

Planning and Implementation of Remediation Strategies following Deposition of Long-lived Radionuclides

Tamara Lynne Yankovich

Assessment and Management of Environmental Releases Unit, WES / NSRW

*Kick-off Meeting for ASEAN Network on Nuclear Power Safety Research
and the 2nd ASEAN Workshop on Nuclear Power Safety Research*

*Bangkok, Thailand,
7-9 March 2017*

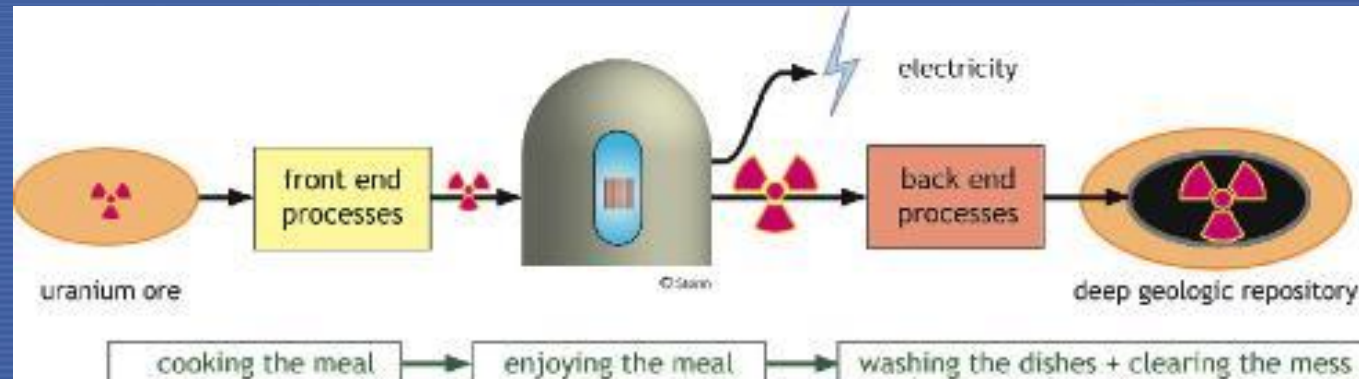


IAEA

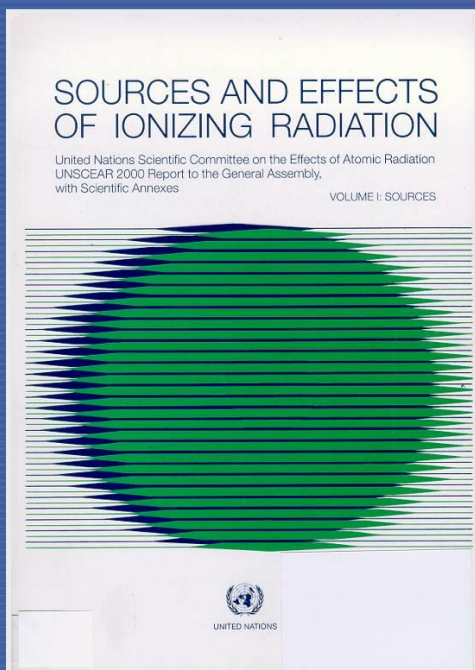
International Atomic Energy Agency

Outline of Presentation

- I. Overview of relevant Safety Standards and key concepts
- II. Examples for consideration
- III. Description of some key IAEA initiatives that may be relevant and the outcomes
- IV. Discussion of possible interfaces between ASEAN and IAEA
- V. Concluding remarks.

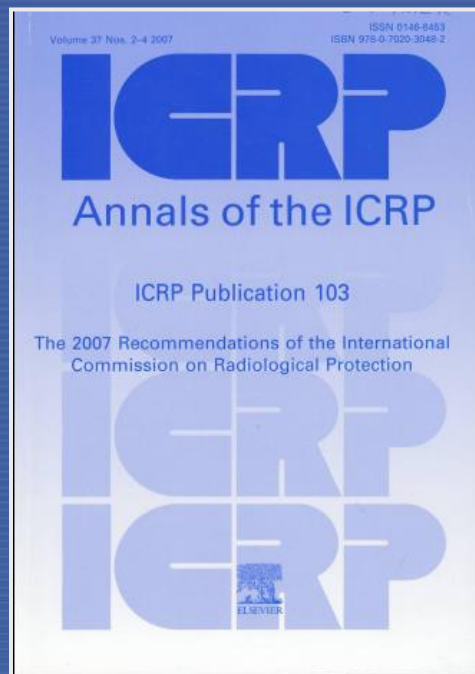
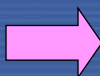


Harmonized Standards Development Process



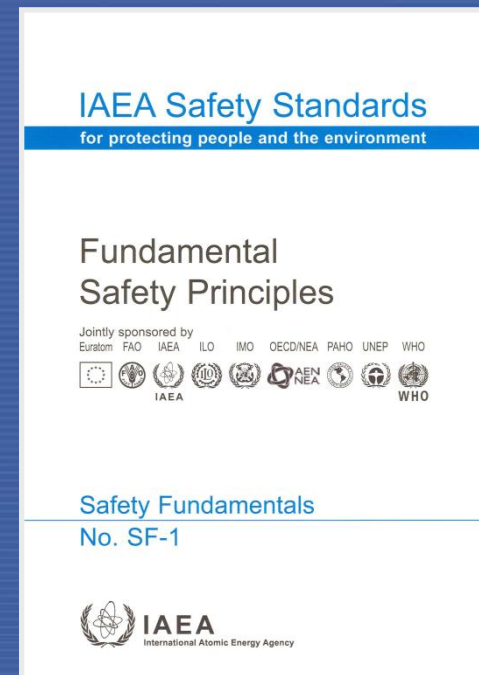
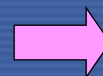
UNSCEAR

- Scientific reports
- Data on sources and effects of radiation



ICRP

Recommendations
for protection



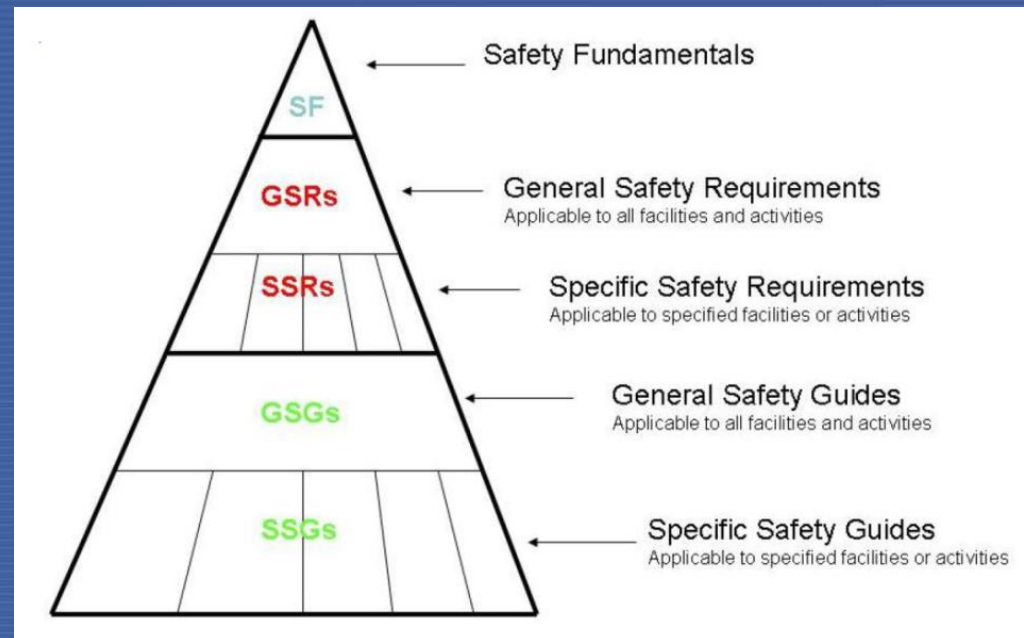
IAEA

Regulatory style
standards

Consistency of the application of IAEA Safety Standards

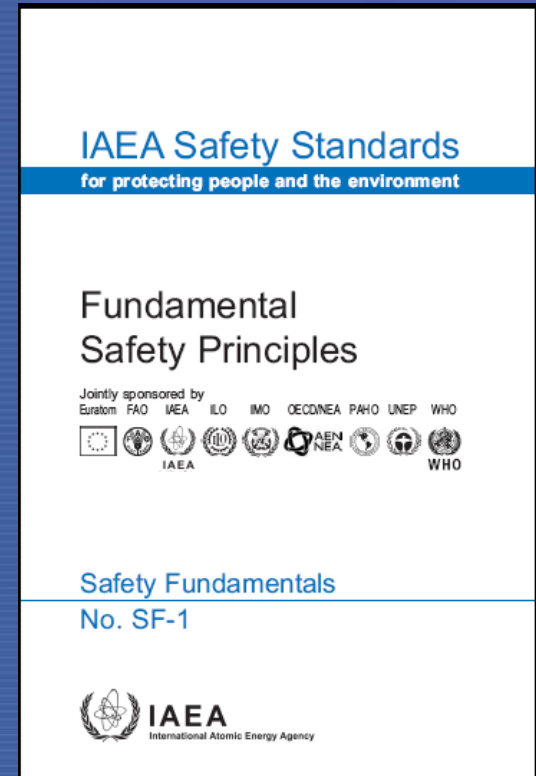
The IAEA has established a hierarchy of Safety Standards, consisting of a set of “Safety Fundamentals” at the highest level, followed by “Requirements”, then recommendations or “guidance”.

The safety standards are supported by documents that provide an underlying technical basis (safety reports, technical reports, technical documents, etc.).

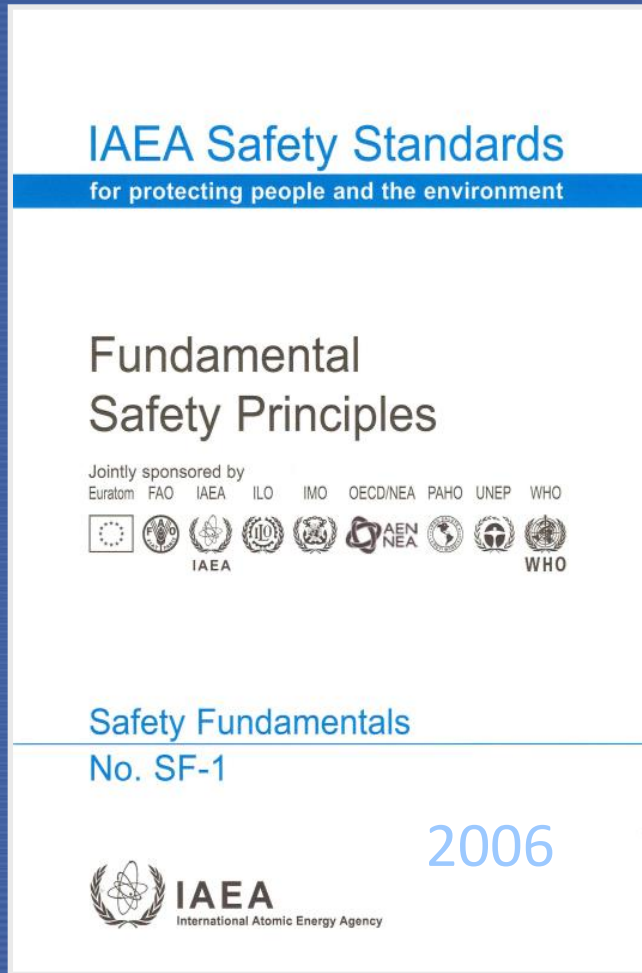


Safety Fundamentals: 10 Safety Principles

- 1 Responsibility for safety
- 2 Role of government
- 3 Leadership and management for safety
- 4 Justification of facilities and activities
- 5 Optimization of protection
- 6 Limitation of risks to individuals
- 7 Protection of present and future generations
- 8 Prevention of accidents
- 9 Emergency preparedness and response
- 10 Protective actions to reduce existing or unregulated radiation risks



The Basis – the Safety Fundamentals



“The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation.”

Where:



- Human activities involving the use of radiation and radioactive substances can cause radiation exposure to people and the environment.
- This exposure should be regulated and monitored in accordance with international safety standards and national legislation.
- It is necessary to assess the potential risks and impacts, and to take measures to prevent or minimize these to ensure and demonstrate protection.

Where the level of regulatory oversight and requirement is dependent upon the facility or activity and is commensurate with risk.

What is the type of facility or activity?

(and what potential issues need to be addressed upfront?)

Definition of 'Facilities and Activities':

A general term encompassing nuclear facilities, uses of all sources of ionizing radiation, all radioactive waste management activities, transport of radioactive material and other practices or situations in which people may be subject to exposure to radiation from naturally occurring or artificial sources.



What is the type of facility or activity?

- The intention is to include **any human activity that** introduces additional sources of radiation or additional exposure pathways, or that modifies the network of exposure pathways from existing sources, so as to **increase the exposure or the likelihood of exposure of people or the number of people exposed**.
- The term ‘facilities and activities’ is very general, and **includes those for which little or no regulatory control may be necessary or achievable**: the more specific terms authorized facility and authorized activity should be used to distinguish those facilities and activities for which any form of authorization has been given.
- It is common regulatory practice to define terms such as radioactive material and radioactive waste in such a way as to include only that material or waste that is **subject to regulation by virtue of the radiological hazard that it poses**.
- Although the exact specifications vary from State to State, this **typically excludes material and waste with very low concentrations of radionuclides** and those that contain only ‘natural’ concentrations of naturally occurring radionuclides.

To Demonstrate and Ensure Protection, a Number of Questions could be Relevant

- How do we decide what to protect?
- How do we determine how to protect it?
- How do we demonstrate that protection is achieved?



Elements of the System of Radiation Protection

as defined in GSR Part 3

IAEA Safety Standards
for protecting people and the environment

Radiation Protection and
Safety of Radiation Sources:
International Basic
Safety Standards

Jointly sponsored by
EC, FAO, IAEA, ILO, OECD/NEA, PAHO, UNEP, WHO



General Safety Requirements Part 3
No. GSR Part 3



- **Three Exposed Groups**
 - Workers
 - Patients
 - General public
- **Three Exposure Situations**
 - Planned exposures (e.g., for worker protection)
 - Emergency exposures
 - Existing exposures
- **Three Radiation Protection Principles**
 - Justification
 - Limitation
 - Optimization

Who could be impacted? (i.e., who are we trying to protect)?

- **Three Exposed Groups:**

- Workers
- Patients
- General public

Who do we need to protect?

- **Three Exposure Situations:**

- Planned exposure situations (*can occur within an existing exposure situation, for example, with respect to protection of workers*)
- Emergency exposure situations
- Existing exposure situations

- **Three Radiation Protection Principles:**

- Justification
- Limitation
- Optimization

IAEA Safety Standards
for protecting people and the environment

Radiation Protection and
Safety of Radiation Sources:
International Basic
Safety Standards

Jointly sponsored by
EC, FAO, IAEA, ILO, OECD/NEA, PAHO, UNEP, WHO



General Safety Requirements Part 3
No. GSR Part 3



A human health risk assessment and an environmental risk assessment are components of the overall EIA.

System of Radiation Protection:



- ***Three Exposed Groups:***

- Workers
- Patients
- General public

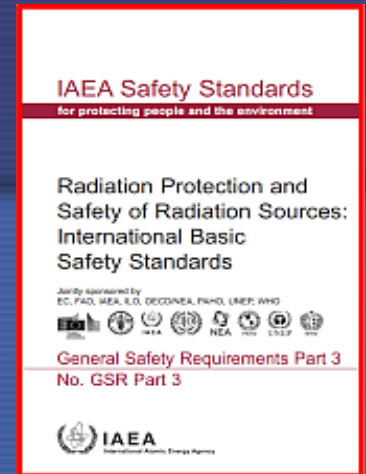
- ***Three Exposure Situations:***

- Planned exposures
- Emergency exposures
- Existing exposures

What is the context in which we protect and how do we take it into account?

