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# Planning basis, hazard assessment and emergency preparedness categories

**IAEA-KINS Workshop on the Emergency Preparedness and Response to Nuclear and Radiological Emergencies**

**19 - 23 June 2023, Daejeon, Republic of Korea**

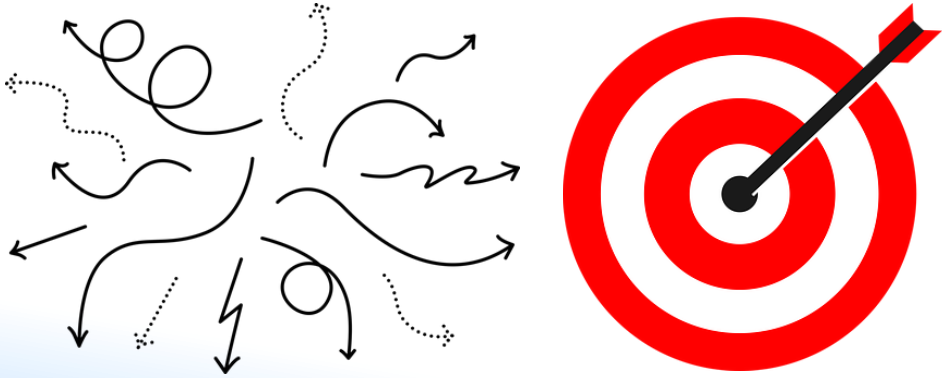
# Planning basis: What is it?

- Relevant information at national, regional and local levels and, where appropriate, at the international level
  - Input to the hazard assessment, development of the protection strategy and overall emergency preparedness

- Overall planning basis includes the results from hazard assessment and drivers of EPR (i.e. EPR goals)

# Emergency response goals as driving principles

- The protection strategy must aim to achieve all the emergency response goals
- Emergency response goals will:
  - Drive the priorities at any time of the emergency response and thus, support decision-making
  - Help identifying appropriate actions to be taken and activities to be conducted in any phase of the emergency



# Goals of emergency response
# GSR Part 7

- To regain control of the situation and to mitigate consequences
- To save lives
- To avoid or to minimize severe deterministic effects
- To render first aid, to provide critical medical treatment and to manage the treatment of radiation injuries
- To reduce the risk of stochastic effects
- To keep the public informed and to maintain public trust
- To mitigate, to the extent practicable, non-radiological consequences
- To protect, to the extent practicable, property and the environment
- To prepare, to the extent practicable, for the resumption of normal social and economic activity

# Means to achieve the goals of emergency response

| Goals of emergency response | Methods of achieving the goal |
|---|---|
| **To regain control of the situation and to mitigate consequences** | Taking measures and actions to prevent, delay and/or reduce the release of radioactive material and exposure of individuals. |
| **To save lives** | Taking actions to save the life of individuals involved in the emergency and provision of prompt medical care. |
| **To avoid or to minimize severe deterministic effects** | Taking urgent protective actions and other response actions to keep the dose below the threshold for severe deterministic effects. In many cases, these protective actions are most effective when taken before, or shortly after, a significant release of radioactive material from a facility or an exposure. |

# Means to achieve the goals of emergency response (cont'd)

| Goals of emergency response | Methods of achieving the goal |
|---|---|
| **To render first aid, to provide critical medical treatment and to manage the treatment of radiation injuries** | Ensuring that the first to arrive at the site qualified to immediately provide first aid. Later, specialized treatment of radiation-induced injuries to be provided by medical specialists. |
| **To reduce the risk of stochastic effects** | Taking protective actions and other response actions to reduce the risk of stochastic effects below levels at which incidence of radiation induced cancers is discernible. Thereafter, keeping the doses as low as reasonable achievable. |
| **To keep the public informed and to maintain public trust** | Providing the public with timely, useful, truthful, consistent and coordinated information about the emergency and emergency response actions, using simple and easily understandable language. |

# Means to achieve the goals of emergency response (cont'd)

| Goals of emergency response | Methods of achieving the goal |
|---|---|
| **To mitigate, to the extent practicable, non-radiological consequences** | Implementing proper public communication strategy, providing social support and consider consequences in overall justification and optimization processes. |
| **To protect, to the extent practicable, property and the environment** | Taking measures to limit the spread of contamination and ensuring that any remedial actions taken to reduce the environmental impact (e.g. decontamination) do more good than harm. |
| **To prepare, to the extent practicable, for the resumption of normal social and economic activity** | Taking various actions and activities that provide for radiation protection to the public as well as for normal living conditions (including promoting resumption of social and economic activity and rebuilding necessary infrastructure). |

# Emergency response goals as driving principles (cont'd)

- Emergency response goals to guide the development of the protection strategy and associated emergency arrangements to be agreed at national level and stipulated at front in the protection strategy:
  - It will help all concerned parties have a common understanding of what they aim to achieve when undertaking the agreed response functions they are responsible for


# Planning basis (cont'd)

- Planning basis is likely to have been gathered in preparing the present emergency arrangements in a State
  - It may be used directly or updated as appropriate for the purposes of developing the protection strategy
- Those States that did not do so before, will have to compile all the planning basis before they will embark on developing the strategy

# Planning basis (cont'd)

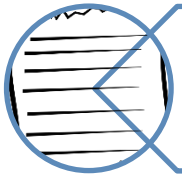
- The level of details gathered in the planning basis will vary depending on its use
  - Not too detailed for the purpose of development of a generic protection strategy
  - More detailed for the purpose of establishing comprehensive operational arrangements

# Planning basis: Who may own relevant information?

- Various organizations at national, regional and local level including:
  - Relevant bodies and organizations in neighboring countries
  - The regulatory body
  - Operating organizations

- All holders to be consulted on data and information they have
  - Conditions under which they can provide the information and data and the manner in which it can be used needs to be agreed

