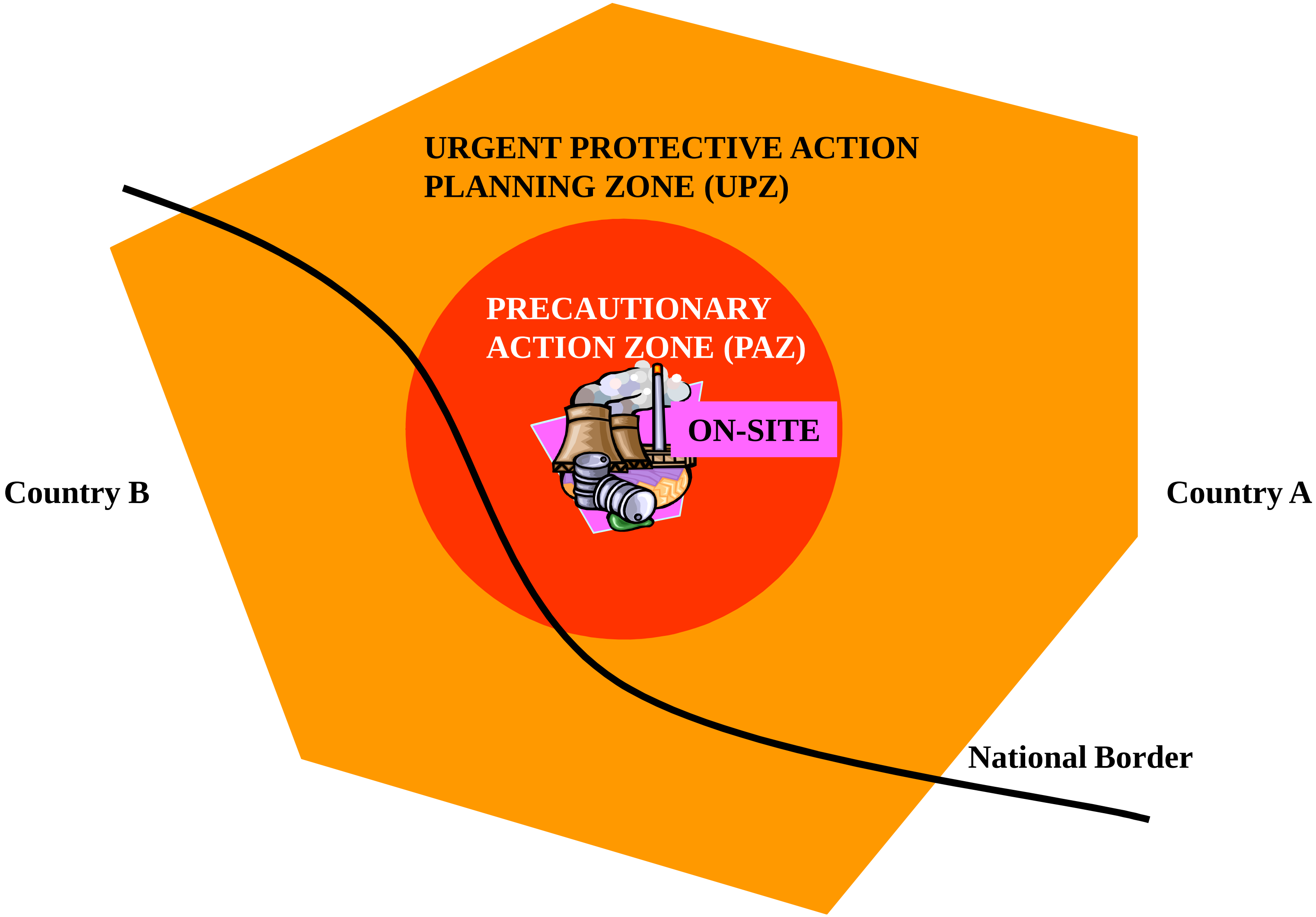
# Threat Categories

| Threat Category | Radiological Threat |
|---|---|
| I | Severe deterministic health effects off-site |
| II | Warranting urgent protective actions off-site, deterministic health effects on-site |
| III | No urgent protective actions off-site are warranted, severe deterministic health effects on-site |
| IV | Minimum level of threat – all countries |
| V | Food contamination due to transboundary contamination necessitating food restrictions |

# Planning Areas and Zones

- Areas
  - On-site area
  - Off-site area
- Zones
  - Precautionary Action Zone (PAZ)
  - Urgent Protective Action Planning Zone (UPZ)
- Food restrictions planning distance

# Concept of Emergency Planning Zones



# Response and Planning Zones Sizes

| Facility | PAZ | UPZ | FRPD |
| --- | --- | --- | --- |
| Category I | 3 – 5 km | 5 – 30 km | 500 – 1000 km |
| Category II | On-site | 0.5 – 5 km | 10 – 50 km |
| Category III | On-site | Not required | Not required |

**PAZ – Precautionary Action Zone**
**UPZ – Urgent Protective Planning Zone**
**FRPD – Food Restrictions Planning Distance**