- ***Three Radiation Protection Principles:***

- Justification
- Limitation
- Optimization



Planned Exposure Situations:



- Planned operation of a source or a planned activity
- Provision for protection and safety:
 - **Before embarking** on the activity concerned
 - Associated exposures and their likelihood of occurrence can be **restricted from the beginning**.
- The primary means of controlling exposure in planned exposure situations are by:
 - **Good design** of facilities, processes, and equipment
 - **Good operating procedures** and **adequate training**
- **Dose limits** are set for planned exposure situations
 - Exposure from all planned activities must not exceed an effective dose of 1 mSv/a.

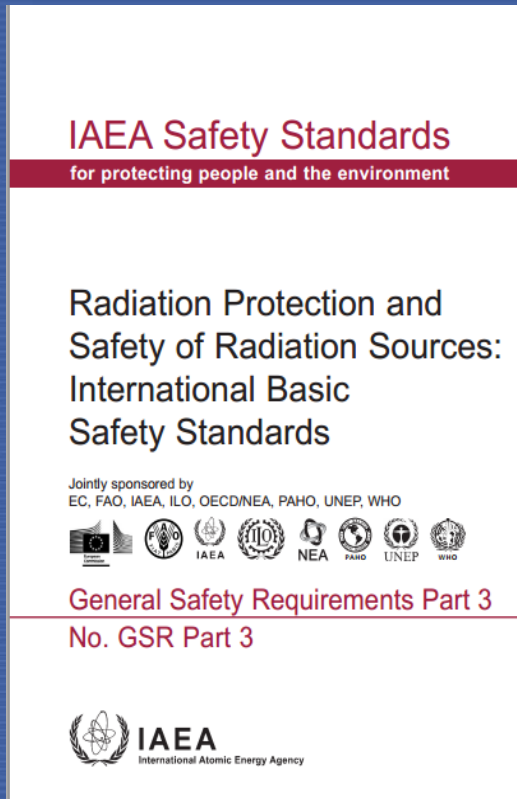


IAEA

Lessons Learned, “Proactive” Decision-making, Prevention

Requirements for Planned Exposure Situations for Protection of the Public

Planned Exposure Situations (Chapter 3):

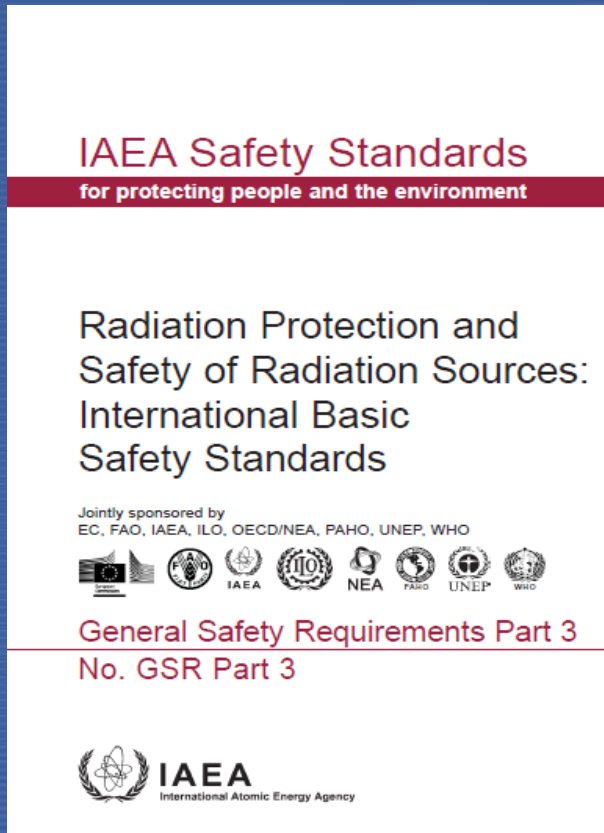


- **Graded approach**
- Notification and authorization
- Exemption and clearance
- Responsibilities of registrants and licensees
- **Justification of practices**
- **Optimisation**
- **Dose limits**
- **Safety assessment**
- **Monitoring and verification**

What is the potential for hazard and impact?

Definition of the Graded Approach

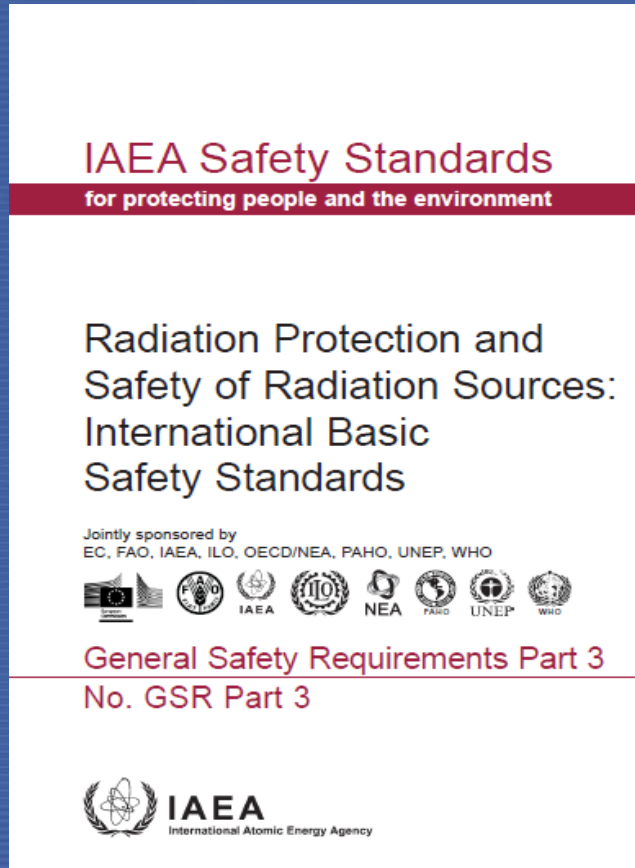
With respect to the application of the graded approach for protection and safety, GSR Part 3 states that:



“For a system of control, such as a regulatory system or a safety system, a process or method in which the stringency of the control measures and conditions to be applied is commensurate, to the extent practicable, with the likelihood and possible consequences of, and the level of risk associated with, a loss of control”.

What is the potential for hazard and impact?

The Basic Safety Requirements state that:



- *“The application of the requirements for the system of protection and safety shall be commensurate with the radiation risks associated with the exposure situation.”*
- *“The government shall ensure that a graded approach is taken to the regulatory control of radiation exposure, so that the application of regulatory requirements is commensurate with the radiation risks associated with the exposure situation.”*
- *“The regulatory body shall adopt a graded approach to the implementation of the system of protection and safety, such that the application of regulatory requirements is commensurate with the radiation risks associated with the exposure situation.”*
- *... and so on.*



IAEA

... and a graded approach should be applied at all levels and for all types of exposure situations – but HOW?

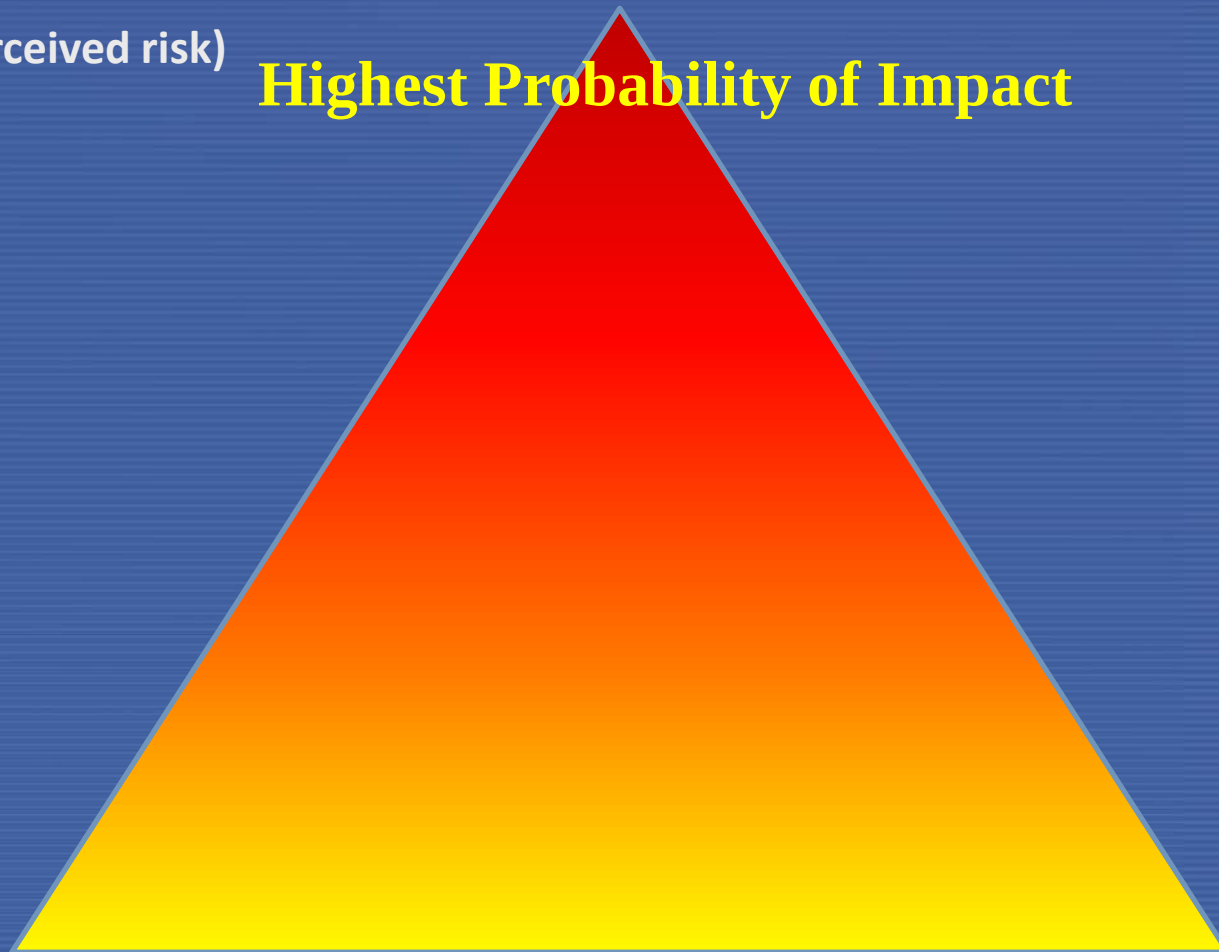
Therefore, the Level of Effort and Regulatory Oversight Should be Commensurate with Risk

High risk (including perceived risk)
High complexity
High level of detail



Low risk
Low complexity
Low level of detail

Highest Probability of Impact



Lowest Probability of Impact

What is the potential for hazard and impact?

Therefore, a key question is:

“What level of protection and safety is adequate and acceptable for different types of facilities and activities?”

System of Radiation Protection:



- ***Three Exposed Groups:***

- Workers
- Patients
- General public

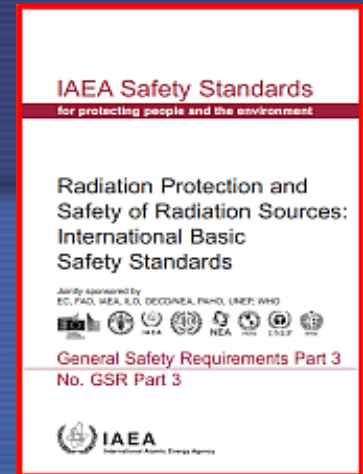
- ***Three Exposure Situations:***

- Planned exposures
- Emergency
- Existing exposures

- ***Three Radiation Protection Principles:***

- Justification
- Limitation
- Optimization

How do we demonstrate protection has been achieved?
How can the principles of Protection be practically applied?



Radiation Protection Principles:

- **Justification** – actions should be commensurate with risk, and there should be adequate net benefit *[The EIA should demonstrate why the planned activity is justified]*.
- **Optimization** - key impacts should be weighed out and balanced with consideration of relevant factors and in consultation with interested parties.
- **Limitation** – establishment of “limits” or “targets”, taking account of the situation.

Radiation Protection Principles

in Identification and Prioritization of Remedial Options

Radiation Protection Principles

Justification

**Actions should be
adequate to the risk**

**Do more good
than harm**

Optimization

**Exposure levels
Number of people exposed
Economic and social
implications**

**As Low As Reasonably
Achievable, economic and
social factors being taken
into account
(ALARA)**

Limitation

**Limitation of doses
and associated
risks**

**Dose limits
Reference levels**

IAEA General Safety Requirements, Part 3 (2014) states:

*“Before authorization of a new or modified practice, the regulatory body shall require the submission of, and shall review, the **safety assessments** and **other design related documents** from the responsible parties that address the optimization of protection and safety, the design criteria and the design features relating to the assessment of exposure and potential exposure of members of the public”.*

GSR Part 4: Safety Assessment for Facilities and Activities

- Establishes the generally applicable requirements to be fulfilled in safety assessment for facilities and activities, with special attention paid to defence in depth, quantitative analyses and the application of a graded approach to the ranges of facilities and of activities that are addressed.

*Safety assessment is the assessment of all aspects of a practice that are relevant to protection and safety. For an authorized facility, this includes siting, design and operation of the facility. Safety assessment is the **systematic process** that is carried out throughout **the lifetime of the facility or activity** to ensure that all the relevant safety requirements are met by the proposed (or actual) design.*

The Safety Assessment is also part of emergency preparedness.



IAEA

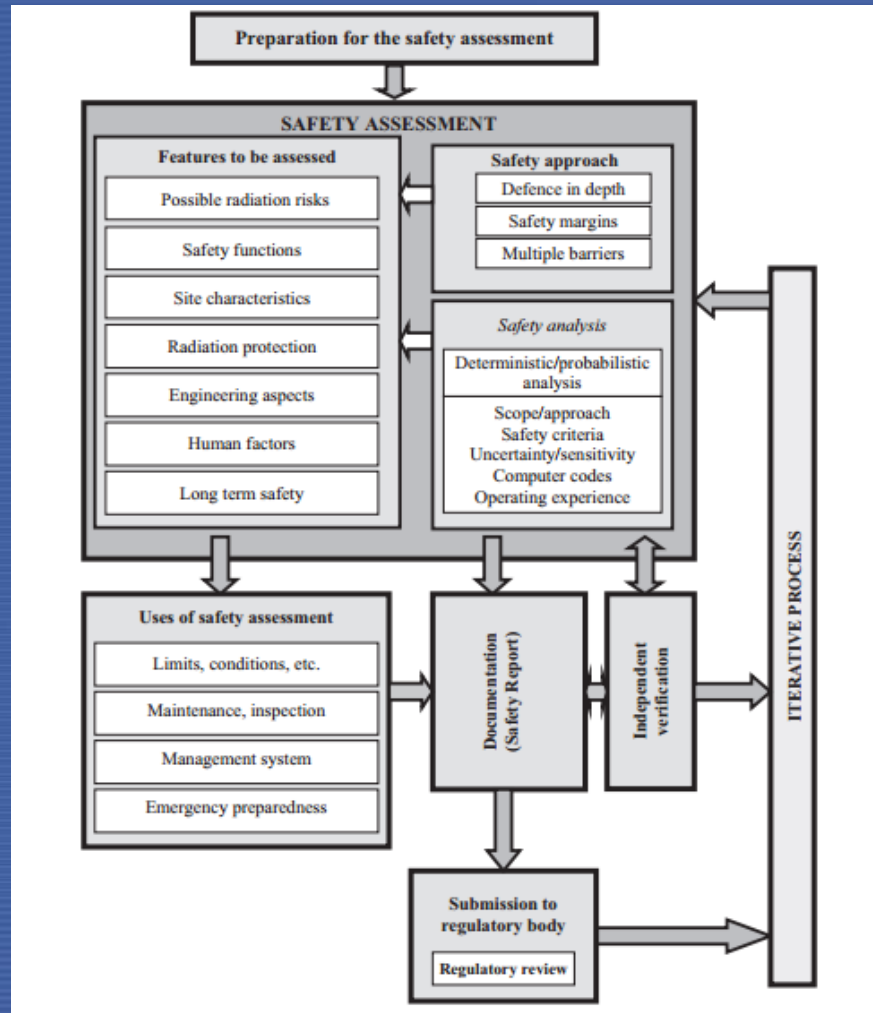
GSR Part 4: Safety Assessment for Facilities and Activities

The term ‘**radiation risks**’ refers to:

- Detrimental health effects of exposure to radiation (including the likelihood of such effects occurring);
- Any other safety related risks (including those to ecosystems in the environment) that might arise as a direct consequence of:
 - Exposure to radiation;
 - The presence of radioactive material (including radioactive waste) or its release to the environment;
 - A loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation.