# Planning basis: What does relevant information and data encompass?



The governmental, legal and regulatory framework in a State

The characteristics of the facilities, activities and sources that can give rise to an emergency

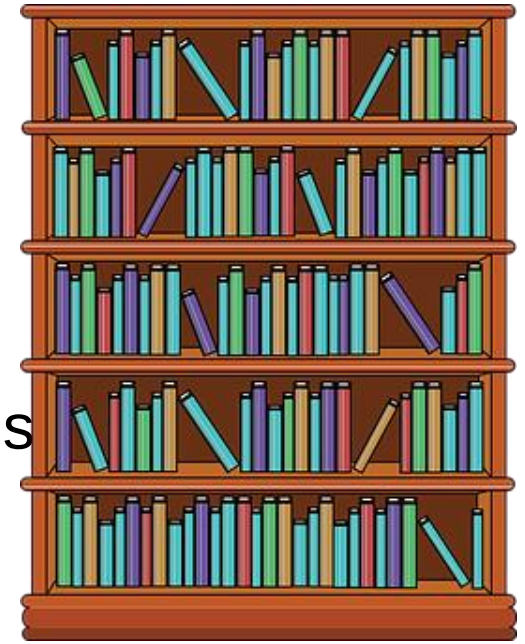
The characteristics of areas that may be impacted and of locations where emergency response actions may be warranted

The resources and infrastructure available to support the implementation of the strategy

Experience

# Governmental, legal and regulatory framework

- Identification of relevant obligations, assigned responsibilities, expectations and any associated constrains set forth in:
  - National legislation and regulations
  - Applicable international conventions
  - Applicable multilateral or bilateral agreements
- Review of applicable international standards and identified best practices

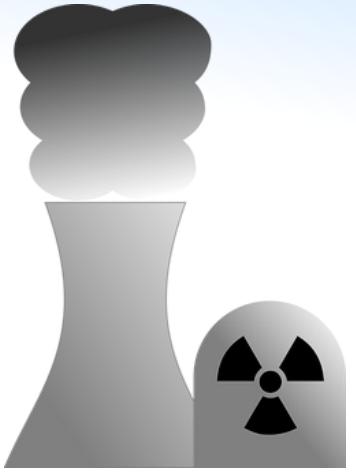


# Governmental, legal and regulatory framework (cont'd)

- Examples to look for:
  - What criteria are set up in national regulations for public protection in an emergency?
  - What provisions should be fulfilled for protection of emergency workers and by whom?
  - Where do responsibilities for decision making on public protective actions and for their implementation rest?
  - What the existing provisions for waste and radioactive waste management are?
  - Who is entitled to own information on transportation systems, land uses, special facilities, population distribution etc.?

# Characterization of facilities, activities and sources

- Inventory of facilities, activities and sources that may give rise to an emergency in the State, including:
  - Locations, transport activities and routes etc.
- Characteristics of these facilities, activities and sources including:
  - Activity, power, associated non-radiological hazards (chemical, physical, biological)
  - Previous analyses of hazards/risks (e.g. safety analysis reports, operator's hazard assessment)



# Characterization of potentially affected areas and relevant locations

- Characterization of areas/locations where emergency response actions may be warranted
- Compilation of information about:
  - Land use (urban, rural, agricultural)
  - Population distribution and habits
  - Location and type of any special facilities (e.g. chemical facilities, hospitals, prisons)
  - Meteorological data
  - Typical housing etc.

# Resources and infrastructure available

## Infrastructure:

- Road and rail networks
- Temporary accommodation
- Hospitals
- …

## Technical:

- Equipment readily available
- Materials
- …

## Human:

- Number of people available
- Skills and qualifications
- …

## Financial:

- Necessary funding
- Means of making funds available
- …

# Relevant experiences

- Records from:
  - Operating experience
  - Response to any types of emergencies from the past
    - All-hazard approach
  - Conducted exercises, lessons learned and corrective actions considered

# Criteria for Determining Emergency Preparedness (EP) Categories

| EP Category | Criteria |
|---|---|
| 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 | Activities and acts with the potential to trigger a radiation emergency that could warrant protective actions and other response actions in an unforeseen location. |
| V | Areas within emergency planning zones and distances for a facility in category I or II not located in the State where the facility is located |

# Category I

- Category I: **severe deterministic health effects off site**
- Reactors with power levels greater than 100 MW(th) (power, nuclear ship and research reactors)
- Spent fuel pools that may contain some recently discharged fuel
- Facilities with inventories of dispersible radioactive material sufficient to result in severe deterministic effects offsite

# Category II

- Category II: **doses warranting taking urgent protective action off site**
- Reactors with power levels greater than 2 MW(th) and less than or equal to 100 MW(th)
- Spent fuel pools containing fuel requiring active cooling
- Facilities with potential for an uncontrolled criticality within 0.5 km of the off-site boundary
- Facilities with inventories of dispersible radioactive material sufficient to result in doses warranting taking urgent protective action off site

# Category III

- Category III: **doses warranting taking urgent protective action on site**
- Facilities with potential, if shielding is lost, of direct external (shine) dose rates of more than 100 mGy/h at 1 m
- Reactors with power levels of less than or equal to 2 MW(th)
- Facilities with inventories of radioactive material sufficient to result in doses warranting taking urgent protective action on the site

# Category IV

- Category IV: **doses warranting taking urgent protective action in an unforeseen location**
- Operators of mobile dangerous sources with potential, if shielding is lost, of direct external (shine) dose rates of more than 10 mGy/h at 1 m
- Satellites with dangerous sources
- Transport of quantities of radioactive material that would be dangerous if not controlled
- Facilities/locations with a significant probability of encountering an uncontrolled dangerous source (e.g. large scrap metal processing facilities, national border crossings, airports and seaports etc.)