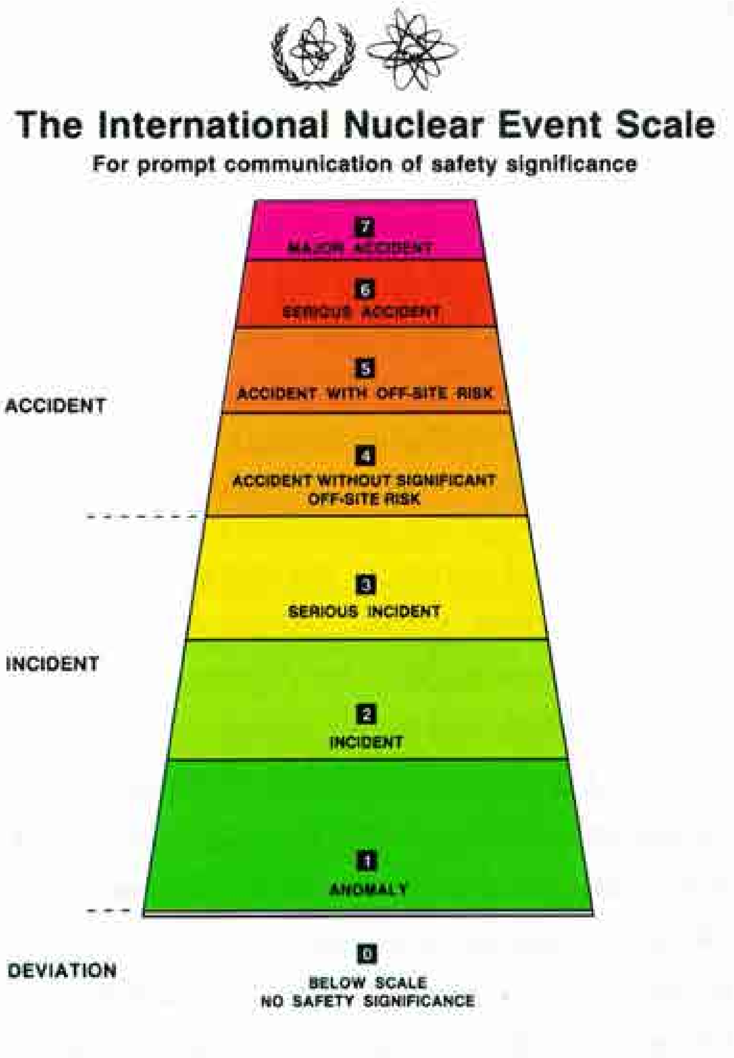
# Planning Levels

- **Effective emergency response requires mutually supportive and integrated emergency planning at three levels:**
  - **Operator level**
  - **Off-site level**
  - **International level**

# Emergency Classes

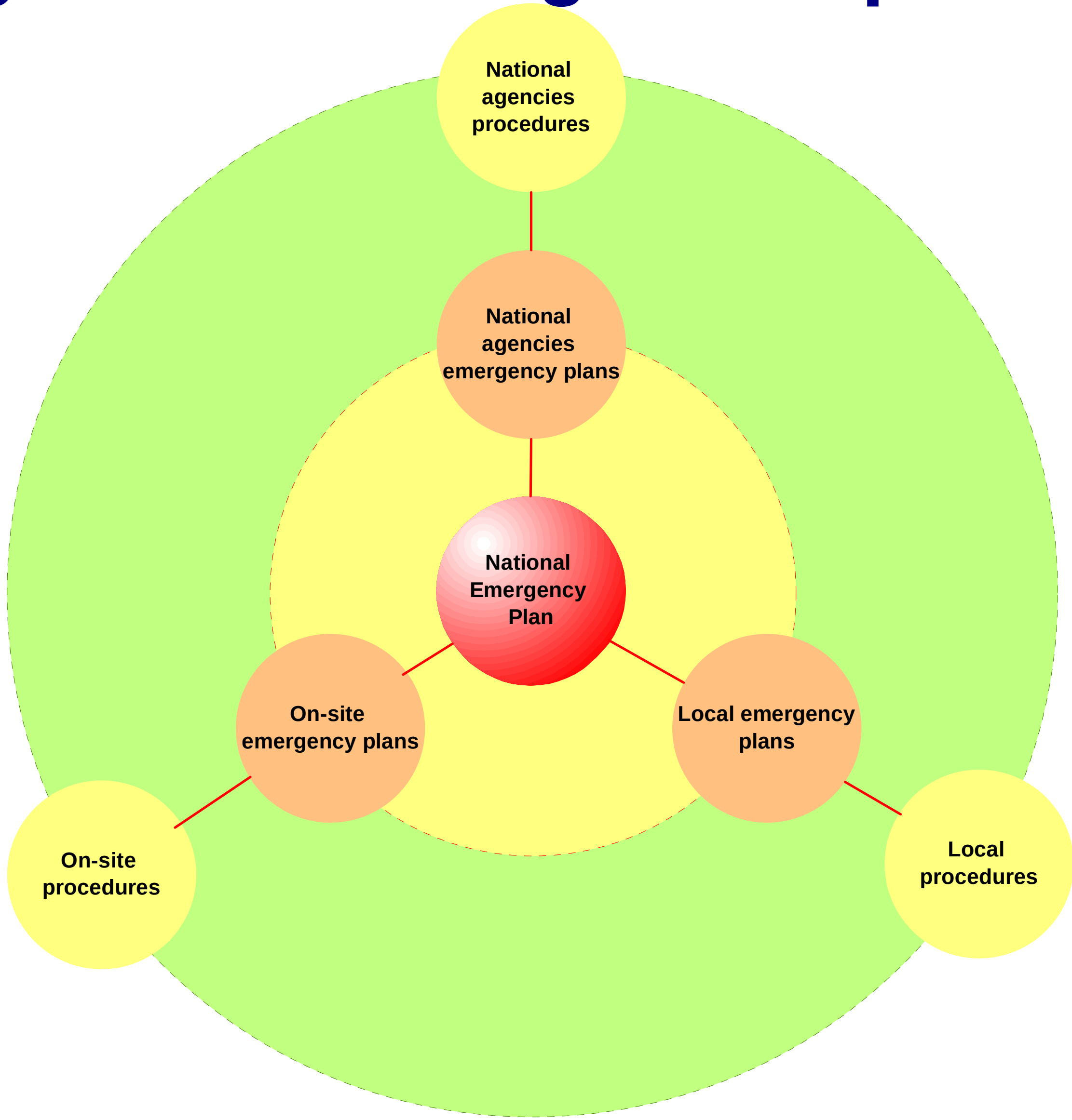
- General emergency
- Site area emergency
- Facility emergency
- Alert
- Uncontrolled source emergency

# International Nuclear Events Scale




- **INES is designed to indicate how serious an event was after it is understood**

# Integrated Planning Concept



# Planning Metodology

- The planning methodology is
  - Modular
  - Based on extensive consultation
  - Iterative

# The Tasks

| Tasks | Implementation Time |
|---|---|
| **Designate National PC** | |
| 1. National policy review | |
| 2. Perform a threat assessment | |
| 3. Develop the planning basis | |
| 4. Develop Con-ops, allocate responsibilities | |
| 5. Develop an interim capability | |
| 6. Write the NREP | |
| 7. Present the NREP | |
| 8. Implement detailed plans | |
| 9. Test the capability | |
| 10. Establish ongoing maintenance | |

# Getting Started

- Designate a single overall National Emergency Planning (EP) Coordinator
  - In-depth technical and operational knowledge of emergency preparedness and response
  - At the early stage involving all parties who have an interest in the development of emergency plan