GSR Part 4: Overview of the Safety Assessment Process

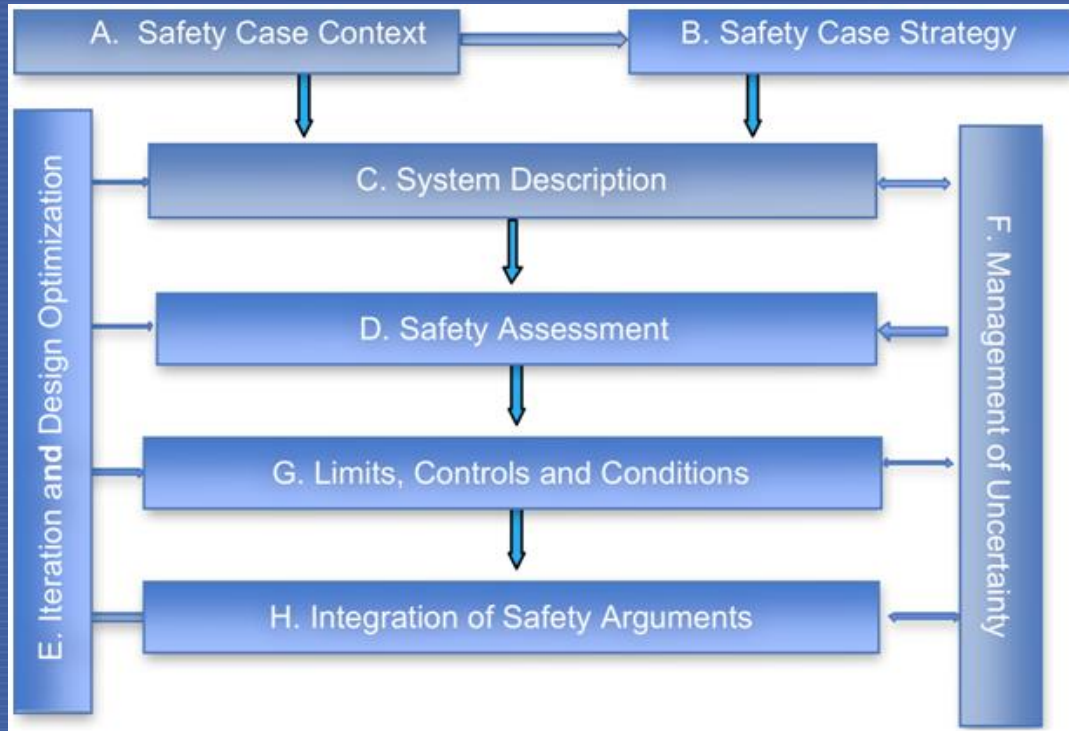


- The Environmental Impact Assessment (EIA) is an integral part of the Safety Assessment.
- An EIA considers all types of potential impacts and is broader than the consideration of potential impacts of ionizing radiation.



IAEA

General Safety Guide, GSG-3: Components of the Safety Case and Safety Assessment



Safety Assessment

Safety Assessment

Safety Case



IAEA

Management System

Non radiological environmental
impact

Radiological Impact

Scenarios

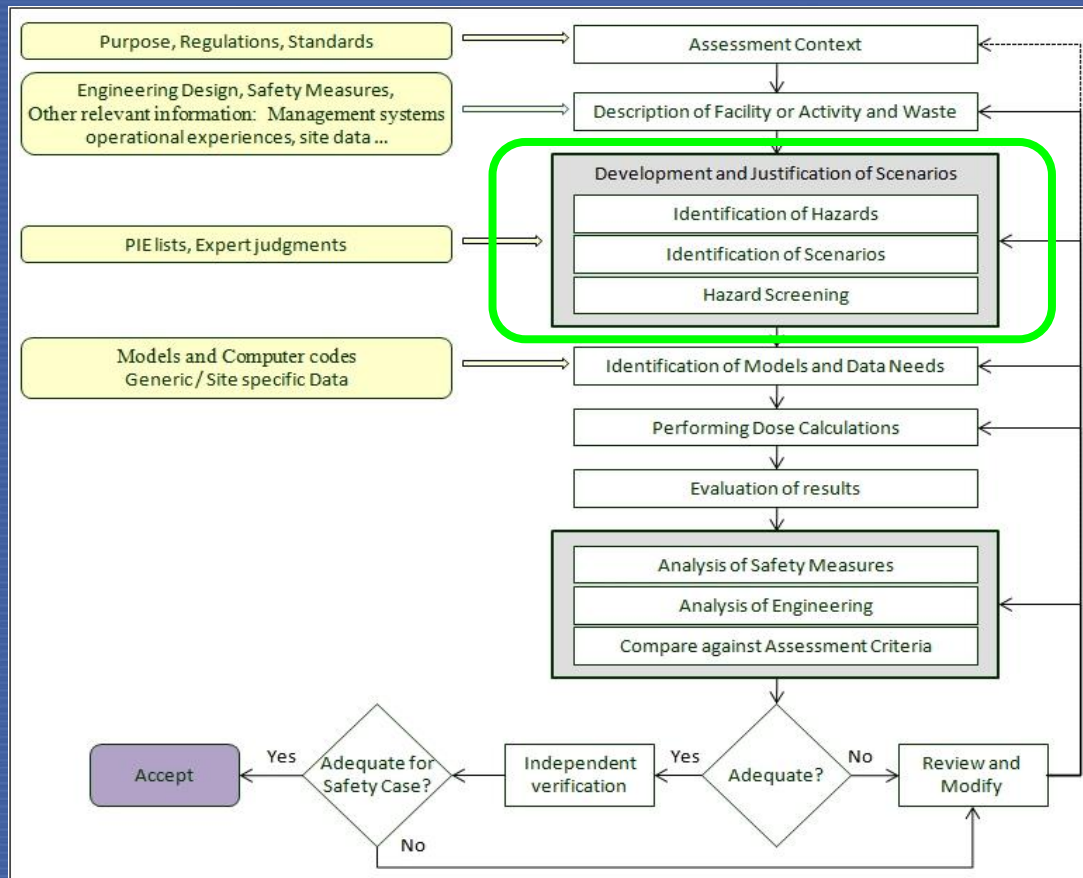
Models

Calculations

Operational Safety

Site and Engineering

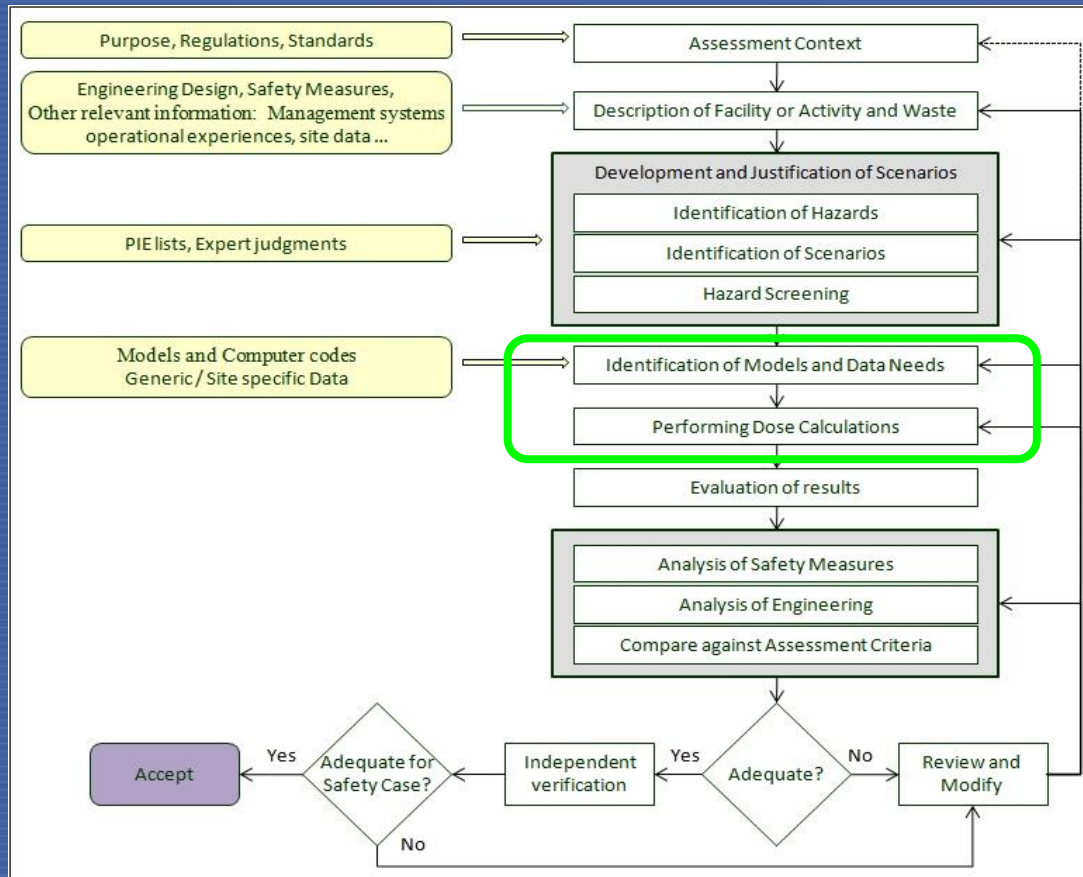
General Safety Guide, GSG-3: Key Steps in Development of the Safety Case



Development and Justification of Scenarios

- Identification of **Postulated Initiating Events (PIEs)** for a given facility design and purpose:
 - Loss of power;
 - Loss of ventilation;
 - Loss of containment;
 - Loss of confinement;
 - Loss of instrument control;
 - Lack of maintenance;
 - Failure of emergency equipment (e.g. malfunction of fire extinguishers);
 - Loss of utilities (e.g. cooling water, steam, compressed air).
- **Scenario testing** for design basis and beyond design basis accidents
- **Screening of hazards** for different scenarios.

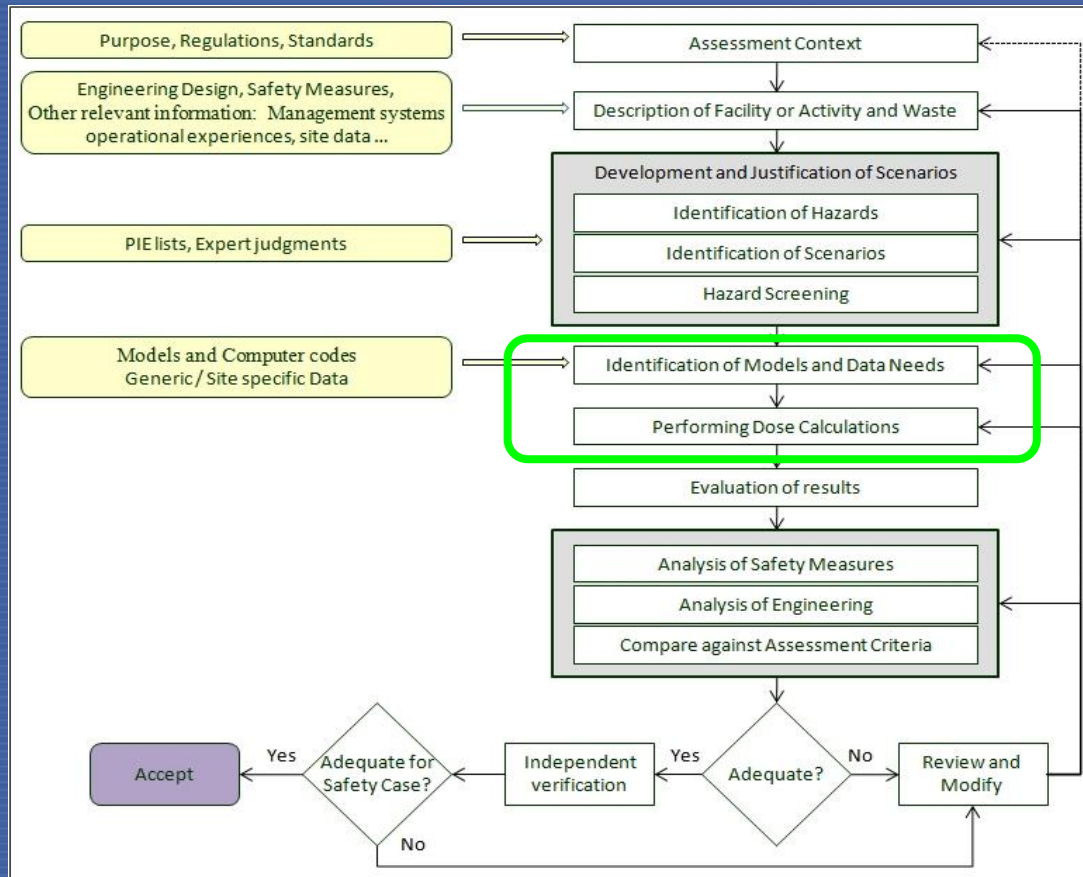
General Safety Guide, GSG-3: Key Steps in Development of the Safety Case



- **Assessments** are then carried out **for defined scenarios** that have not been screened out during the screening of hazards
- This is commonly done using assessment models:
 - **Conceptual Model** – Provides a description of the system, its components and the interactions between them. It also includes a set of assumptions concerning the geometry of the facility or activity and the chemical, physical, biological and mechanical behaviour of the facility or activity, consistent with the available information and knowledge.
 - **Mathematical Model** – Provides a representation of the conceptual model using mathematical equations. For traceability the equations should be adequately documented, thereby supporting arguments of the selected models. The assessment model should consider different alternatives.