# Category V

- Category V: **areas within emergency planning zones and distances in a State for a facility in:**
  - Category I or
  - Category II located in another State

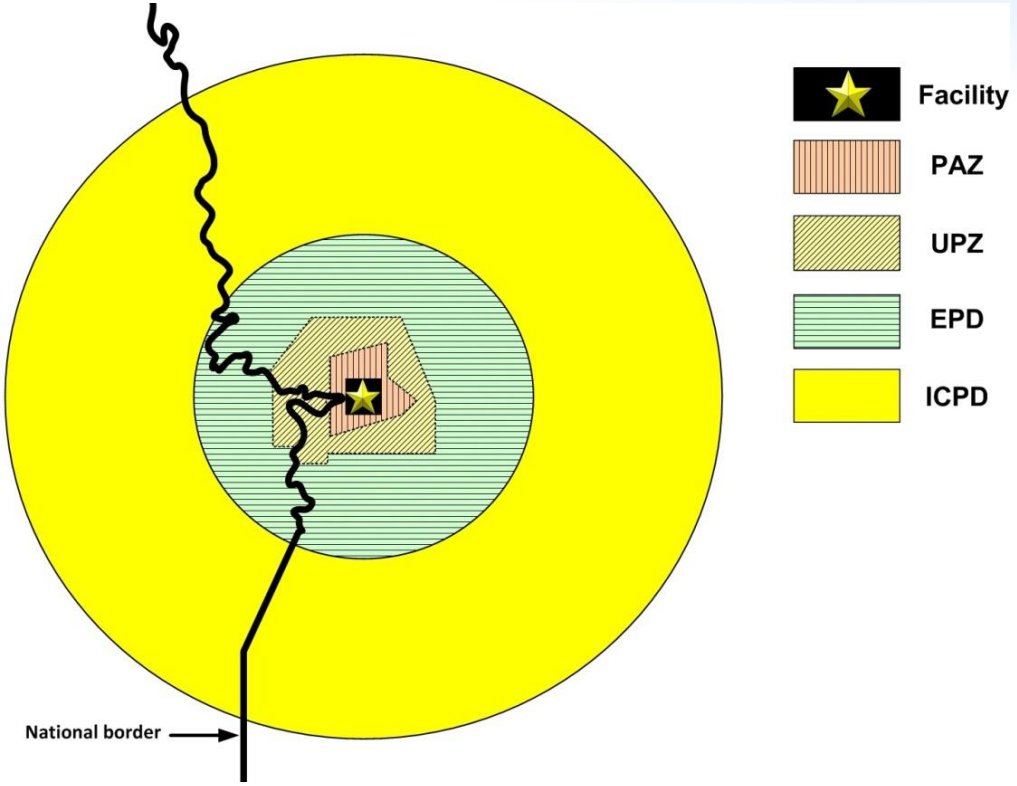
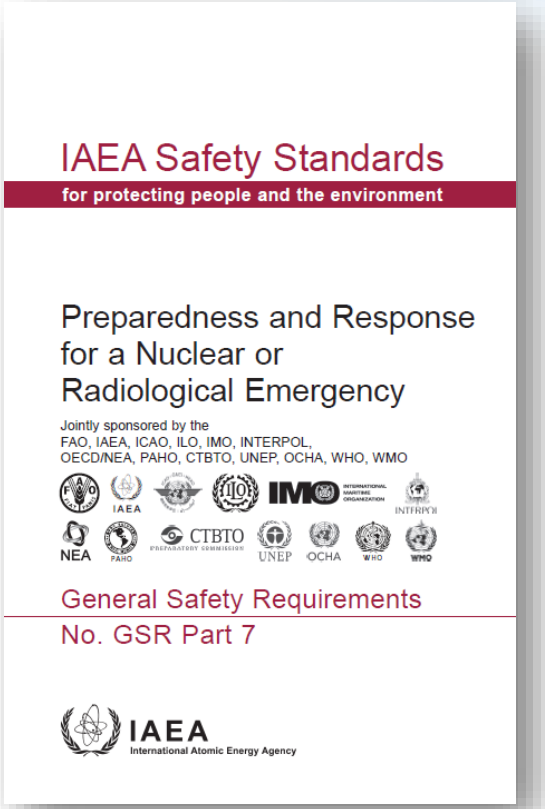



*Image courtesy IAEA*

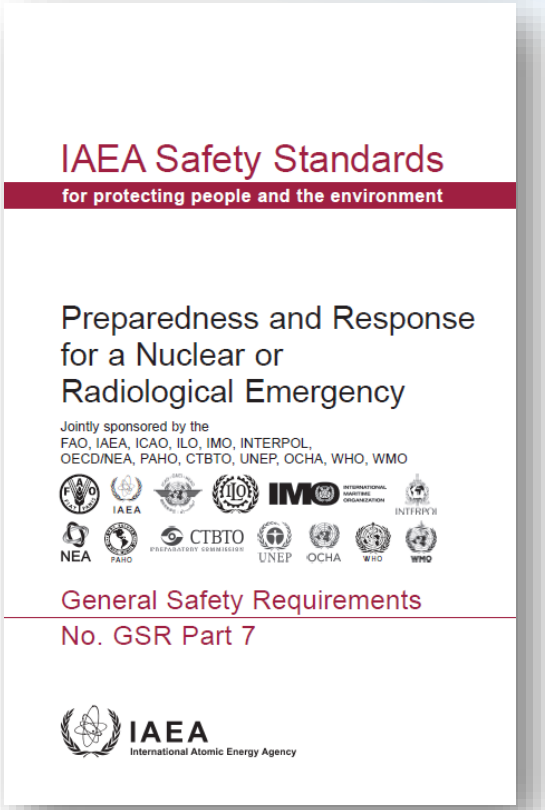
# Hazard assessment Req. 4 of GSR Part 7

"The government shall ensure that a hazard assessment is performed to provide a basis for a graded approach in preparedness and response for a nuclear or radiological emergency."