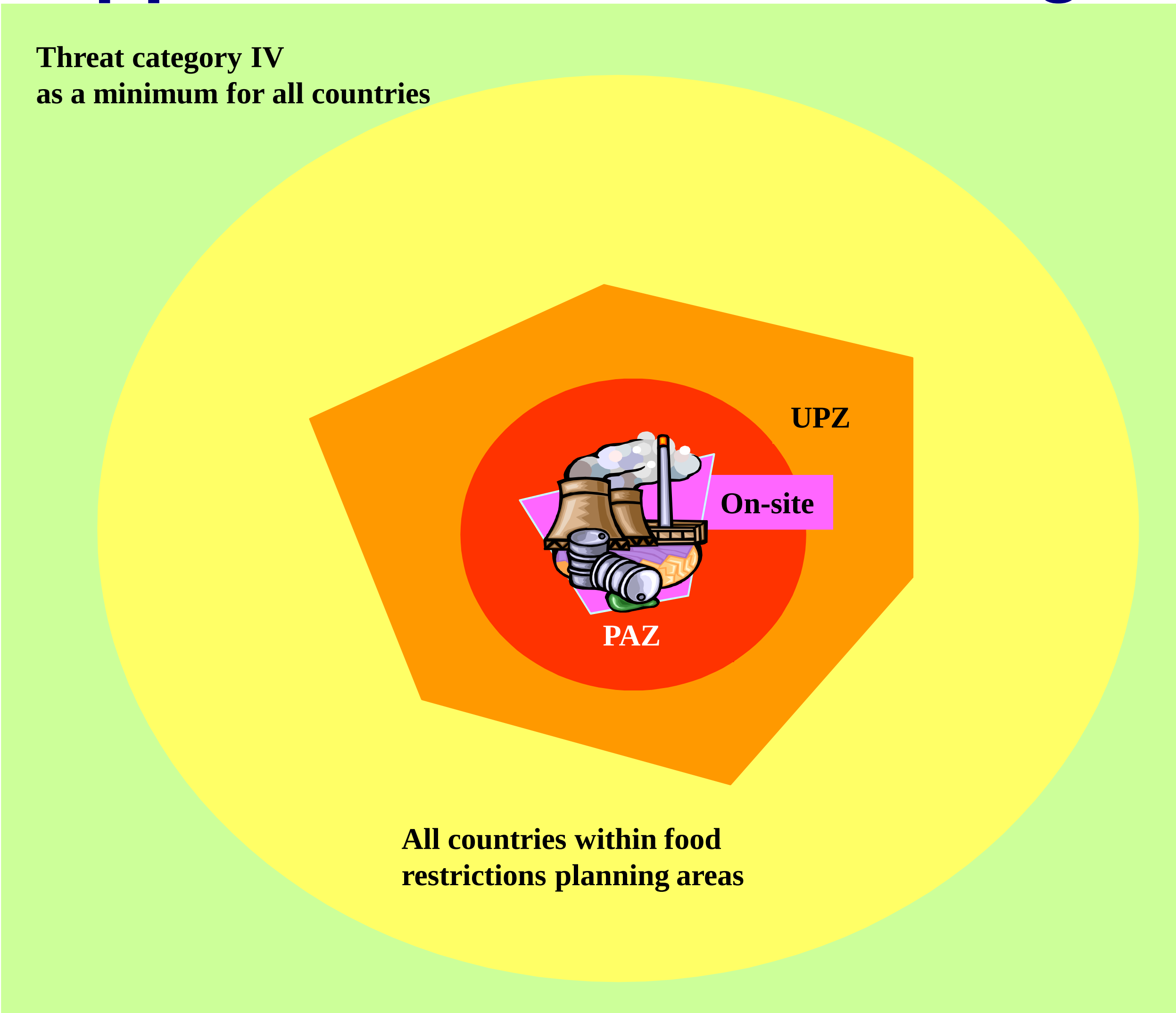
# Task 1 – National Policy Review

- **A list of the national laws or Acts for emergencies**
- **International agreements**
- **A description of roles, responsibilities and capabilities of**
  - **Major national ministries**
  - **Local governments and operators**
- **A description of integration into the planning for other types of emergencies**

# Task 2 – Perform a Threat Assessment

- **Conduct a national threat assessment to identify practices and facilities that may possibly necessitate emergency interventions within the country**
- **Include facilities outside the country**
- **Determine the level of preparedness required by determining which threat categories apply**

# Application of Threat Categories




**On-site:**
**I or II or III**

**Precautionary Action Zone**
**I and V+IV**

**Urgent Protective Action Planning Zone**
**I or II and V+IV**

**Food restrictions planning areas**
**V+IV**

**All countries**
**IV**

# Task 3 – Develop the Planning Basis

- Gather and document information about the possible accidents and local areas
  - Operator information
  - Off-site information
  - Off-site environmental conditions

- Describe the information in the NREP

# Task 4 – Develop Con-ops, Allocate Responsibilities

- Develop a basic concept of operations describing the response to each basically different accident type

- Determine and assign the roles and responsibilities of each group, organization or individual involved in emergency preparedness and response

# Task 5 – Develop an Interim Capability

- **Establish an interim emergency response capability**
- **Establish a notification point where potential radiation emergencies can be reported and assistance obtained**

- **This task should not be overlooked**

# Task 6 – Write National Emergency Plan

- **Develop a national radiation emergency response plan**
- **The plan is a summary of the more detailed plans**
- **It assures that all the other planning is integrated and compatible**
- **The NREP should address all the facilities and jurisdictions identified in task 2**
- **In developing the plan, consider the data gathered in tasks 1, 2, 3 and 4**

# Task 7 – Present National Emergency Plan

- **Give formal presentations to the organisations that may be involved, directly or indirectly, in the maintenance and implementation of the plan**
- **This will achieve a common understanding of the response concepts and principles**
- **It will allow unforeseen issues to be raised and resolved before they become real difficulties**

# Task 8 – Implement Detailed Plans

- **Develop the infrastructure and functional capabilities needed to implement the NREP for each facility and jurisdiction identified in task 2**
- **This will include plans, procedures, staff, organisation, facilities, equipment and training**
- **A group should be assigned the responsibility to assist and help in this effort**

# Task 9 – Test the Capability

- **Conduct drills and exercises**
  - **Drills provide training**
  - **Exercises test and verify the adequacy of entire system to include the plans, procedures, facilities, equipment and training**
- **Identify and correct deficiencies**

# Task 10 – Implement Ongoing Maintenance

- Ensure that the emergency response capability is maintained and periodically validated
- All groups should develop the means to maintain and update the emergency response programme, including the following:
  - a review of plan and procedures
  - a review of training programme
  - an exercise programme
  - a feed-back process for lessons learned during exercises and real emergencies

# Remember

**A long-term staff and budget must be provided to ensure that the capability is maintained**

# Summary

- A minimum level of planning is appropriate in every country
- Effective emergency response requires mutually supportive and integrated emergency planning
- There are ten tasks to develop and implement emergency response capability
- Plans are dynamic documents