Models and Compare Codes using Generic and Site-specific Data

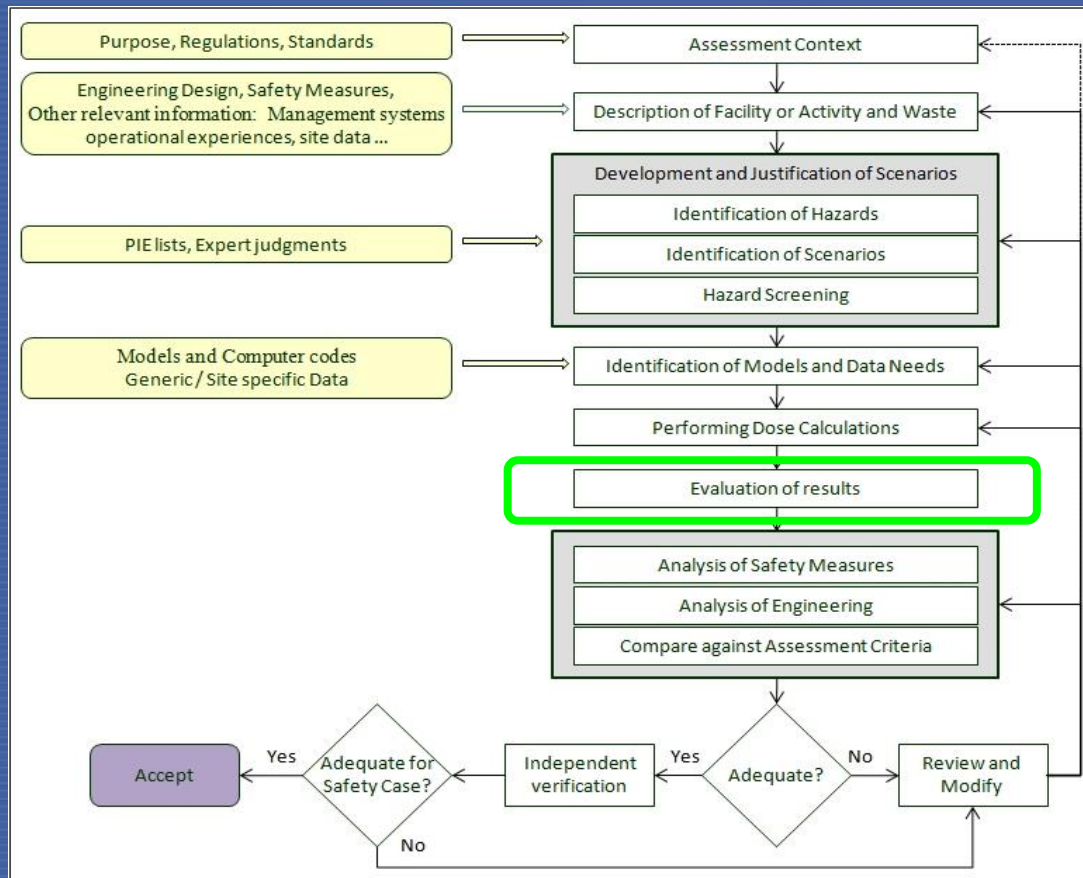
General Safety Guide, GSG-3: Key Steps in Development of the Safety Case



- **Computer codes (software tools)** can then be used to implement the mathematical model to perform the assessment calculations.
- The computer code(s) may include **numerical schemes** for solving the equations in the mathematical model.
- **Verification and validation** of model predictions is then undertaken to build confidence in model results for different alternatives.
- **Characterization and monitoring** are important in model verification and validation.
- **Documentation** is needed throughout the process for traceability.

Models and Compare Codes using Generic and Site-specific Data

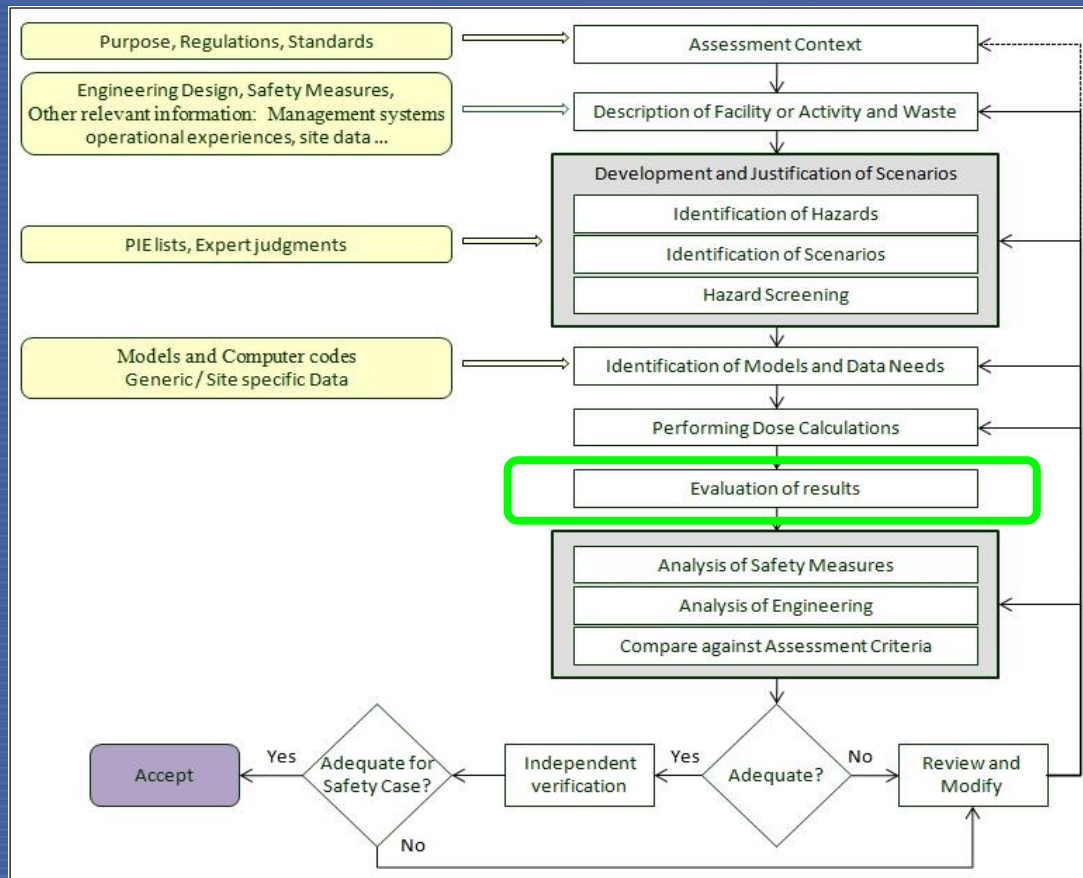
General Safety Guide, GSG-3: Key Steps in Development of the Safety Case



Evaluation of Results

- The analysis of **uncertainties and their significance** should be an integral part of the dose or risk calculation process:
 - Whenever possible, reported results should include ranges of possible values
 - The analysis of uncertainty should be adequate for the purpose of the assessment.
- **Model uncertainty:**
 - Imperfect knowledge of the processes leads to imperfect conceptual models;
 - The mathematical representation of the conceptual models may be approximate or over-simplified
 - Imprecision in the numerical solution of mathematical models
- **Data / parameter uncertainty:**
 - Uncertainty in the values of the parameters used (e.g., system or process uncertainties).

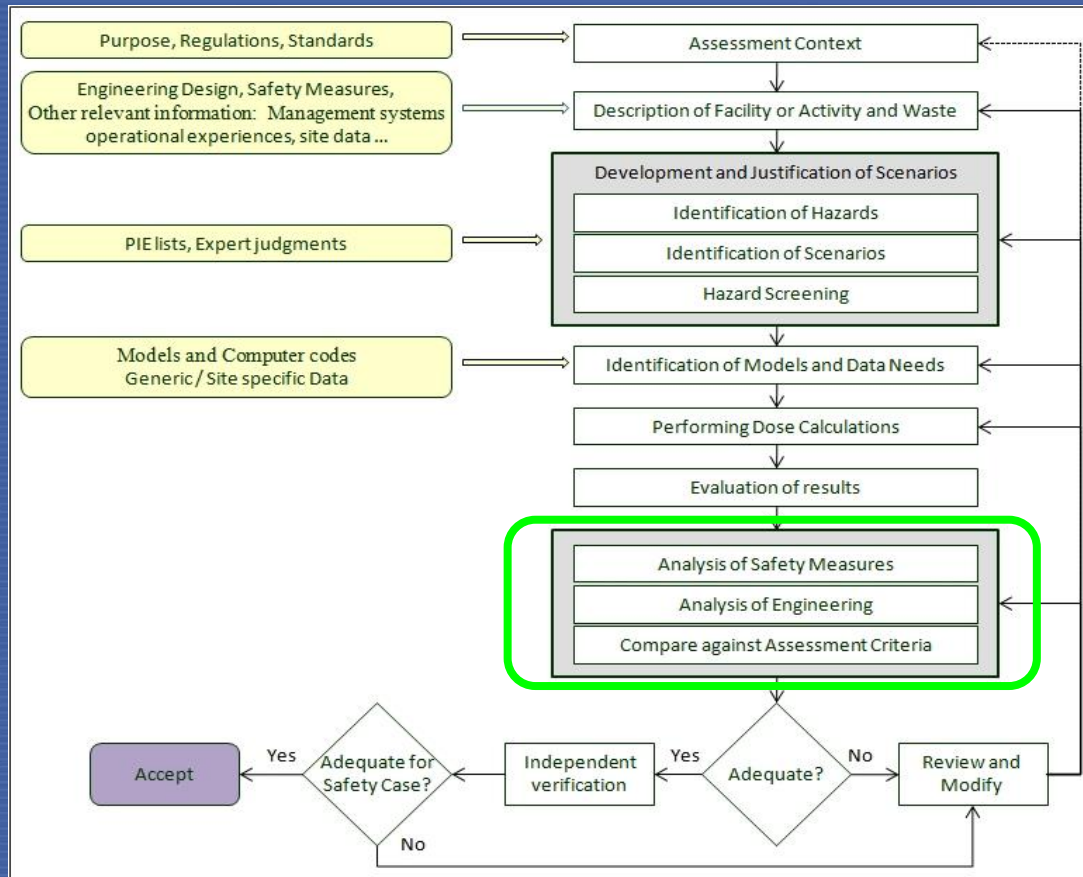
General Safety Guide, GSG-3: Key Steps in Development of the Safety Case



Evaluation of Results

- **Sensitivity and/or uncertainty analyses** may demonstrate that a given uncertainty is not significant to safety:
 - The **graded approach** to Safety Assessment applies equally to uncertainties (e.g., a commonly used approach to treat uncertainty is to use conservative assumptions when simplifying the models).
 - However, in some cases the conservative assumptions may lead to extremely unrealistic or impossible situations.
 - **The level of conservatism of the assumptions within the assessment should be justified in relation to their impact on the assessment endpoints.**

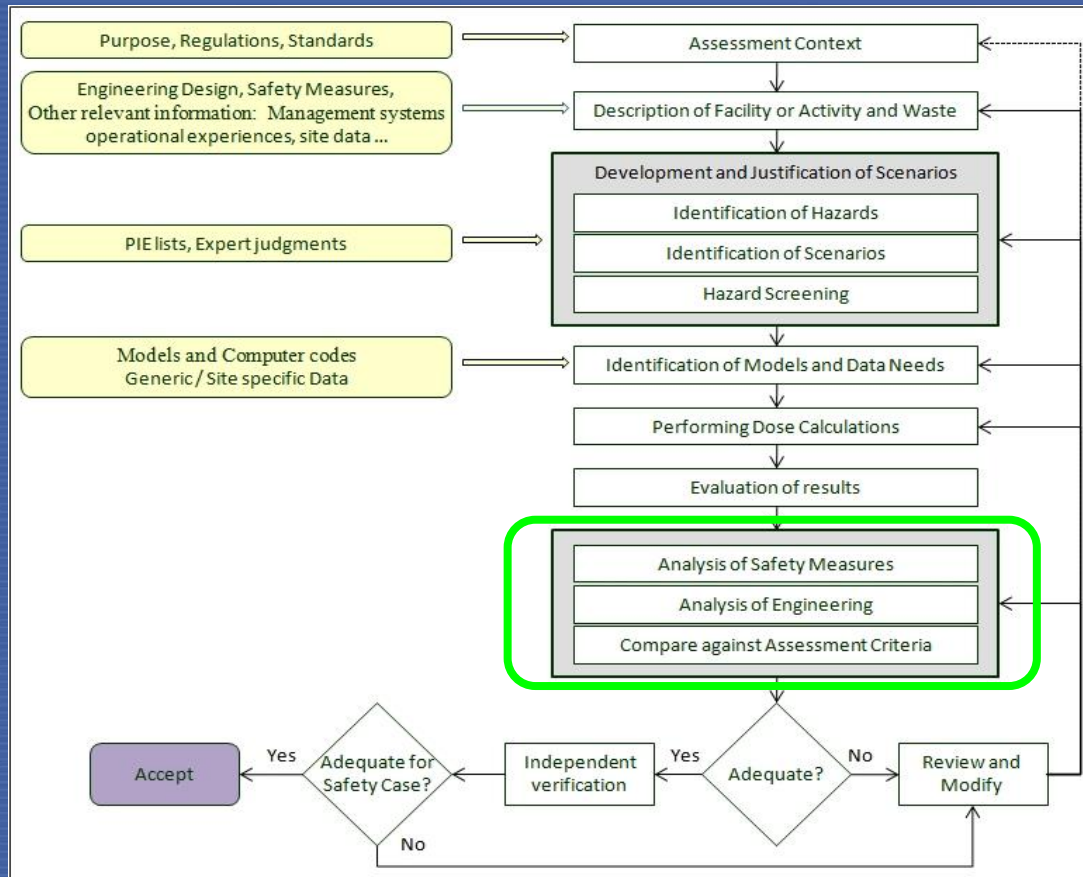
General Safety Guide, GSG-3: Key Steps in Development of the Safety Case



Analysis of Assessment Results

- Comparison of **dose calculations** with **assessment criteria** in the Safety Assessment:
 - Involves comparison of the assessment endpoints with specific indicators, which can vary, depending on the exposure situation.
 - However, it is not in itself sufficient for acceptance of a Safety Case, since protection needs to be optimized.
 - Conversely, an indication that calculated doses could, in some unlikely circumstances, exceed the dose criterion need not necessarily result in rejection of a Safety Case.
- **If the Safety Assessment results do not demonstrate compliance with safety requirements, the assessment should be revised.**

General Safety Guide, GSG-3: Key Steps in Development of the Safety Case



Analysis of Assessment Results

- Results from the Safety Assessment should be used to **identify possible amendments to the existing Safety Case**, or to identify activities, engineering and protective safety measures, and, where appropriate, additional safety measures to **ensure compliance** with the requirements and criteria.
- This can include amendments to the Safety Case that would result in a **reduction in the potential impacts** of an accident.
- Treatment or reduction of uncertainties** in the Safety Assessment should be reviewed and, where necessary, revised.

Adaptive Management of the Safety Assessment



- The Safety Assessment (and corresponding update of the Safety Case) is an iterative process, and must account for:
 - Any **significant change** that may affect the safety of the facility or activity.
 - Any **significant developments** in knowledge and understanding (e.g., during operation of a facility, undertaking of an activity, or internationally – such as technological or safety-related advancements)
 - Any **emerging safety issue** owing to a regulatory concern or an incident
 - Any **significant improvements in assessment techniques** such as computer codes or input data used in the safety analysis.

Summary of Key Aspects of the Safety Case

- ✓ The Safety Case needs to be developed in a **systematic manner** using a **graded approach**.
- ✓ The context should **define** the purpose, philosophy, regulatory framework, endpoints, and time-frame of the **Safety Case**.
- ✓ The recommended approach to safety assessment includes the following **key components**:
 - Assessment context;
 - Description of the facility or activity and waste;
 - Development and justification of scenarios;
 - Identification of models and data needs;
 - Calculation, evaluation and use of results.
- ✓ **Development of the Safety Case is an iterative process**. It is particularly important that any lessons learned in applying the models and interpreting the results should be used to revisit assumptions and decisions made.