# Hazard assessment Concept

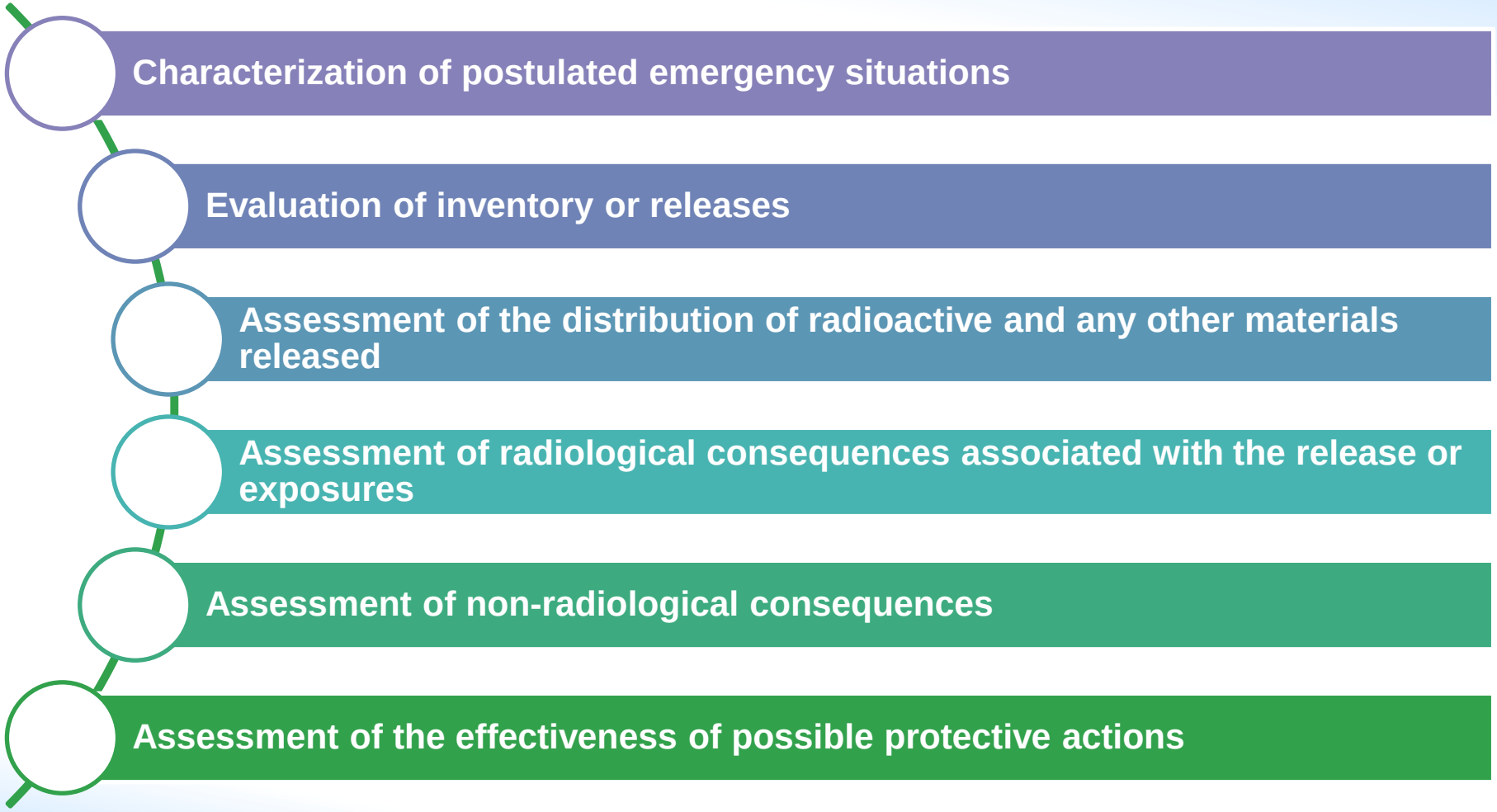
- Assessment of hazards
  associated with facilities, activities or sources within or beyond the borders of a State in order to identify:
  a. Those **events** and the associated **areas** for which protective actions and other response actions may be required within the State;
  **b.** **Actions** that would be effective in mitigating the consequences of such events.



# Hazard assessment (cont'd)

- Different approaches and methodologies for hazard assessment available
  - To be decided at national level taking into account:
    - Its implication on amount of information and data available and that needs to be gathered as part of the planning basis
    - The way in which the results and associated uncertainties are to be factored into the strategy and associated arrangements

# Hazard assessment process



# Discussion

- Have you performed detailed hazard assessment for EPR purpose at national level?
- Does it encompass all these six stages?

# Hazard assessment process (cont'd)

- Each stage calls for involvement of a range of expertise beyond EPR community
- For each stage, it is important to identify early:
  - What is the needed expertise?
  - Who can provide this expertise?
  - What inputs are expected to be provided and how?
  - How this expertise will be further taken into account?