# Where to Get More Information

**INTERNATIONAL ATOMIC ENERGY AGENCY**

**Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency**

**EPR-METHOD 2003**

**Vienna, 2003**

# Development of a Response Capability

# Outlines of Emergency Plans and Procedures

## Seminar

# Introduction

- **The Emergency Plan is a description of the roles and responsibilities of all the responding persons, units, organizations and their relationships**
- **Procedures are then needed to carry out the plans - a set of procedures should be used as a basis for practical response to every emergency situation – to carry out the emergency response plan**

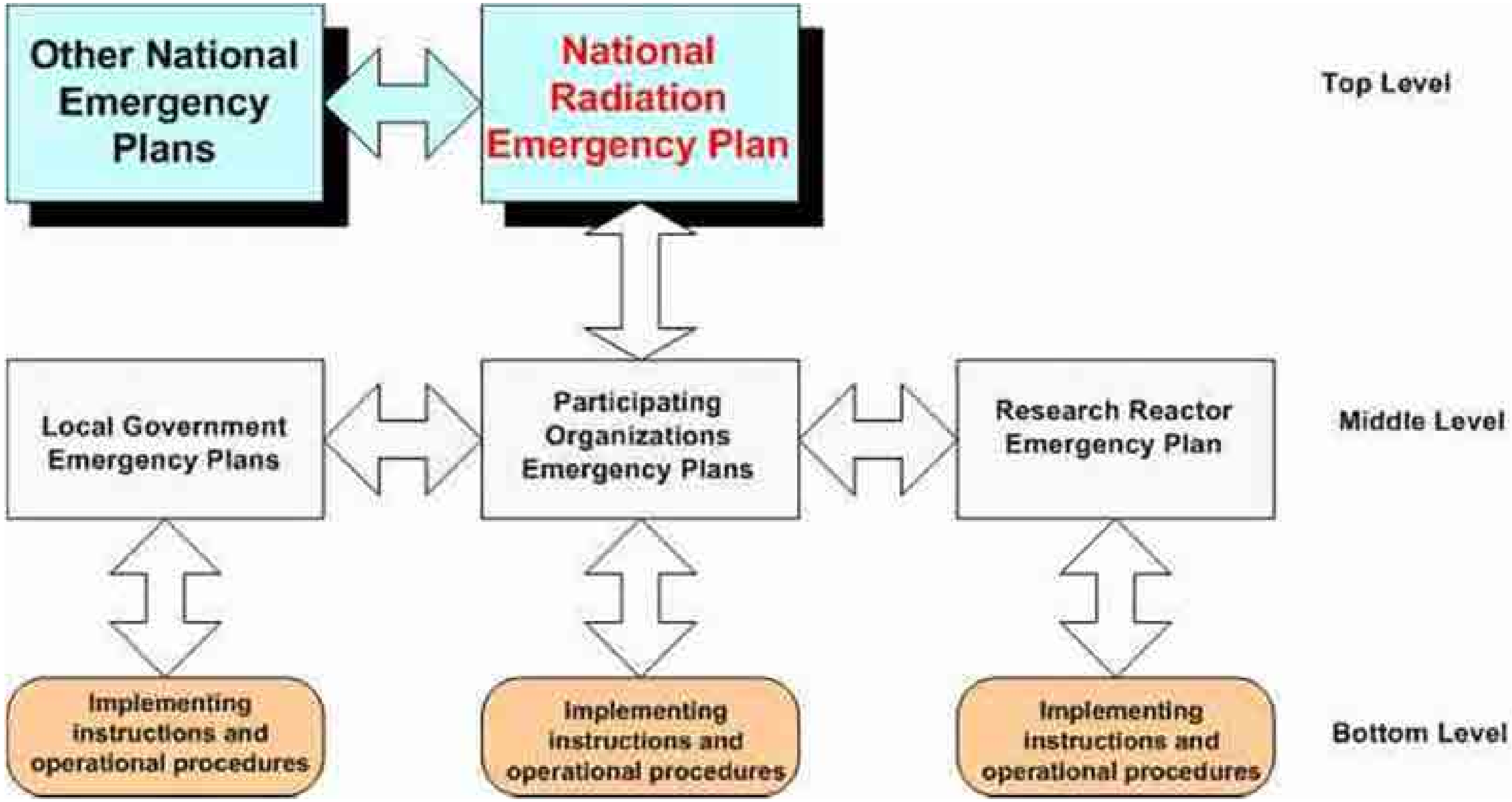
# Introduction

- **In this module suggested plan outlines at national, local and operator level are given**
- **The objective of this module is also to explain the process of developing and writing procedures**

# Content

- Outline of a Generic Radiation Emergency Plan
- Developing a procedure
- Writing a procedure
- QA system for procedures
- Summary

# Overall Emergency System



# Generic Radiation Emergency Plan

- **The REP is a description of the roles and responsibilities of all the responding organizations and their relationships**

- **Level of detail will vary between National, Local and Facility plans (see EPR-METHOD 2003)**

# REP Outline

- **Title (cover) page**
- **Table of Contents**
- **Chapter 1: Introduction**
- **Chapter 2: Planning Basis**
- **Chapter 3: Emergency Response Basis**

# REP Outline – Cont'd

- Chapter 4: Emergency Preparedness Process

- References
- List of Abbreviations
- Distribution List
- Appendices

# Title (Cover) Page

- Title of the plan
- Version No.
- Approval date
- Validation date
- Signatures

# Chapter 1: Introduction

- Purpose
- Participating organizations
- Scope
- Legal Basis
- Related plans and documents

# Chapter 2: Planning Basis

- Types of the threats
- Terms
- Response roles and responsibilities
- Response organization
- Response facilities
- Response communications
- Logistics/resource commitments
- Concept of operation

# Chapter 3: Emergency Response Process

- **Notification, activation and request for assistance**
- **Emergency response management**
- **Taking Urgent Protective Actions**
- **Warning and informing the public**
- **Protecting Emergency Workers**
- **Providing medical assistance**

# Chapter 3: Emergency Response Process (cont.)

- **Assessing the early phase**
- **Keeping the public informed**
- **Taking agricultural, ingestion and loner term protective actions**
- **Conducting recovery operations**
- **Financing**
- **Maintaining records and data**

# Chapter 4: Emergency Preparedness Process

- **Authorities and responsibilities**
- **Organization**
- **Co-ordination**
- **Plans and procedures**