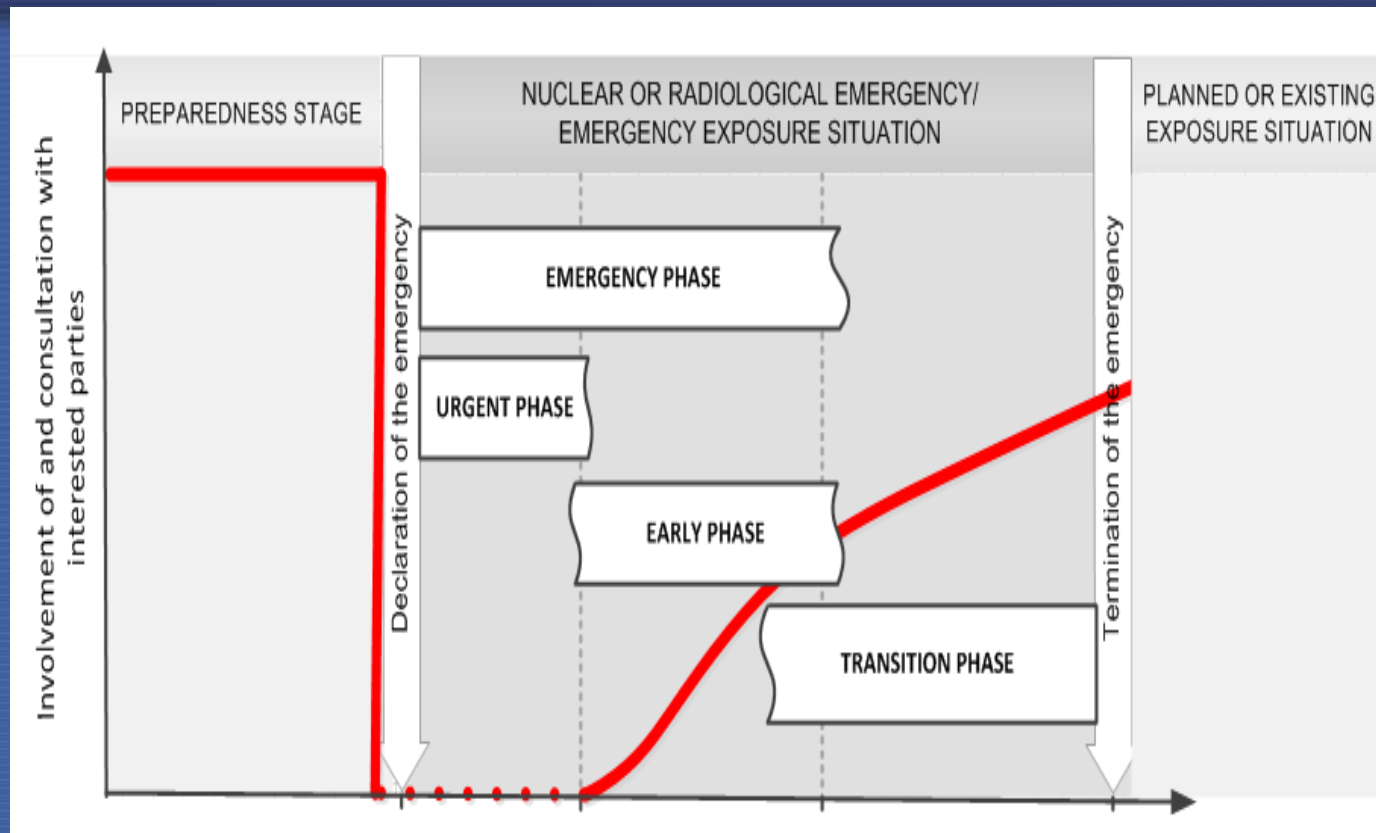
Summary of Key Aspects of the Safety Case

- ✓ The **description of the facility or activity** should provide the **basis** on which the safety assessment is carried out.
- ✓ Assessment cases should be specified for **normal operating conditions, anticipated operational occurrences** and **accidents**.
- ✓ **Scenarios** link hazards, activities, or Postulated Initiating Events (PIEs) with impacting conditions and associated impacts that may arise and evolve.
- ✓ **Screening of hazards** allows to identify and direct efforts towards all significant and relevant hazards for the facility or activity.

In cases where things do not go as planned:

- The situation will be either an **emergency** or **existing** exposure situation (as opposed to a planned exposure situation).
- As a result, the **dose criterion will not be a hard limit**, but will be a 'target' that is selected applying the principles of **justification** and **optimization**, and taking account of the situation (**with consideration of the 'prevailing circumstances'**), as well as the expectations of relevant stakeholders (or 'interested parties').

In cases where things do not go as planned:



- Planning
- Prevention
- Preparedness

- Control
- Characterization and Monitoring
- Dose Assessment
- Countermeasures
- Remediation

Emergency Exposure Situations:

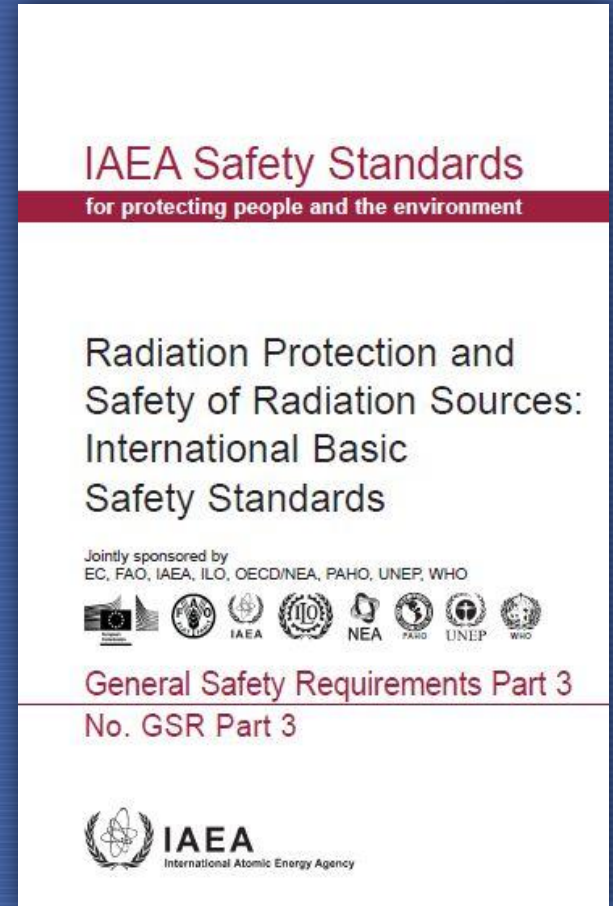
- Applies to activities undertaken in preparedness for and in response to a nuclear or radiation emergency.
- Requires that an integrated and coordinated emergency management system is established and maintained.
- Provision for protection and safety:
 - **Public protection strategies** are developed, **justified and optimized at the planning stage**, and **emergency response** is undertaken through timely implementation.
 - Program for **managing, controlling and recording radiological doses** to emergency workers in an emergency.
- **Reference levels** are set for emergency exposure situations:
 - Emergency situations: 20 - 100 mSv/a
 - **Not a limit**, but a target
 - **Situation-dependent**: feasibility and experience
 - **All reasonable steps shall be taken** to prevent doses remaining above the reference level

Safety Requirements on EPR

Safety Requirements No. GSR Part 3

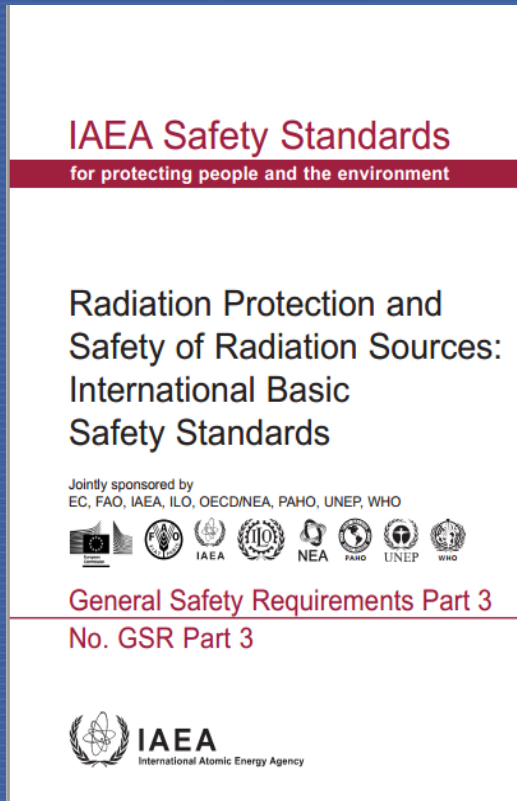
provides relevant requirements on
Emergency exposure situations in
Section 4.

Requirements level: **‘Shall’** or **‘What’**
is to be done



Requirements for Emergency Exposure Situations for Protection of Emergency Workers and the Public

Emergency Exposure Situations (Chapter 4):



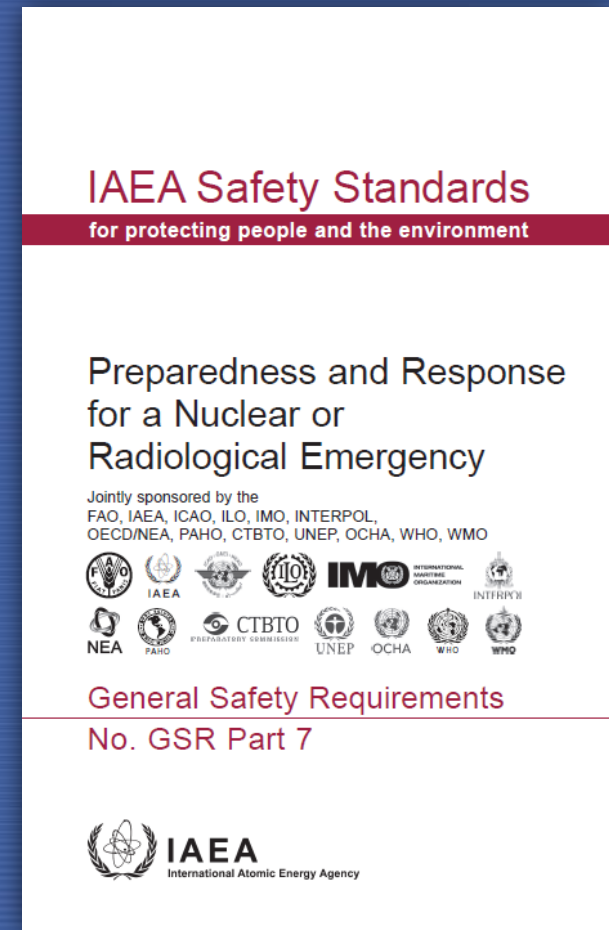
- Emergency management system
- Emergency preparedness and response (for control of public exposure)
- Arrangements for controlling exposure of emergency workers
- Transition from emergency to existing exposure situations
- Arrangements for transition from emergency to existing exposure situations

Safety Requirements on Emergency Preparedness and Response (EPR)

Safety Requirements No. GSR Part 7

establishes requirements for an adequate level of preparedness and response for a nuclear or radiological emergency, irrespective of its cause.

Requirements level: **‘Shall’** or **‘What’** is to be done



Preparedness for Emergency Exposure Situations

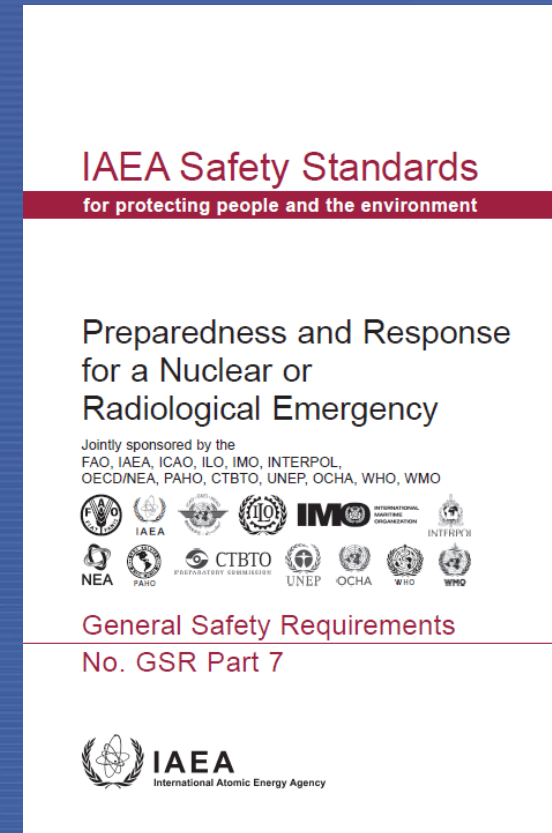
- The planning process shall include specification of:
 - Roles and functions of all organizations
 - Methods of transferring information
 - Means for assessing radiological and non-radiological consequences
 - Conditions, criteria and objectives
 - Review of the hazard assessment and of the emergency arrangements
 - Establishment of national guidelines for termination of an emergency
 - Arrangements for communication and consultation with the public and other interested parties

Goal of Emergency Response:

- Para. 3.2 of GSR Part 7:

“To prepare, to the extent practicable, for the resumption of normal social and economic activity”.

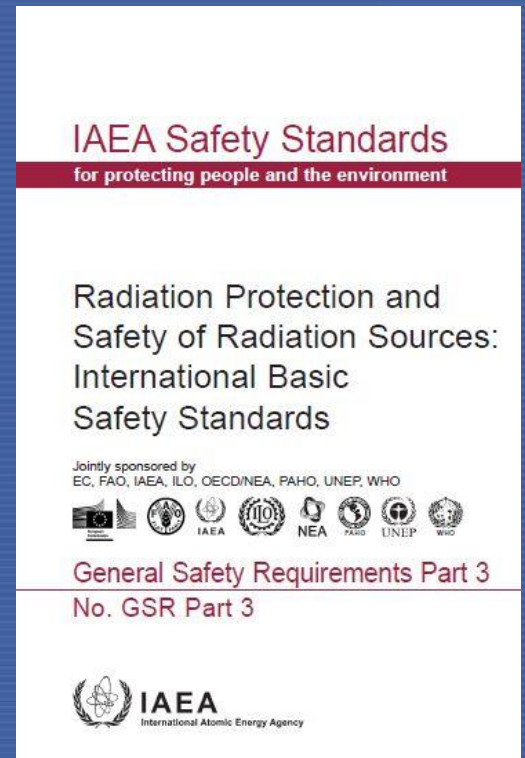
- Req. 18 of GSR Part 7 addresses this goal



Emergency Exposure Situations:

- **Requirement 46 of GSR Part 3:**

The government shall ensure that arrangements are in place and are implemented as appropriate for the transition from an emergency exposure situation to an existing exposure situation.