# Stage 1: Characterization of Postulated Emergency Situations

- Aim: To identify and characterize an appropriate range of postulated emergencies for each type of facility, activity and source that may warrant prompt action to mitigate the consequences in the State

| Includes determination of: |
| --- |
| • Events<br>• Evolution<br>• Dynamics |

# Stage 1: Characterization of Postulated Emergency Situations (cont'd)

Events of very low probability but with high consequences and events not considered in the design

Events involving a combination of a nuclear or radiological emergency with a conventional emergency

Events that could affect several facilities and activities concurrently and the interactions among the facilities and activities affected

Events at facilities in other States or events involving activities in other States

Example events:

- Loss of reactor core cooling resulting in fuel damage
- Damage to spent fuel pools
- Criticality events
- Large fires and explosions
- Loss of a radioactive source
- Removal of the source from its shielding
- Malicious use of radioactive sources
- Events at ports or crossing border points

# Stage 1: Characterization of Postulated Emergency Situations (cont'd)

- Allow for preparedness and response for 'unexpected' situations with wide consequences as seen in the past
  - e.g. Fukushima Daiichi NPP accident, Chernobyl Accident etc.
- Events that are beyond those considered as part of the design or design extension conditions:
  - Resulting in emergencies for which protective actions limited in terms of lengths of time and areas of application would not be sufficient
  - Resulting in emergencies involving releases of radioactive material which cannot be kept within acceptable limits

# Stage 2: Evaluation of the Inventory

Aim: To assess the inventory of the release or source, including its chemical composition and total activity, and the projected release (e.g. proportion of the inventory and the radionuclide composition) that could arise under defined emergency conditions

- Research into fundamental chemical and physical processes involving interaction with experts outside EPR community
- Involves consideration of radionuclides present or released from the source, including decay products and of chemical and other hazards

# Stage 2: Evaluation of the Inventory (cont'd)

- Example factors in an emergency **at an NPP**:
  - The extent and type of damage to the reactor fuel
  - Conditions within the plant
  - Extent to which the fuel is cooled
  - Possibility for concurrent events happening

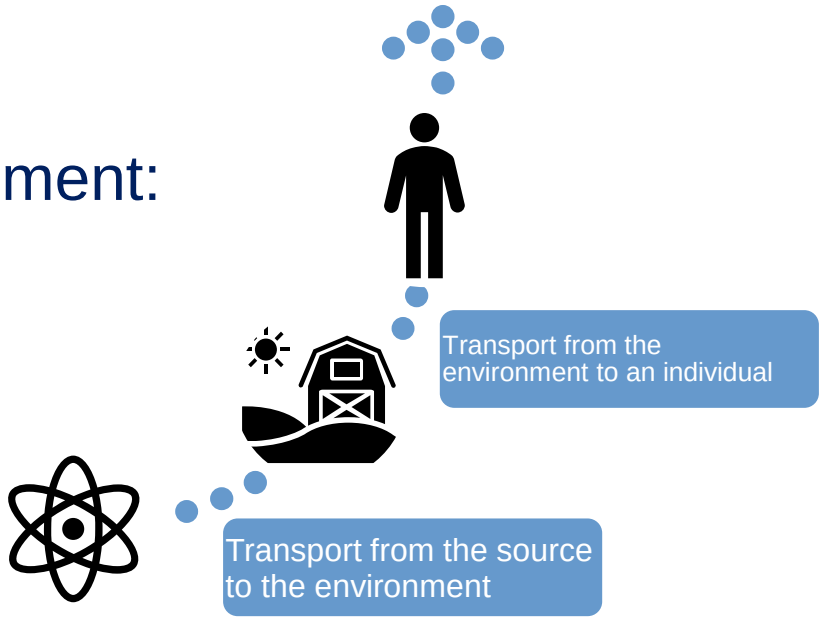
- Example factors in a **radiological emergency**:
  - Type of event and exposure scenario
  - Chemical and physical form of the source
  - Quantity of radioactive material

# Stage 3: Assessment of the Distribution of Materials Released

Aim: To consider the impact on the release during the "transport" from the source (that is the accident site) to the individual

Transport from the source to environment:

- **Direct -** the radionuclide mixes determined at the previous stage would not change significantly
- **Indirect** - the radionuclide mix is affected by a facility/source specific structure before getting to the environment



# Stage 3: Assessment of the Distribution of Materials Released (cont'd)

## Indirect Release Impact:

*For determining the impact from an **indirect** release the following factors need to be considered:*

- The behaviour of the source during the emergency progression
- The retention of any released mixes in the containment/source specific structure
- Mitigatory actions implemented
- Release pathways within the facility/source specific structure
- Other source/facility specific effects

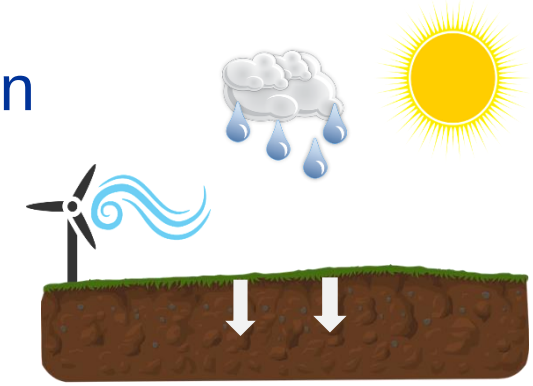
*Requires consideration of **dispersion** and **deposition** of radionuclides during the process of release and once released into the environment:*

- At the facility (e.g. plate-out)
- On the release route from the facility (e.g. spent fuel pools)
- In the atmosphere, terrestrial environment or water body into which material is released
- Environmental migration of materials from the ground or surfaces on which they are deposited

# Stage 3: Assessment of the Distribution of Materials Released (cont'd)

Transport from the environment to an individual:

- Dependent on various factors such as:
  - Characteristics of radionuclides
  - Position of specific foods in the food chain
  - Topography of the local area
  - Speed of the wind
  - Rainfall patterns
  - Processes leading to further distribution among various media
    - e.g. migration through the soil, washout by rainfall



# Stage 4: Assessment of Radiological Consequences

Aim: To assess the radiological consequences of the range of postulated emergencies being considered


- ***Exposure scenario***:
  - Helps determining who might be exposed and how, including what relevant ***exposure pathways*** are
  - Helps determining ***characteristics of representative person***

# Stage 4: Assessment of Radiological Consequences (cont'd)

- Relevant exposure pathways:

**External exposure:**

- The source
- Activity in the plume
- Deposition on surfaces
- Resuspension of deposited radioactive material