# Chapter 4: Emergency Preparedness Process (cont)

- Logistic support and facilities
- Training
- Exercises
- QA and program maintenance

# Additional Information

- References
- List of abbreviations
- Distribution list

# Appendices

- Authorities, Responsibilities and Capabilities of Organisations
- Agreements
- National Guidance
- Maps, planning zones
- Emergency classification system
- Protective actions and OILs
- Facilities and Specialized Radiological Resources
- Implementing Procedures
- Supporting Documentation

# Procedures (Action Guides)

- A procedure is a step by step description of the actions
- The procedure should be:
  - Connected to your response plan
  - Integrated into a system
  - Easily readable and traceable
- A procedure is not a stand-alone document, it is an instruction that implements parts of the response plan

# Why We Need Procedures

- To organize the responses and list all the actions that may need to be taken
- Without written documentation the response system can be dangerously ineffective
- Procedures form basis for training the emergency staff

# Write the Procedure

- **EPR-RESEARCH REACTOR provides suggested procedures for research reactors (called Action Guides) and they are generic, that is, focused on actions and not site details**
- **The procedure must be written in a manner suitable for the user, so adapt to your facility**
- **A balance between training needs and details in the procedures must be found.**

# QA System for Procedures

- There needs to be a system for preparation, approval, release and distribution of procedures
- Changes to the procedures need to be controlled
  - Reviewed, approved, released and distributed regularly

# Train the Staff

- **Approved procedures should not be implemented immediately**
- **Before procedure become effective, staff will need to be trained**

# Maintain up to Date

- **Procedures are not static**
- **They need to be reviewed, updated, approved, released and distributed regularly**
- **Measures should be provided for ensuring those performing a procedure are aware of and use the appropriate, correct procedures**

# Example Action Guide

**ACTIONS**

***Assess the situation and classify the emergency***

- o Receive a briefing from the individual(s) who discovered the emergency or the Facility Response Manager if relieving that individual.
- o Question thoroughly to understand the scope of the emergency.

**NOTE**

Activating the Facility Response Manager position is the transition from normal reactor operations to site emergency response.

- o Verify the appropriate reactor emergency operating procedure is in progress or is complete.
- o Consider immediately requesting assistance appropriate to the event, for example the fire brigade or police.
- o Using Table A.1 review a recommended classification from the Nuclear Condition Analyst and determine the appropriate class of the emergency. Emergency classification is expected within 15 minutes of identification that an emergency exists.
- o Assemble the necessary emergency response team and initiate the response using Table A.2 to determine priorities.

NOTE

Worksheet A.2 is an action item checklist that may be of assistance.

# Example Action Guide, cont

***Establish Communications***

- Inform on-site personnel and off-site authorities of the emergency. Notification is expected within 15 minutes of classification.
- Initiate on-site protective actions with recommendations from the Protective Action Manager.

**CAUTION**

Usually a release of radioactive material needs to be imminent or in progress before off-site protective actions would be proposed. Off-site authorities should be informed of the off-site environmental monitoring that determines if urgent protective actions will be recommended for off-site individuals.

- Determine if off-site individuals should take protective actions prior to determination of the radiation environment beyond the site boundary. Inform off-site authorities using Worksheet C.5 if only preparations for urgent protective action are advised, or Worksheet C.6 if urgent protective actions are recommended.
- Review status of on-site protective actions and Priority 2 and 3 actions with the Radiological Protection Manager, the Communicator and the Nuclear Condition Analyst.

# Example Action Guide, cont

**ACTIONS**

- For an ongoing emergency, review current radiological status and receive a briefing from the departing Protective Action Manager and Projection Analyst.
- Verify expected activity for the next shift with the Facility Response Manager.
- Recommend on-site protective actions from Table C.1 after the emergency classification has been made by the Facility Response Manager. Record the recommendations and completion of implementation of the recommended actions on Worksheet C.4, On-site Protective Actions.
- Evaluate the need for urgent protective actions for off-site personnel. Recommended urgent protective actions for off-site populations are provided to the appropriate off-site authorities with a copy of Worksheet C.6, Recommended Off-site Protective Actions.

# Summary

- **Suggested plan outlines have been presented**
- **Other formats or structures can be entirely adequate**
- **The structure of the radiation emergency plan should be consistent with that of other existing emergency response plans**

# Summary

- Procedures are needed to carry out the emergency response plan
- A procedure is a step-by-step description of the actions
- A procedure is not a stand-alone document
- A formal system for preparation, approval, release, distribution and maintenance of both plans and procedures should be in place

# Where to Get More Information

**IAEA EPR-METHOD 2003**

**IAEA EPR-RESEARCH REACTOR**

**IAEA TECDOC-1162**

**IAEA GS-R-2 AND GS-G-2.1**

# Emergency Preparedness and Response

# Discussion Problems

## Work Session

# Question 1

- Inadvertent criticalities can cause more damage to a research reactor than to a nuclear power plant.
- Agree or Disagree – WHY?

# Question 2

- Research reactors are less susceptible to loss of flow accidents than a nuclear power plant.
- Agree or disagree – WHY?

# Question 3

- In 1983 an operator at the RA-2 reactor in Argentina violated operating procedures during a modification of the core configuration and caused a critical excursion. The reactor became prompt critical and the operator was exposed to a fatal dose of radiation. What might be the root cause of this event?

# Question 4

- **Table C.2, Protective Actions based on Environmental Measurements, proposes sampling locally grown produce, water and milk from local grazing animals out to 10 times the distance that OIL3 is exceeded. Why is this appropriate?**

# Question 5

- **What are the benefits of sheltering while awaiting environmental monitoring results when a release has occurred or is imminent as opposed to immediately evacuating the population from the UPZ.**

# Question 6

- **An Emergency Worker returns from an emergency intervention task. No contamination is found. The three TLDs on the individuals chest, back and waist show an average of 127 mSv and a self-reading dosimeter located on the chest reads 90 mSv. The expected dose for the intervention was 90 mSv. Are any additional actions required?**

# Question 7

- **Same as the previous question except the average of three TLDs is 55 mSv and the highest reads 62 mSv. The self reading pocket dosimeter, 200 mSv full scale, is off-scale high and the worker states that it was dropped. Expected dose was 125 mSv. Are any follow-up actions required?**

# Question 8

- **Measurements 1.2 km from the release point show 1.5 mSv/h gamma dose rate from deposition. How far from the release point would you project exceeding OIL1? OIL2?**

# Question 9

- **A fire in the Control Room for the reactor has damaged or destroyed all instrumentation. The reactor was scrammed and the operators observed rod bottom lights before evacuating. Portable instruments show no abnormal radiation levels. Only NC flow and losses to ambient are available to remove decay heat. Classify the event.**

# Question 10

- Piping located below the elevation of the core fails and cannot be isolated from the reactor tank. Makeup water flow rate is insufficient to replace the leaking water. Classify the event.