GSR Part 7 is focused on Preparedness and Response for a Nuclear or Radiological Emergency

- **Requirement 18 of GSR Part 7:**

*The government shall ensure that arrangements are in place and are implemented for the **termination of a nuclear or radiological emergency**, with account taken of the **need for the resumption of social and economic activity**.*

- An emergency exposure situation can transition to a planned or existing exposure situation.
- **Focus today will be placed on transitioning to an existing exposure situation.**



Contacts:

Ms Svetlana NESTOROSKA MADJUNAROVA
(S.Nestoroska-Madjunarova@iaea.org)

Mr Phillip VILAR WELTER (P.Vilar-Welter@iaea.org)

IAEA Safety Standards

for protecting people and the environment

Preparedness and Response for a Nuclear or Radiological Emergency

Jointly sponsored by the
FAO, IAEA, ICAO, ILO, IMO, INTERPOL,
OECD/NEA, PAHO, CTBTO, UNEP, OCHA, WHO, WMO



General Safety Requirements

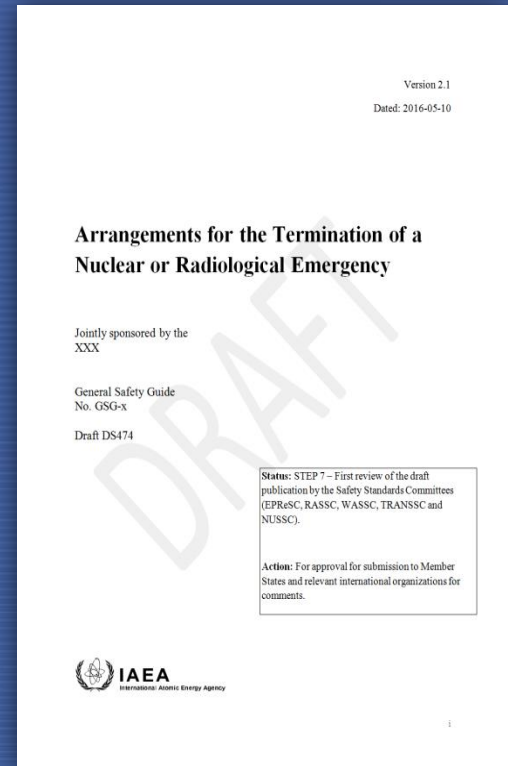
No. GSR Part 7



Draft Safety Guide DS474 - Objectives

To provide guidance and recommendations:

- On developing arrangements needed to terminate the emergency and to allow for subsequent transition to:
 - ✓ A planned exposure situation
 - ✓ An existing exposure situation
- On the primary objective of the termination and preconditions to be fulfilled for the emergency to be terminated



IN PREPARATION



Contacts:

Ms Svetlana NESTOROSKA MADJUNAROVA

(S.Nestoroska-Madjunarova@iaea.org)

Mr Phillip VILAR WELTER (P.Vilar-Welter@iaea.org)

Draft Safety Guide DS474 - Guidance

The draft Safety Guide on Arrangements for the Termination of a Nuclear or Radiological Emergency (DS474) provides guidance supporting:

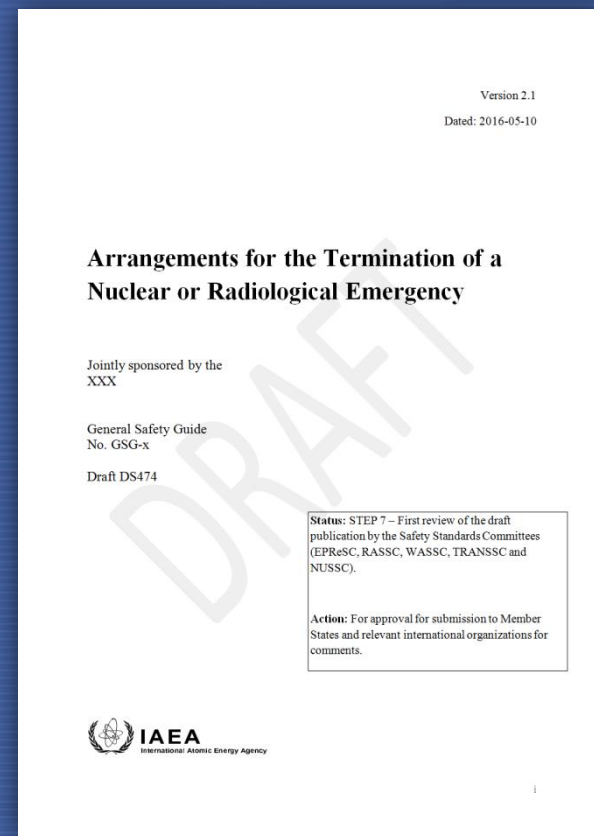
- Requirement 18 of GSR Part 7:
The government shall ensure that arrangements are in place and are implemented for the termination of a nuclear or radiological emergency, with account taken of the need for the resumption of social and economic activity.
- Requirement 46 of GSR Part 3
The government shall ensure that arrangements are in place and are implemented as appropriate for the transition from an emergency exposure situation to an existing exposure situation.

Contacts:

Ms Svetlana NESTOROSKA MADJUNAROVA

(S.Nestoroska-Madjunarova@iaea.org)

Mr Phillip VILAR WELTER (P.Vilar-Welter@iaea.org)



IN PREPARATION

Cases where an Emergency Situation Transitions to an Existing Exposure Situation

- Emergencies involving significant releases of radioactive material into the environment:
 - Result in an emergency exposure situation;
 - Long-term exposures of the public due to residual radioactive material are eventually to be managed as an existing exposure situation;
 - Termination of the emergency will delineate entering into the existing exposure situation for the public while the facility, the activity or the source will be subject to clean-up, decommissioning, remediation or ending the operational life of the source.

“Transition to an existing exposure situation.”



IAEA

Safety Requirements (cont.)

- Termination of the emergency shall be based on a formal decision made public *[characterization, monitoring, and dose assessment will inform this decision]*.
- Once the emergency is terminated:
 - All workers shall be subject to the relevant requirements for occupational exposure in planned exposure situations
 - Individual monitoring, environmental monitoring and health surveillance shall be conducted subject to the requirements for planned exposure situation or existing exposure situation

Urgent/Early

- Bring situation under control
- Public protective actions
- Small number of organizations

Transition

- Enabling timely resumption of social/economic activities
- Additional organizations involved

Relevant GENERAL PREREQUISITES for Termination



Urgent and early protective actions implemented



- Source of exposure under control
- No further significant release expected

Relevant GENERAL PREREQUISITES for Termination (continued)

Overview External Dose Rate

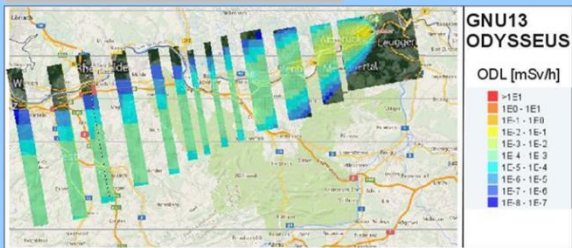
EXERCISE

Valid at: 20.11.2013 16:15

Result of airborne measurements

Airborne measurements between 06:00 bis 10:00 UTC

Gamma Dose Rate (GDR, mSv/h)



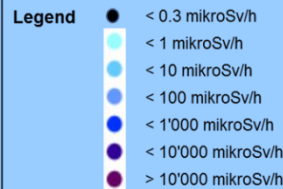
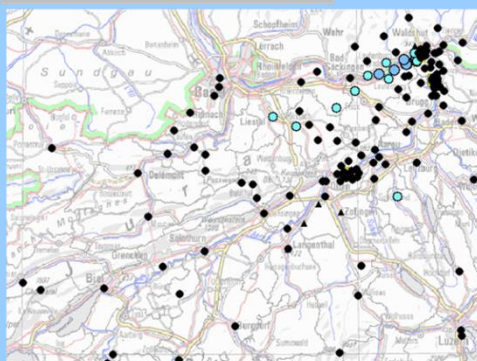
Cs-137 (Ground Deposition, Bq/m²)



Results of mobile teams + automatic networks

Overview of results from mobile teams 07:00-14:15 UTC and fixed stations at 16:15 UTC

Gamma Dose Rate (GDR, µSv/h)



Characterization of:

- Radiological situation
- Exposure pathways
- Doses to affected people

Consideration of impact of:

- Lifting or adapting earlier implemented protective actions
- Possible future land use options.

Urgent/Early

- Bring situation under control
- Public protective actions
- Small number of organizations

Transition

- Enabling timely resumption of social/economic activities
- Additional organizations involved

Relevant GENERAL PREREQUISITES for Termination (continued)

Assessment of radiological situation:

- **Reference levels**
- **Generic criteria**
- **Operational criteria**

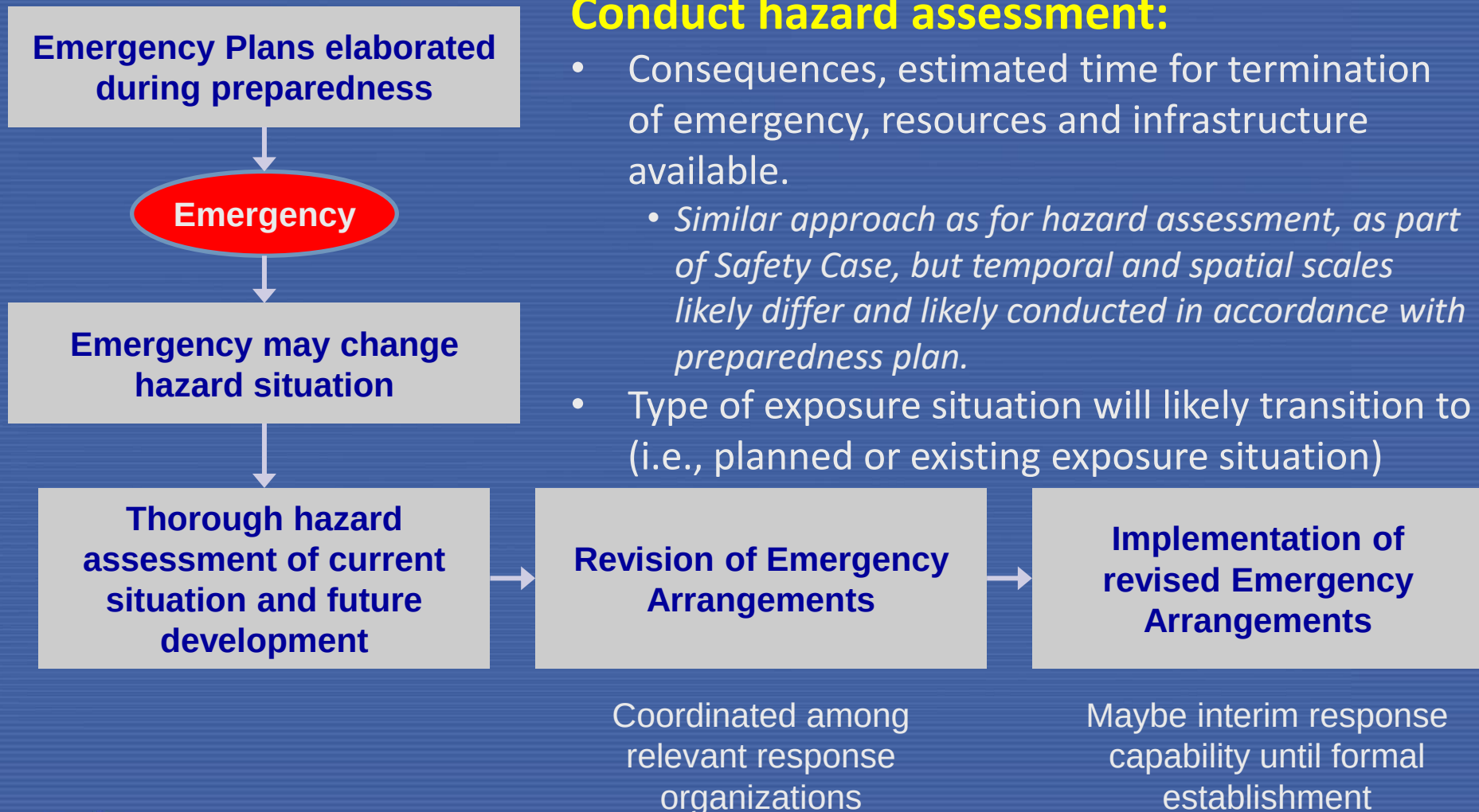
to determine if meet the relevant prerequisites for transition.

Identification and consideration of non-radiological and other factors:

- **Technology**
- **Land use options**
- **Availability of resources**
- **Community resilience**

Strategy for waste management arising from the emergency developed.

GENERAL PREREQUISITES (cont.)



SPECIFIC PREREQUISITES

Transition to an existing exposure situation



Justified and optimized actions taken



REFERENCE LEVELS FOR THE RESIDUAL DOSE	APPLICABILITY
20–100 mSv (acute or annual effective dose)	Emergency exposure situation
~ 20 mSv (annual effective dose)	Transition from an emergency exposure situation to an existing exposure situation
1–20 mSv (annual effective dose)	Existing exposure situation



SPECIFIC PREREQUISITES

Transition to an existing exposure situation (cont.)

- **Delineation of areas** if not feasible to allow unrestricted use of these areas (areas of evacuation or relocation and/or already imposed restriction continue to be implemented)
- For these delineated areas, **administrative and other provisions** have been put in place to monitor the compliance with the restrictions in place;
- Development of a **strategy for restoration of infrastructure, workplaces and public services** necessary to support normal living in the affected areas;
- Mechanism and means for **continued communication and consultation** with all interested parties, including local communities, is put in place;

SPECIFIC PREREQUISITES

Transition to an existing exposure situation (cont.)

- **Change or transfer of authority** and responsibilities from the emergency response organization to organizations responsible for the long term recovery operations completed;
- **Sharing of any information and data** gathered during the emergency exposure situation relevant for the long term planning organized among relevant organizations and authorities;
- **Administrative arrangements, legislative and regulatory provisions** are in place, or the corresponding amendments are underway, for the management of the existing exposure situation including provisions for necessary financial, technical and human resources

SPECIFIC PREREQUISITES

Transition to an existing exposure situation (cont.)

- A **long-term monitoring strategy** has been developed in relation to residual contamination;
- A **programme for long-term medical follow-up** for the registered individuals has been developed;
- A **strategy for health surveillance** of the affected population and for consultation in relation to psychosocial health consequences has been developed;
- **No individual dose monitoring** of members of the public for radiation protection purposes needed;
- Consideration has been given on **compensation of victims** of damage resulting from the emergency.

Characterization of the Exposure Situation

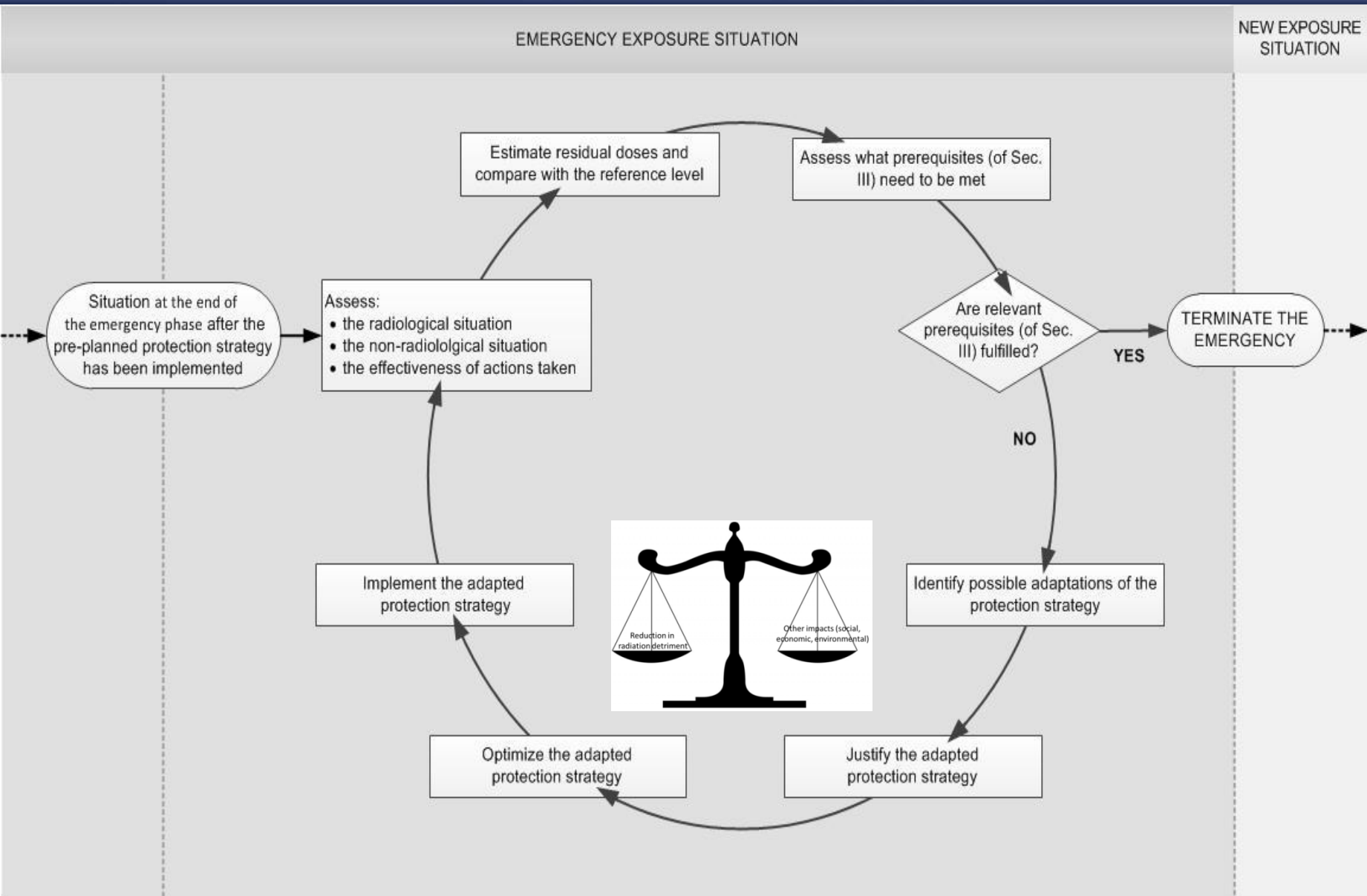
In transition phase:

- Need to obtain reliable monitoring data to characterize radionuclide mix and contamination footprint, etc.
- Pay attention to possibility of heterogeneity of deposition
- Prepare deposition and external dose rate maps
- Share such maps only if accompanied by plain language explanations/advice on hazards/protective actions
- Comprehensive monitoring of food, feed, milk, drinking water
- Consider special circumstances (e.g., very arid areas) for dose pathways assessed
- Estimate doses using realistic habits data

Radioactive Waste Management

- Radiation emergency may generate waste (radioactive and conventional)
 - National framework for radioactive waste management may not necessarily recognize this waste stream
 - Authorities may be under pressure (public/political) to treat all waste as radioactive waste thus producing large volumes
- Protection strategy should not be compromised
- Generation of radioactive waste one of many factors to be considered in justification/optimization
- As response progresses radioactive waste management activities will become important and integral part of the overall response

Implementation of Protection Strategy during the Transition Phase



Existing Exposure Situations:



Problem already exists when a decision on the need for control needs to be taken.