**Internal exposure:**

- Inhalation of material from the radioactive plume
- Inhalation of deposited material that has been resuspended in the air
- Ingestion of food, milk and drinking water contaminated with radionuclides
- Inadvertent ingestion

# Stage 4: Assessment of Radiological Consequences (cont'd)

- Dose calculations to be performed for representative person
  - A hypothetical construct that is characteristic of the most highly exposed individual under the assumed circumstances
  - Considers those most vulnerable to radiation exposure (i.e. pregnant women and children)

- Realistic habits of representative person associated e.g. with food consumption and consumption rate, breathing rate and other local and site-specific characteristics to be considered
  - Extreme characteristics not to be driving force

# Stage 4: Assessment of Radiological Consequences (cont'd)

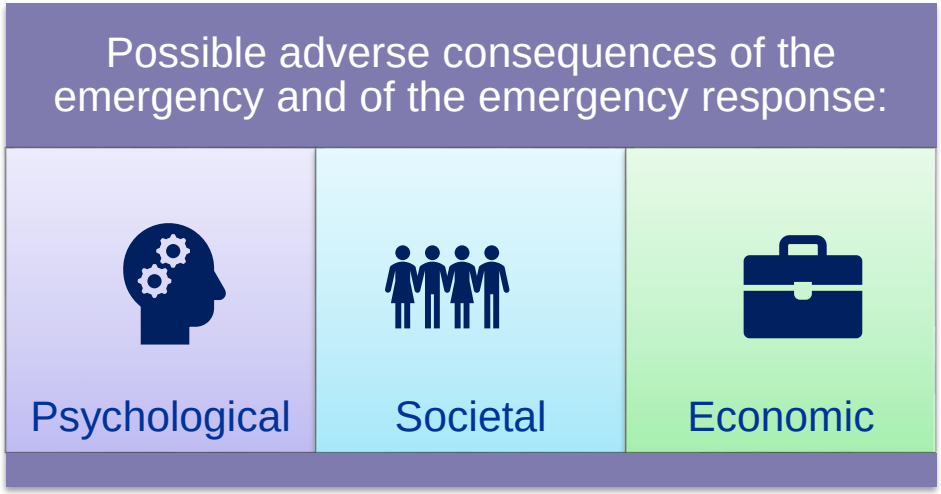
- Ensure proper diametric concepts are used and relevant dose quantities are calculated:
  - RBE weighted absorbed dose in an organ or tissue; Equivalent dose to an organ or tissue; and/or Effective dose
  - Projected and residual doses
- To prevent severe deterministic effects and to reduce the risk of stochastic effects

# Stage 5: Assessment of Non-Radiological Consequences

- Aim: To identify the range of adverse psychological, societal and economic consequences of the emergency or the emergency response

- Basis to identify suitable other response actions to support the effective implementation of necessary protective actions

# Stage 5: Assessment of Non-radiological Consequences (cont'd)




Lessons learned (*Chernobyl NPP accident, Fukushima Daiichi NPP accident, etc.)* can help identifying non-radiological consequences

Fear
Lack of trust in authorities
Lack of information

→

Adverse psychosocial consequences

→

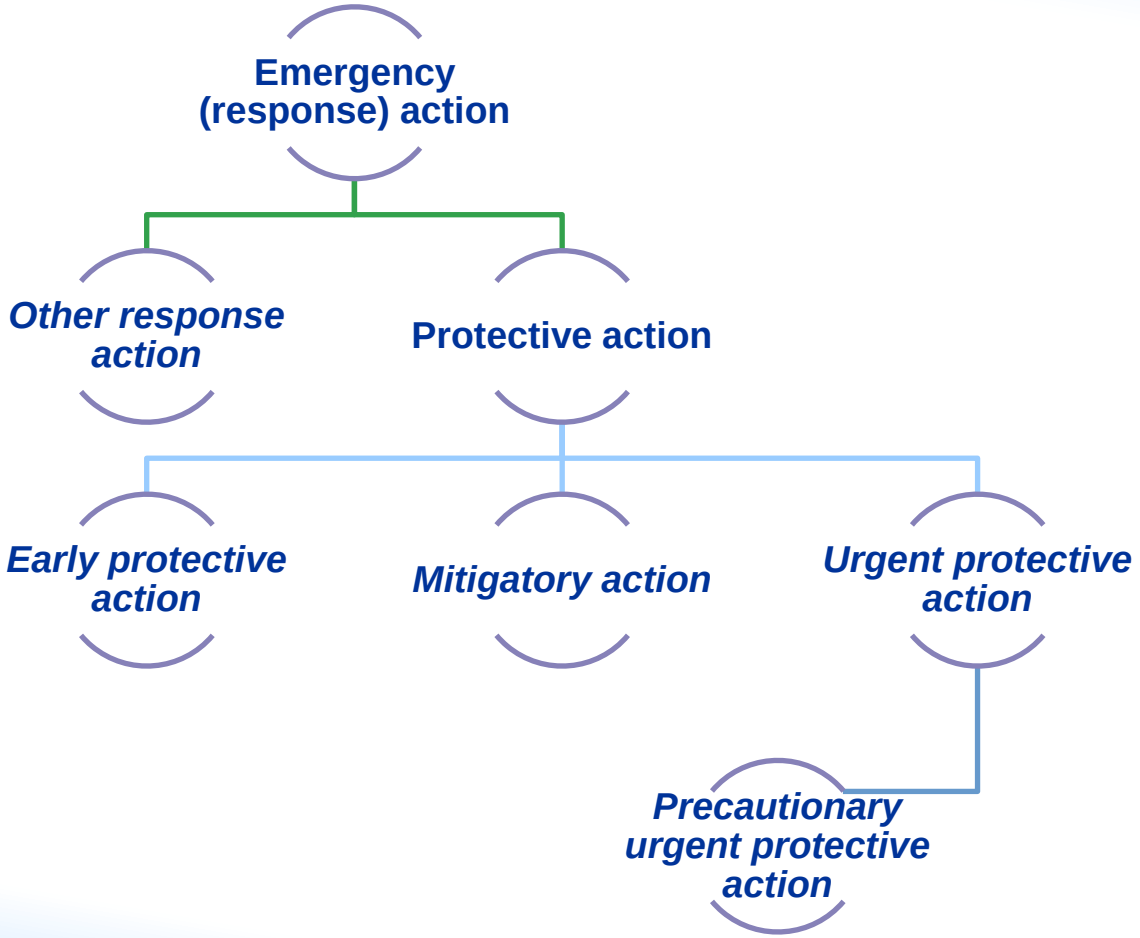
Unwarranted actions being taken by the public