# Question 1

Answer:

- **The question has many answers, so treat the question as a starting point for discussion. One response is that an inadvertent criticality has the potential for very high power levels relative to the design power level of the fuel elements. Another is that past experience shows that more frequent manipulation of reactor components in a research reactor, as compared to a nuclear power plant leads to errors, and usually the individuals doing the movement are at a high risk of radiation exposures.**

# Question 2

Answer**:**

- **This is another question that can lead to discussion. Anticipated answers include availability of natural circulation and low decay heat, depending on reactor design and operating power.**

# Question 3

Answer**:**

- **One might wonder why the operator made such a serious mistake and was in violation of procedures when he caused the accident.**
- **Anticipate some answers such as:**
  - **poor safety culture, no oversight of operations and feedback of needed improvement**
  - **"This is how we really do the work, the procedures are just in the way"**
- **lack of supervision**

# Question 4

Answer

- **A release may deposit hot spots or other unevenly distributed radioactive contamination. Sampling beyond areas with recognized excessive contamination is performed to identify, or refute, this potential concern. Negative results are also a benefit to public confidence and reduce psychological concerns in the potentially affected areas.**

# Question 5

Answer

- **The UPZ is chosen to identify areas that have a lesser risk of radiological consequences than the zone nearer the facility. Evacuation is disruptive and probably not necessary for most, perhaps all, of the UPZ. Therefore, monitoring is used to make an evacuation decision in this zone. Sheltering is much less disruptive, provides some protection from radiation, and allows people to prepare for evacuation if that becomes necessary.**

# Question 6

Answer

- **In this case the TLD readings are as valid as the pocket dosimeter and are >100 mSv. The Emergency Worker should be enrolled in a tracking system with medical follow-up to detect early signs of stochastic effects.**

# Question 7

Answer

- **Judgement would believe the TLDs and reject the reading on the potentially damaged pocket dosimeter, so no medical follow-up would be appropriate. What other factors should one consider? Discuss.**

# Question 8

## Answer

Projections use Worksheet C.3 for simple linear distance extrapolation (no rain) or square root extrapolation for rain conditions. Then:

| Measured | At | Project | No rain | Rain |
|---|---|---|---|---|
| 1.5 mSv | 1.2 km | OIL1 | $1.2km \times \left(\frac{1.5mSv}{1.0mSv}\right) = 1.8km$ | $1.2km \times \sqrt{\frac{1.5mSv}{1.0mSv}} = 1.5km$ |
| | | OIL2 | $1.2km \times \left(\frac{1.5mSv}{0.1mSv}\right) = 18km$ | $1.2km \times \sqrt{\frac{1.5mSv}{0.1mSv}} = 4.6km$ |

# Question 9

**Answer:**

**Use the classification Table:**

- **Facility Emergency due to loss of control and instrumentation.**
- **could elevate to Site Area Emergency, need to evaluate potential for fuel damage**

# Question 10

**Answer:**

**Use the classification Table:**

- **Alert – level decreasing, but**
- **Facility Emergency unless leak can be stopped or additional makeup provided**
- **could escalate if level drops to the point where radiation levels increase or fuel may be uncovered**

# Development of a Response Capability

# Development and Implementation of an Action Plan

## Seminar

# Introduction

- This workshop presented the scope of emergency planning
- You need to define what comes next
  - That will become YOUR action plan
- And you need to define how it will be implemented
  - That is your project management plan

# Content

- What is an action plan?
- Project management fundamentals
  - What is project management?
  - Project management contents
  - Project management process
- Generic action plan

# Overview

- **What Is an Action Plan?**
  - **It is the steps to get from here to there**
    - **It is a project, or part of a project**
    - **It should be defined, developed and implemented according to good project management procedures and guidelines**
  - **Your mission after this workshop:**
    - **Define what needs to be done (action plan)**
    - **Define how it will be done (project management plan)**

# What Is Project Management?

- It is a way to develop, implement, control and monitor the implementation of an action plan
- Without a good project management framework, actions plan implementation will not be effective

# Components of the Project Management Plan

- Objectives
- Scope
- Milestones
- Tasks
- Responsibilities
- Schedule
- Budget
- Project control
- Risk management

# Project Management Plan

## Objectives

- What do you want to achieve - the overall results
- Objectives should be:
  - Specific
  - Measurable
  - Realistic and achievable
  - Agreed
- Example:
  - Adapt and implement new emergency response procedures for research reactor emergencies

# Project Management Plan
## Scope

- Clarifies the extent of the objectives
- Defines the boundaries of the project:
  - What is included?
  - What is not included?
- Example:
  - This project will address the radiological aspects of emergency management. It does not include conventional training for emergency response personnel, which is assumed to be well covered by other programs

# Project Management Plan
## Milestones

- Define the intermediate results that must  be achieved to get to the final objective
- Example:
  - Generic plan modified
  - Generic procedures adapted
  - Training program defined
  - Training schedule promulgated
  - Training completed
  - Validation completed
  - Project evaluation completed

# Project Management Plan
## Tasks

- Define the work breakdown required to achieve individual milestones
- Example: to adapt procedures
  - Distribute generic procedures for review
  - Review generic procedures
  - Collect comments from reviewers
  - Produce draft 1 of adapted procedures
  - Send for review
  - Meetings of reviewers
  - Produce final draft
  - Distribute final draft

# Project Management Plan
## Responsibilities

- **Defines who is responsible and accountable for which task**
- **Designates support persons or organizations**

# Project Management Plan

## Responsibility Matrix

| Activity | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Send invitations | P, X | | I | |
| Procure equipment | C | P | X | D |
| Train technicians | | X | P | |

P : Manages Progress
X : Does
D : Decides
d : Decides jointly
I : Must be informed
C : Must be consulted
A : Available to assist