Existing exposure situations include:

- Natural background radiation (e.g., radon)
- Residual radioactive material from past practices not subject to regulatory control, or not subject to regulation in accordance with current standards (e.g., when standards become more stringent over time)
=> Nuclear legacies
- After an emergency exposure situation is finished

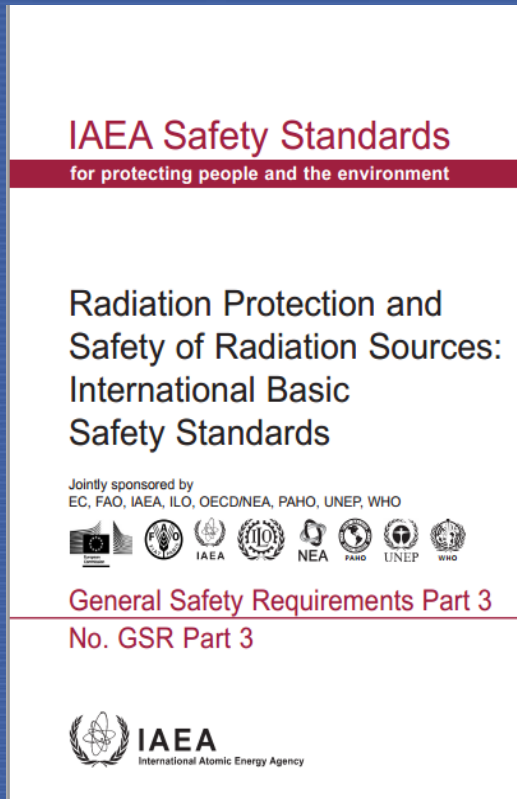
Reference levels are set for existing exposure situations:

- Existing situations: 1 - 20 mSv/a
- **Not a limit**, but a target
- **Situation-dependent**: feasibility and experience
- **All reasonable steps shall be taken** to prevent doses remaining above the reference level

Lessons Learned from existing situations can be applied to “proactive” decision-making and prevention of impacts for Planned Exposure Situations.

Requirements for Existing Exposure Situations for Protection of Emergency Workers and the Public

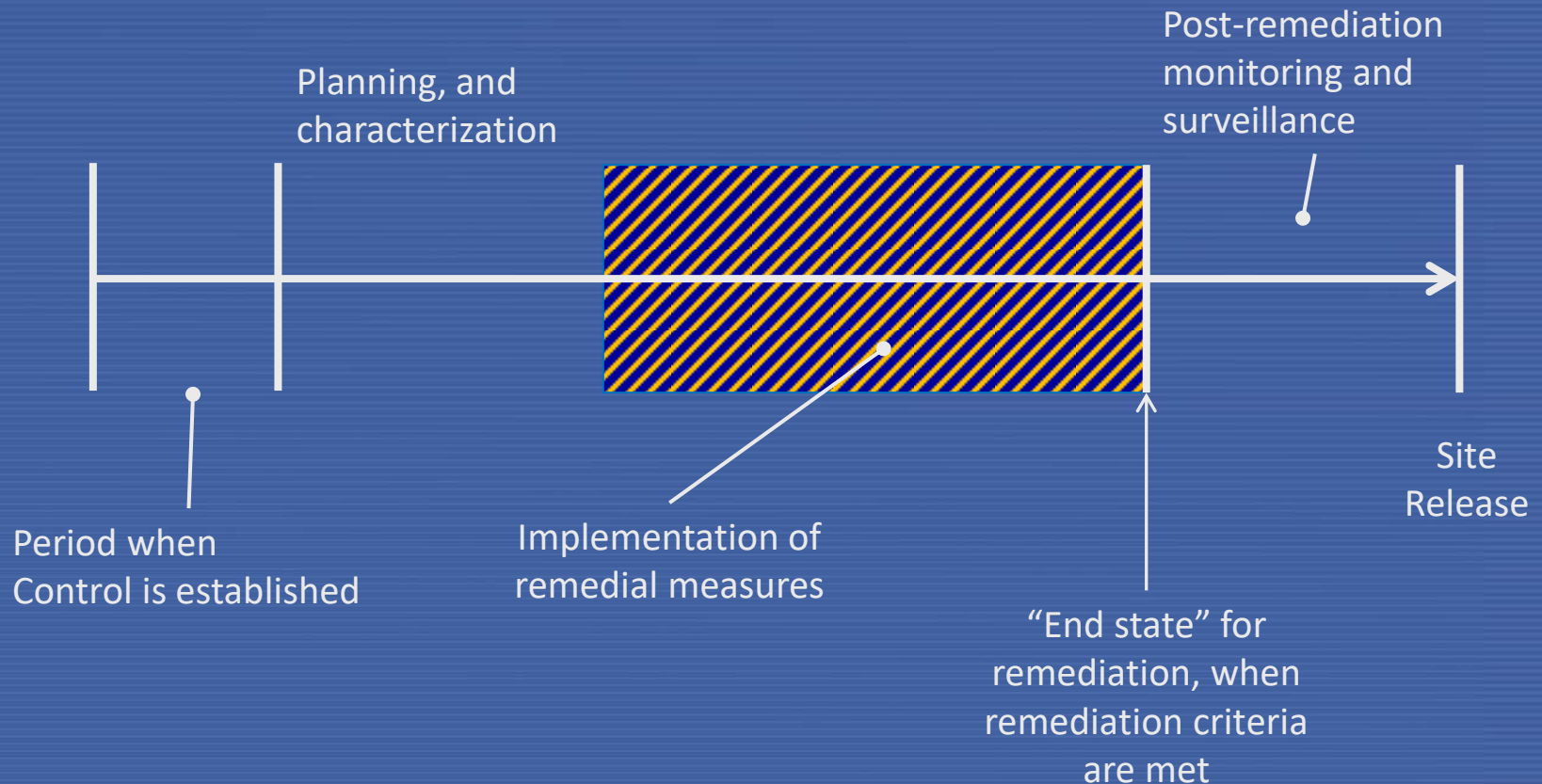
Existing Exposure Situations (Chapter 5):



- Responsibility of the government specific to existing exposure conditions
- Justification for protective actions and optimization of protection and safety (in context of control of public exposure)
- Responsibility for remediation of areas with residual radioactive material
- Public exposure to radon indoors
- Exposure due to radionuclides in commodities
- Exposure in work places

Lessons Learned from existing situations can be applied to “proactive” decision-making and prevention of impacts for Planned Exposure Situations.

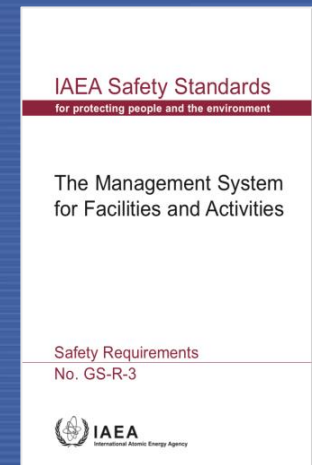
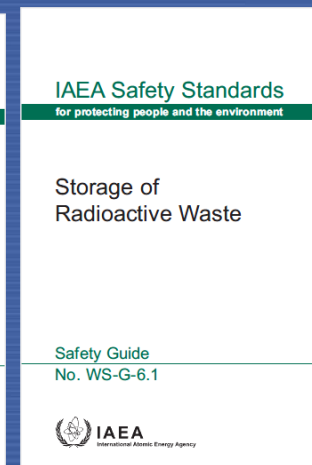
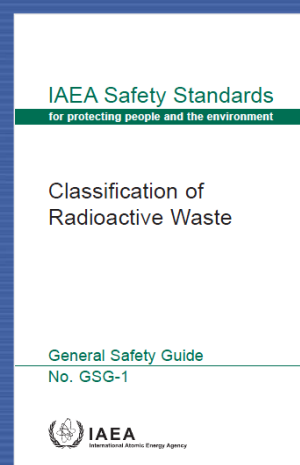
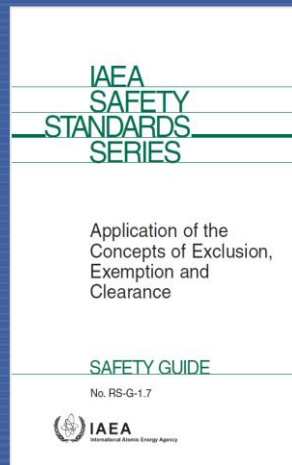
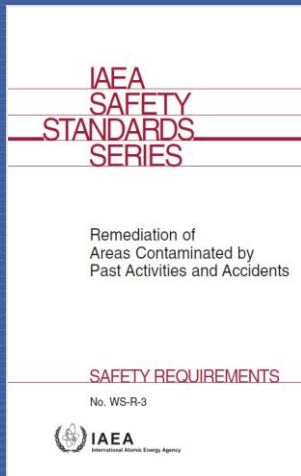
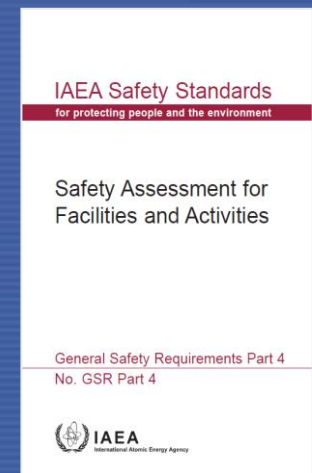
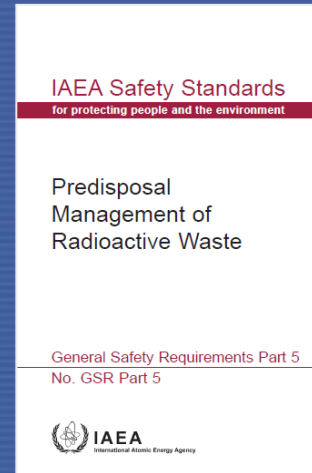
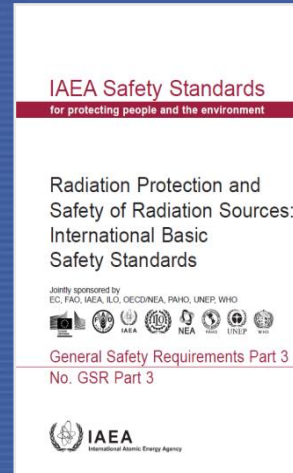
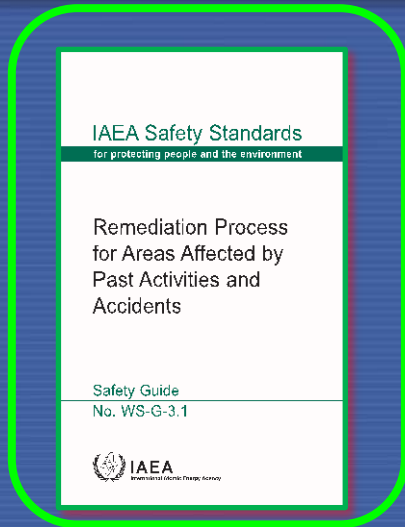
Remediation Process:



Existing Exposure Situation

Safety Standards on Remediation

WS-G-3.1 is under revision [DS468]

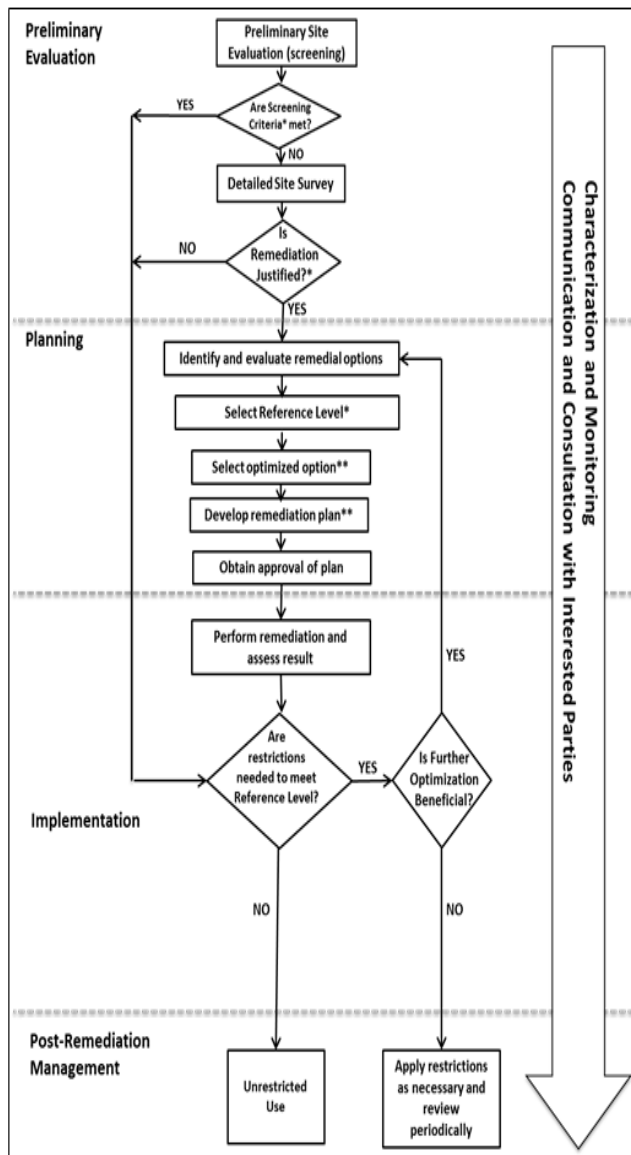


Update of WS-G-3.1 on Remediation Scheme of the Remediation Process

Remediation is a well established process, and is described in WS-G-3.1.

WS-G-3.1 is currently being revised and DS468 is under development.