# Stage 6: Assessment of effectiveness of possible protective actions

Aim: To identify protective actions and other response actions that would be effective in mitigating the consequences of a postulated emergency

- Various options would be available comprising individual actions or different combinations of actions at varying degree of efficiency
- Final options for the strategy to be selected after their justification and optimization

# Stage 6: Assessment of Effectiveness of Possible Protective Actions (cont'd)




# Stage 6: Assessment of Effectiveness of Possible Protective Actions (cont'd)

## Consider:

**Timing and progression**
and their implications on the time available for decision-making and for effective implementation of protective actions

**Spatial and temporal variations**
in the need for actions and their efficiently

**Dependency between actions**

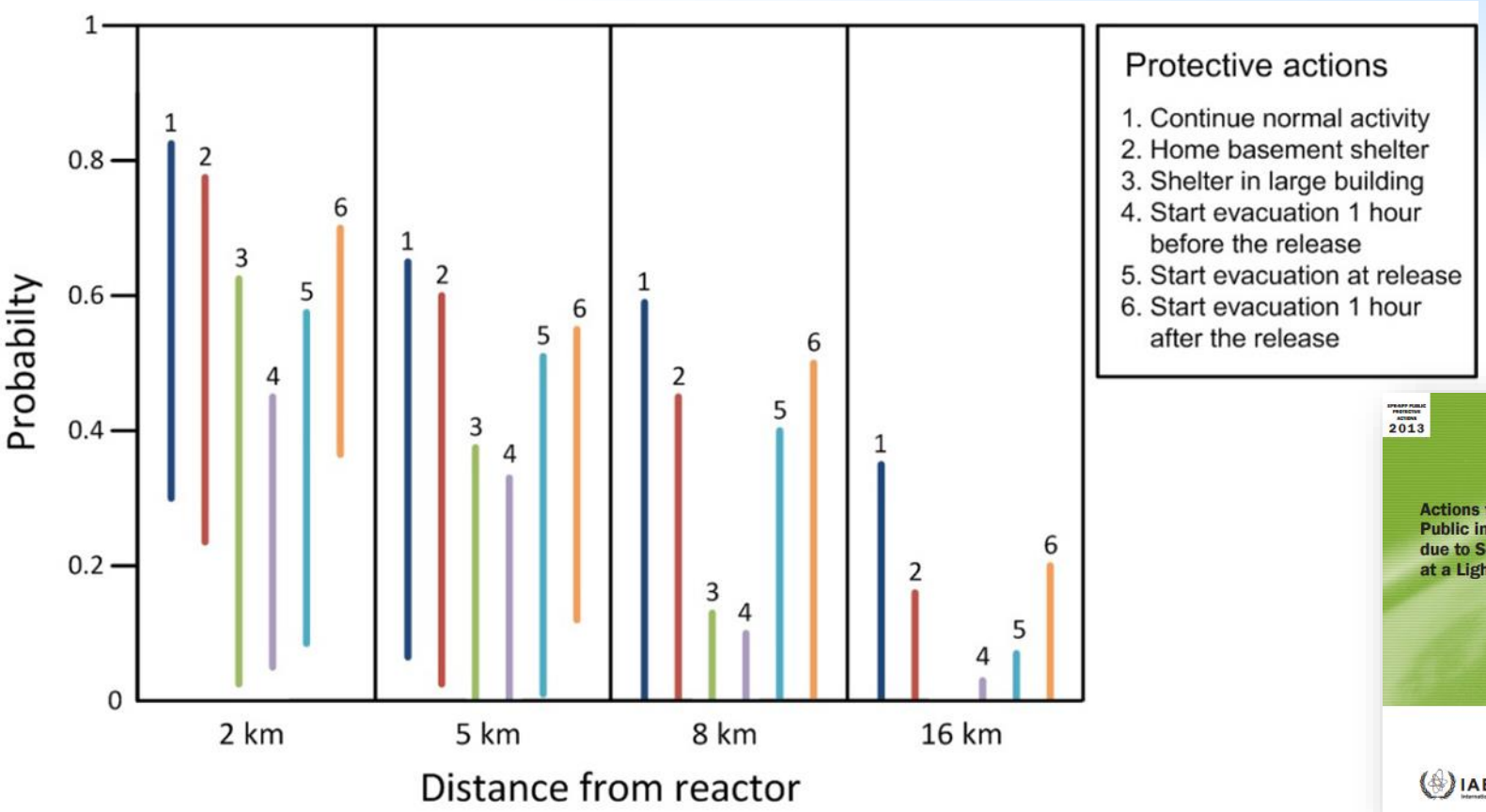
- Sheltering in case of emergency involving release of radioiodine will invoke the need for iodine thyroid blocking simultaneously
- Provision of medical care and psychosocial counselling to evacuees