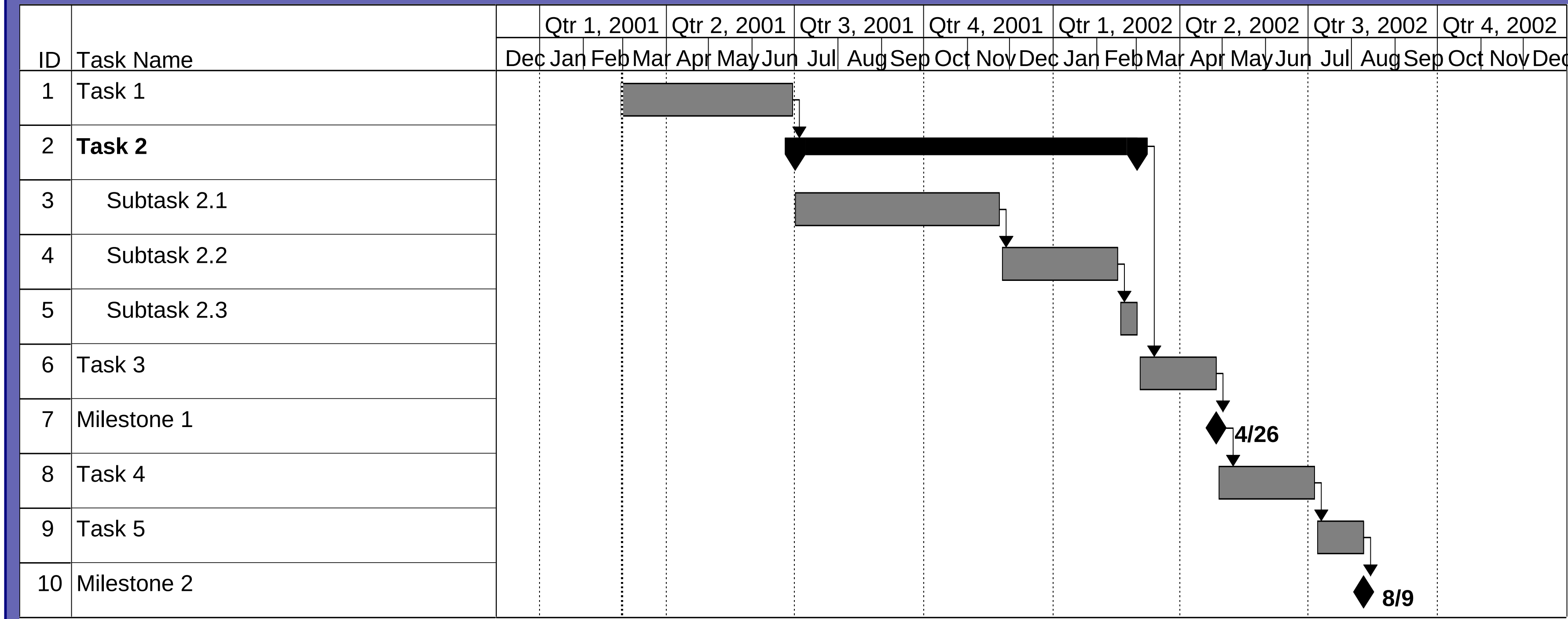
# Project Management Plan
## Schedule

- **Define the time available for each task and the dates at which milestones must be achieved**

- **Baseline vs actual**
  - **Schedule may change but milestones and tasks do not normally change**

# Project Management Plan

## Schedule (Example)



# Project Management Plan
## Budget

- Identifies the cost of the project
  - Total budget available
  - Estimated cost of each task
  - Management budget
  - Contingency fund
- Depending on the budget available, the scope may need to be adjusted
- Consider “real” cost
  - Cost of people
  - Travel, equipment and other expenses

# Project Management Plan
## Project Control

- A way to track progress and determine if corrective actions need to be taken
- Project schedule tracking:
  - Is the project on time?
- Project cost tracking:
  - Is the project within the initial budget estimate

# Project Management Plan

## Project Control (Schedule Tracking)

- Compare actual task achievement with project schedule
- If tasks are late, determine the impact on the other tasks
- Determine impact on overall project
- Make adjustments:
  - Adjust schedule OR
  - Adjust level of efforts

# Project Management Plan
## Project Control (Cost Tracking)

- **Once a month:**
  - **Estimate actual spending so far: this is the "actual cost of work performed" or ACWP**
  - **Estimate degree of completion of each task:**
    - **0, 25%, 50%, 75% or 100%**
  - **Calculate "budgeted cost of work performed" or BCWP = SUM (task budget x degree of completion)**
  - **If ACWP > BCWP, you may have a problem. Make adjustments!**

# Project management plan
# Project control (Cost tracking)

| Task | Planned budget | Percent completed | BCWP |
|---|---|---|---|
| Task 1 | $10 000 | 0% | $0 |
| Task 2 | $5 000 | 50% | $2 500 |
| Task 3 | $20 000 | 75% | $15 000 |
| Total | $35 000 | | $17 500 |
| ACWP = $20 000 | | | |
| ACWP/BCWP = 1.14 | | | |

In this example, the project is about 14% over budget

# Project Management Plan

## Risk Management

- Defines what could go wrong and how to deal with it:
  - What could delay the project or make it more expensive?
  - What can we do to prevent these things from happening?
  - What do we do if these things happen?

# Project Management Process

- Determine the objectives
- Appoint a project manager
- Develop a preliminary project plan and budget estimate
- Get funding
  - You may need to scale up or down the project objectives and scope

# Project Management Process

- Develop project management plan
- Communicate project management plan
- Discuss responsibilities with main project organisations and personnel
  - Adjust project management plan as required
  - Get their <u>formal</u> agreement on their responsibilities
- Implement
- Monitor and adjust
- Evaluate

# Generic Action Plan
## EPR-METHOD 2003 and Module 15

- National policy review
- Determine level of preparedness
- Develop planning basis
- Allocate responsibilities
- Write National Plan
- Inform all organizations
- Form and train interim response group
- Develop and implement detailed plans
- Coordinate and test plans and procedures
- Develop and implement ongoing updating and training programmes

# Potential Problems

- Insufficient support for project
- Poor project definition
- Planning tools are too complex
- Planning time scale is too long (or too short)
- Planning of time and cost are over-optimistic
- Distribution of responsibility is not defined
- Principles of co-operation are not clear

# More Potential Problems

- Key resources are not available or not motivated when needed
- Line managers are not committed
- Project leader is a specialist and not a manager
- Project leader has responsibility but no authority
- Changes to the plan are uncontrolled
- Activities are not completed and documented before others begin

# Summary

- This lecture presented the way how to develop and implement an action plan
- The main points important to note are:
  - You are asked to develop an action plan based on what you learned in this workshop
  - Carry out the action plan based on sound project management principles
  - Remember the contents of a project management plan
  - Project management also includes validation, control and evaluation
- Comments are welcomed

# Where to Get More Information

- **Modules 12, 15 and 16 of the current Course**

IAEA Training Course for Research Reactor Emergency Response

# Tabletop Exercise

# Exercise Preparations

# Ground Rules

- Three rooms for this exercise
  - Reactor facility
    - Reactor Control Room at first
    - Facility Emergency Center after Reactor Hall evacuated
  - Off-site Emergency Center
  - Standby Room

# Emergency Centers

- On-site and Off-site response teams report to the appropriate room when informed of the emergency
- Use phones to contact other response team
- If phones busy, use runners with written messages
  - Be sure to write time and person to receive the message on the message

# Phone Numbers

- Facility Emergency Center
- Off-site Emergency Center
- Standby Room
  - Hospital
  - All other

# Standby Room

- **All participants except operators and one health physics technician start in the Standby Room**
- **Two operators and one health physics technician start in the Reactor Control room**

# Controllers

- **Four Controllers:**
  - **Operators –**
  - **Facility Emergency Response Team –**
  - **Radiological Protection –**
  - **Off-site response team –**

# Evaluators

- **Off-site Group -**
- **Facility Group –**
- **Overall exercise –**

# Message Guidance

- Announcements to on-site and media to be written out, with time of the announcement, signed by the response team leader, and given to the controller for that organization
- If the controller doesn't have a signed message in writing, it is as if the information was never distributed
- Please write the messages in English

# Message Guidance, continued

- Identify who will receive incoming messages for the team
  - Facility Team
  - Off-site Team
- At the Facility who will be in charge of Radiological Protection?

# Other guidance

- **Asking for data may not be answered by your controller if you do not give instructions to someone to obtain the information, collecting environmental monitoring data is one example**
- **Monitoring results will be delayed for some time to simulate the actual work to obtain the information**

# Other guidance

- **Monitoring teams – when directed to obtain survey data, inform the Radiological Protection controller, then leave the room and wait in the hall outside**

- **Retain all written materials, such as worksheets and logbooks**

# Initial Facility Conditions

- **Reactor operating at full power of 10 Mw**
- **Tellurium dioxide (180 gm) capsules installed and have been irradiated for 200 hours**
  - **Irradiation flux – 2E14 n/cm$^2$/sec average**
  - **Capsule heating – 5 watts/gm**
- **Visitors from local school expected in the late morning**

# Ready, Set, Train!

- The two response teams, facility and off-site, now have at least 90 minutes to train themselves, in separate locations, to be a response team.

# Conclusion

- **Any questions?**

IAEA Training Course for Research Reactor Emergency Response

# Tabletop Exercise

# Controller and Evaluator Training

# Ground Rules

- Your copies of the Exercise Guide are not to be shared with the other players
- Notes on actions aren't very useful unless they have a time associated with them
- Three rooms for this exercise
  - Reactor facility
    - Reactor Control Room at first
    - Facility Emergency Center after Reactor Hall evacuated
  - Off-site Emergency Center
  - Standby Room

# Scenario

- Capsule being irradiated in the reactor ruptures, release is radio-iodine, some to the environment
- Alarms and increased radiation levels in the reactor hall
- Operators expected to shutdown reactor, isolate the hall, and evacuate
- One of two technicians injured during evacuation, also is contaminated
- What happens next is up to the responders

# Expected Immediate Actions

- Expect the operators to:
  - contact site emergency response team
  - may contact off-site
  - may ask for ambulance
- Emergency Response Team may:
  - interview operators to understand situation
  - notify all site personnel
  - may evacuate site staff to assembly areas
  - contact off-site unless already complete
  - request ambulance
  - direct surveys be performed
  - consider reentry to search for others

# Expected Actions

- Site subsequent actions could include
  - receive and assess survey data
  - inform off-site that no risk to public
  - try to deal with the reluctant hospital
  - consider reentry to assess conditions
  - start press release
  - send school children back
  - notifications to others (school, family of injured technician)

# Planned Distractions

- Reporters wanting information
- Distraught site personnel in Clinic
- Wild rumors on the news
- Distraught wife of injured technician
- Worried school administrator
- Unwanted protective action recommendations
- Concern for city water supply

# Injects

- Follow the Master Event List and release you information injects on time
- You might want to highlight your inject actions on the Master Event List
- All injects have a time to initiate expressed as H:MM after start of the exercise

# Master Event List

- We are unlikely to change the injects if they seem inappropriate, but we may delete some, please consult with the IAEA Controller if you think that is advisable

- Lets take several minutes to review each event on the list

# Radiological Protection Coordinator

- Start in the simulated Reactor Control Room
- Monitoring teams are asked to inform you when they are directed to perform surveys
- Ask what protective actions they were told to implement
- Provide the data after several minutes, see the Injects
- If Section 5 doesn't have the data, the readings are background

# Operator Controller

- No additional support until the operators tell you who they will call, and place a phone call to the Standby Room to ask for that support.
  - On-site response team may be a single call
  - Off-site response team may be a single call, but must be a separate call
- Note if the operators make a classification, don’t prompt them for one

# Controller with on-site Response Team

- Start in the Standby Room, move to the response team room when the team get notified
- Observe the turnover from the operators, what information is exchanged
- Note if classification is announced, but don't prompt for one
- Response teams asked to write out and sign announcements and news releases and give them to you
- Please inform the IAEA controller of significant announcements to on-site personnel and of any press release

# Controllers with off-site Response Team

- Start in the Standby Room, move to the response team room when the teams get notified
- Response teams asked to write out and sign announcements and news releases and give them to you
- Note if the off-site response team is informed of the emergency class
- Please inform the IAEA controller of announcements to on-site personnel and of any press release

# Reporter

- Be aggressive in asking questions
- If you feel comfortable, act as if you don't believe the answers to your questions
- At one point, attempt to enter the room where the response team is working to ask questions
- If allowed to talk to the facility emergency team, attempt to talk to the off-site team to compare information

# Concerned Public

- These are:
  - Facility Medical Clinic
  - Concerned wife of employee
  - School
- Work from the Standby Room
- Attempt to use the phone, but if you can't connect due to busy phones, provide the inject to the controller associated with the group you are trying to contact

# Hospital Simulator

- Work from the Standby Room
- No hospital support will be provided until Inject 190 at T+2:10, same for ambulance transport
- Only provide support if site agrees to the conditions listed in Inject 190

# Critique

- Prompt and brief critique after the exercise
- More detailed critique Friday morning
  - Please prepare written comments for this, be thoughtful and objective
- The responders may be asked to deliver a press briefing within a specific time after the end of the exercise.

# Conclusion

- **Any questions?**