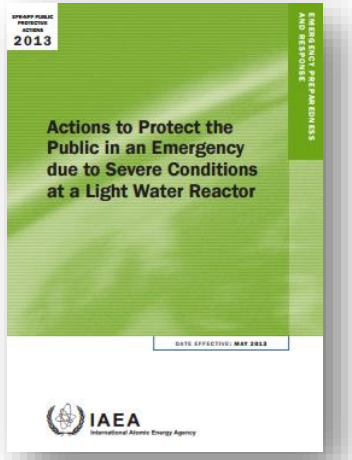
Other **non-radiological hazards**

- Chemicals and other toxic hazards
- Fires or explosions

**Uncertainties**

# Example of assessment of effectiveness of various actions as a function of the distance




Probability of exceeding 0.5 Gy RBE weighted absorbed dose to the red marrow for various protective actions assuming core melt and an early containment failure for a nuclear power plant of about 3000 MW(th) as a function of the distance from the release point

# How can countries implement the hazard assessment?

**Follow each stage of the hazard assessment process**

- Using pre-agreed approach and methodologies at national level

**Use the results of the generic hazard assessment in EPR Safety Standards**

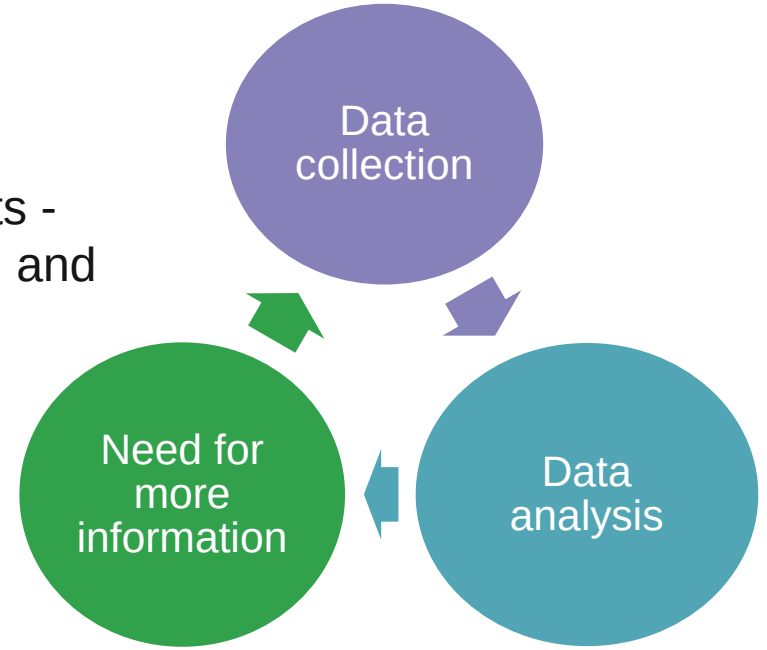
- Using the information from the planning basis without necessity for a thorough hazard assessment process and:
  - Emergency Preparedness Categories and associated emergency arrangements (such as suggested area sizes)
  - Justifying and optimizing the approach contained therein to account for national, local or site-specific characteristics

# Consideration of the Threat Assessment

> *"The government shall ensure that the hazard assessment includes consideration of the results of threat assessments made for nuclear security purposes"*

- **Threat** – A person or group of persons with motivation, intention and capability to commit a malicious act

- **Threat assessment** – An evaluation of the threats - based on available intelligence, law enforcement, and open sources information – that describes the motivations, intentions and capabilities of these threats
  - is a rigorous and formal analytical process
  - results in a **Threat Statement** document describing the postulated threat
  - is repeated periodically or when significant new information becomes available



# Threat Assessment and Hazard Assessment

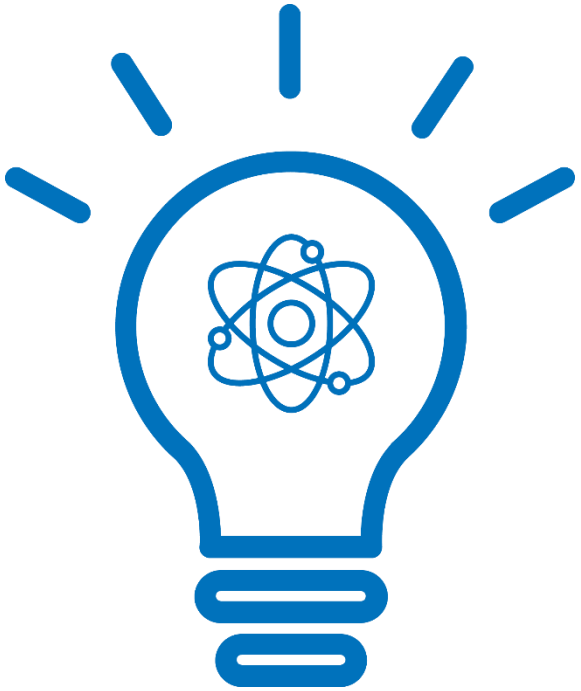
**An emergency** can be caused by a malicious act, such as sabotage of a nuclear facility

**Results of the Threat Assessment** can be used to inform hazard assessment and overall EPR

- Assessment of credibility of a malicious act and its consequences at a specific facility (or activity)
- Development of necessary technical data (source term, etc.)

**Safety and security** are not mutually exclusive. Results of the threat assessment can contribute to the characterization of the postulated emergency and its consequences

# Summary



- Planning basis brings together relevant information at national, regional and local levels and, where appropriate, at the international level
- Planning basis includes results from the hazard assessment and the goals of emergency response as main drivers for formulating the protection strategy
  - How effective our strategy will be is depending on how good our hazard assessment and the overall planning basis is
- The level of details gathered in the planning basis will vary depending on its use

# Where to Get More Information

- IAEA GSR Part 7 (2015) requirement 4
- IAEA GS-G-2.1 (2007) section 3
- IAEA EPR-Method (2003) Appendices 9 and 12

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# *Thank you!*

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