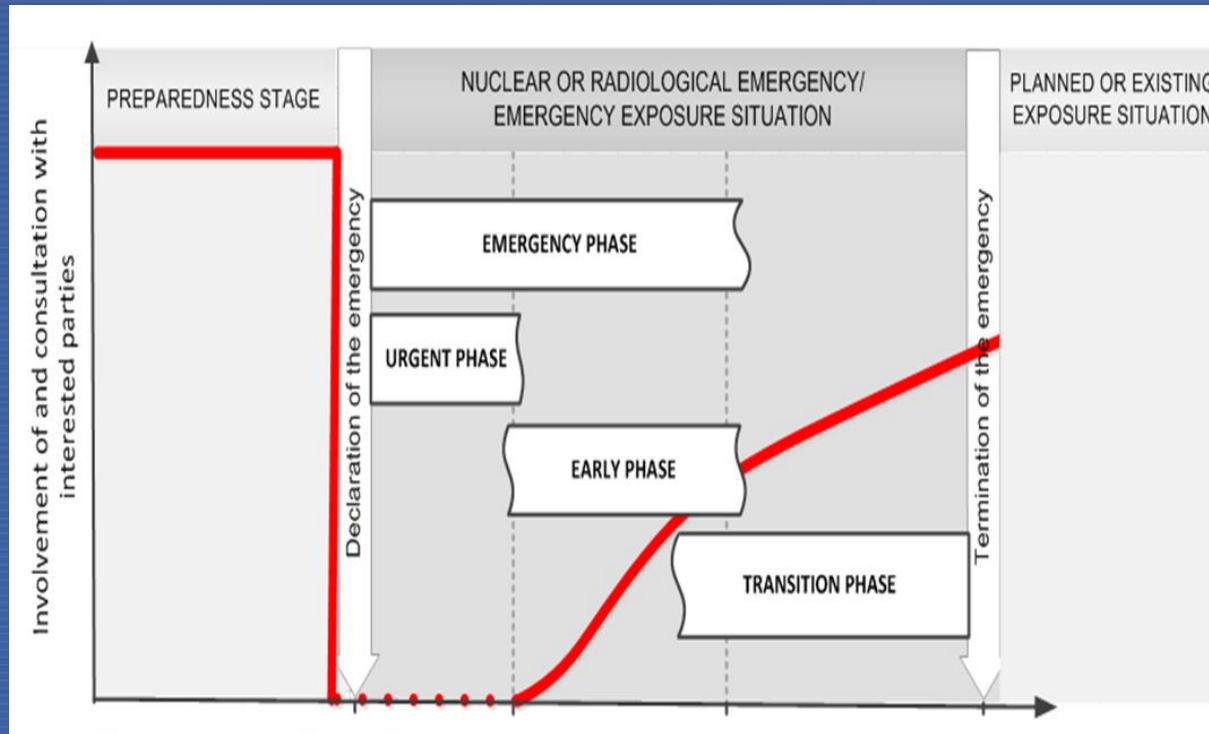
Draft document is out for Member State review (comments due 2 June 2017).



* - Assume a screening criterion of 20 mSv/a to start, based on Para. 6.21 on dose levels that can inform the decision regarding the need for remediation.

** - To ensure maximum net benefit, taking account of prevailing circumstances and conditions, including those related to safety and protection, as well as socio-economics, available funds, and others.

Criteria for Initiation of Remediation:



- **Control** over the radiological situation
- **Adequate characterization data** to make decisions regarding appropriate remedial options.



- Prevention
- Preparedness

- Control
- Characterization and Monitoring
- Dose Assessment
- Countermeasures
- Remediation

Remediation is likely to be initiated during the emergency exposure situation and to continue on during the existing exposure situation.

Objectives of DS468:

To provide guidance on implementing the requirements on remediation of:

- Areas contaminated by residual radioactive material arising from past activities that:
 - were never subject to regulatory control; or
 - were subject to regulatory control but not in accordance with the requirements of the existing IAEA and national safety standards.
- Areas affected by a nuclear or radiological emergency, after the release and deposition has finished and the radiological situation has been characterized.
- Areas affected by incidents, such as malicious acts, involving release of radioactive material.

Key Issues Being Addressed in DS468:

- Consistency with the BSS (2014) requirements for control of public and occupational exposure in existing exposure situations
- Strategic planning for severe accident recovery (including remediation preparedness)
- Application of a risk-based approach in the management of remediation and prioritization of remedial options
- Graded approach to dose assessment (including appropriate level of conservatism, such that effort is commensurate with risk)
- Application of principles of optimization, justification and limitation to existing exposure situations, as defined in GSR-Part 3 (2014)
- Application of the principle of optimization in the establishment of reference levels for existing exposure situations
- Integration of the optimization process in decision-making in the remediation process
- Considerations regarding the implications of relatively short-term protective actions and countermeasures taken just following an emergency on the long-term situation and remediation

Key Issues Being Addressed in DS468:

- Remediation planning and implementation as it relates to the potential generation of large amounts of low-level waste following an emergency
- Distinction between radioactive waste and residual materials in the context of remediation
- Exemption and clearance of radioactive waste as it relates to remediation
- Remediation planning with consideration of end-use and end-state, and institutional control (e.g., restricted vs. unrestricted land-use)
- Strengthened guidance on involvement of interested parties, including communication and consultation during remediation planning, implementation, and post-remediation management in the context of perceived versus actual risk
- Guidance on self-help in the context of remediation
- Experience gained in light of the Fukushima-Daiichi accident

TERMINOLOGY: Distinction between *‘Decommissioning’* and *‘Remediation’*

Decommissioning:

- is defined as *“Administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a facility”*.
- Is undertaken as part of a *“planned exposure situation”*.
- **Is focused on transitioning a planned (normal) situation, such that it is no longer under regulatory control (as control is no longer needed).**

Remediation:

- is defined as *“Any measures that may be carried out to reduce the radiation exposure due to existing contamination of land areas through actions applied to the contamination itself (the source) or to the exposure pathways to people”*.
- Is undertaken as part of an *“existing exposure situation”* or may be initiated during the transition of an *“emergency exposure situation”* to an *“existing exposure situation”* [linkage to DS474].
- **Is focused on bringing a situation under control that is not normal under regulatory control.**

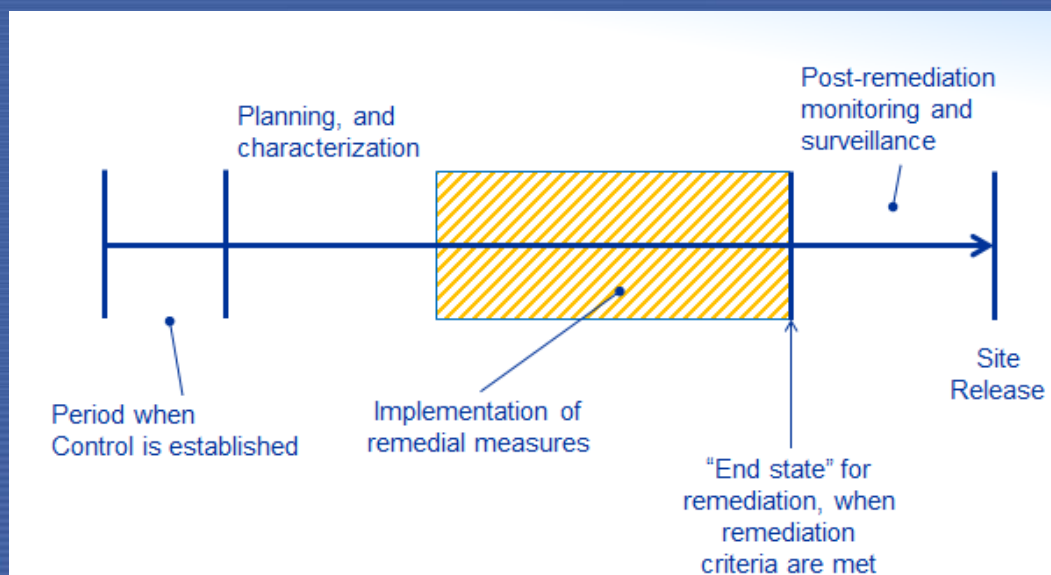
TERMINOLOGY: Distinction between ‘Protective Action’ and ‘Remedial Action’

Protective Action:

- is defined as *“An emergency response action for the purposes of avoiding or reducing doses that might otherwise be received in an emergency exposure situation or an existing exposure situation”*.

Remedial Action:

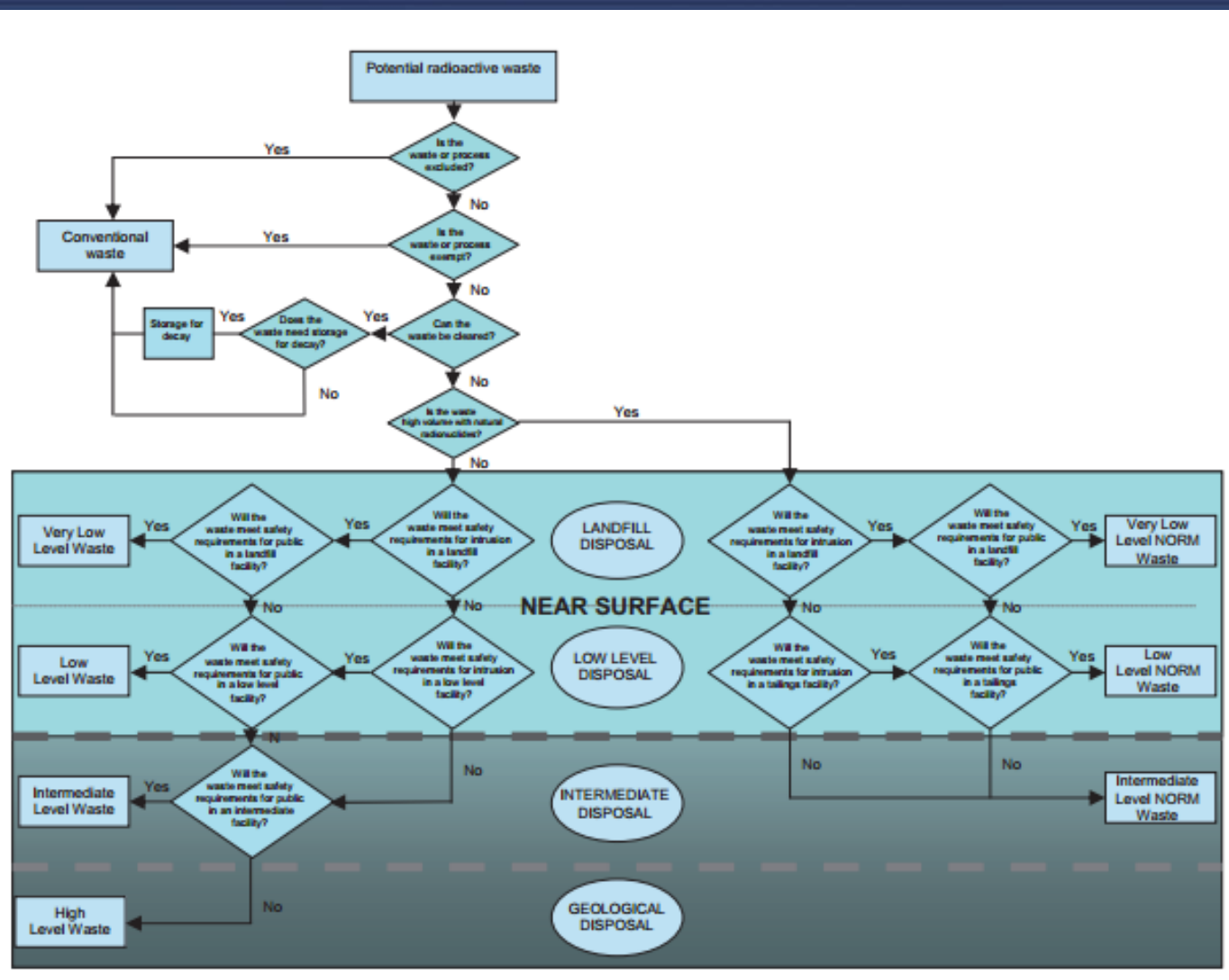
- is defined as *“The removal of a source or the reduction of its magnitude (in terms of activity or amount) for the purposes of preventing or reducing exposures that might otherwise occur in an emergency or in an existing exposure situation”*.



TERMINOLOGY: Residual Materials

- There has been detailed discussion on relevant concepts related to planning and implementation of remediation to minimize the generation of radioactive waste.
- The definition of residual materials, and the associated concepts of waste classification, clearance, recycling and reuse are integral aspects of this concept.
- For the purposes of DS468, it is proposed that 'residual materials' should be a comprehensive term, which includes:
 - Radioactive waste
 - Conventional waste
 - Materials that can be reused; and
 - Materials that can be recycled.
- **Classification of 'residual materials' is considered an important step in radioactive waste minimization.**
- **Concept of clearance is important.**

TERMINOLOGY: Residual Materials



IAEA

(from GSG-1 on “*Classification of Radioactive Waste*”)

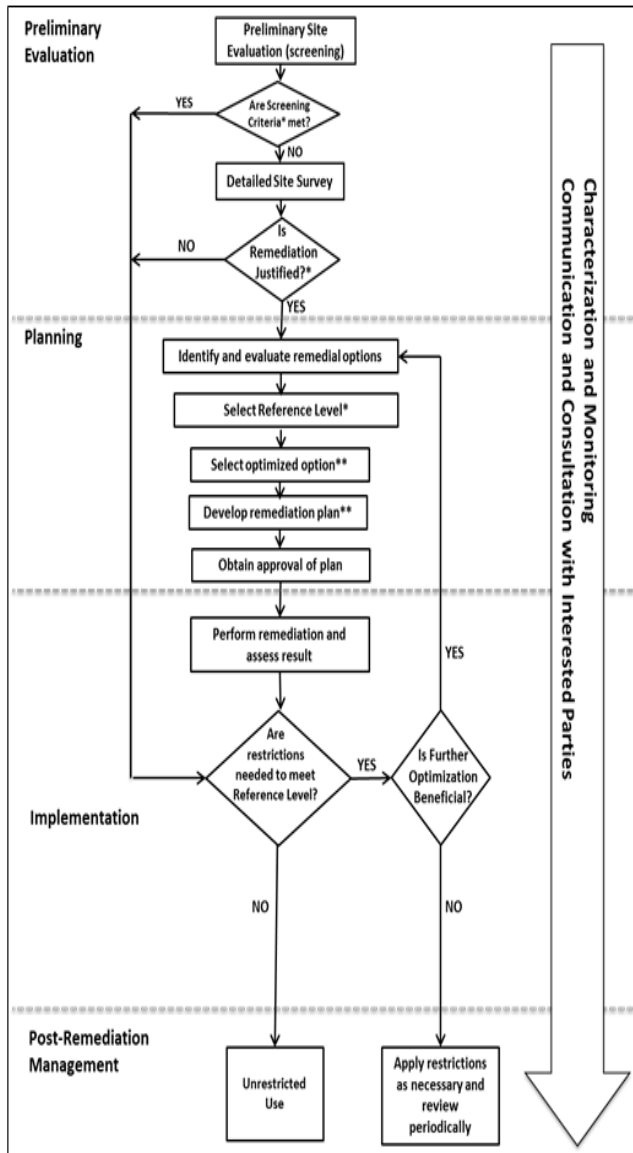
Guidance on Setting of Reference Levels (with an example):

1. Conduct **radiological surveys** [*i.e., characterization*] of each area to be remediated.
2. Conduct a **dose assessment** to predict doses to workers and members of the public.
3. **Review outcomes of the dose assessment and select remedial actions** to be undertaken.
4. Identify **possible remedial options** to meet Reference Level.
5. Make a decision regarding **end-state** and **end-use of land** and determine if remediation can be **justified** [*this was important because legally, it can affect the reference level that would be appropriate for the situation*]
6. **Set the Reference Level** [*which represents the start point for the optimization of protection*], as well as corresponding **measurable or 'operational' Derived Reference Levels** [*e.g., ambient dose rate, activity concentrations in dietary items, etc.*].
7. Development of a **plan to optimize protection** [*i.e., through process of optimization and applying the graded approach*].
8. Conduct **monitoring** to verify that doses and Derived Reference Levels fall within the predicted/authorized values.

Process-based Document Structure:

- Step-wise process-based document structure:

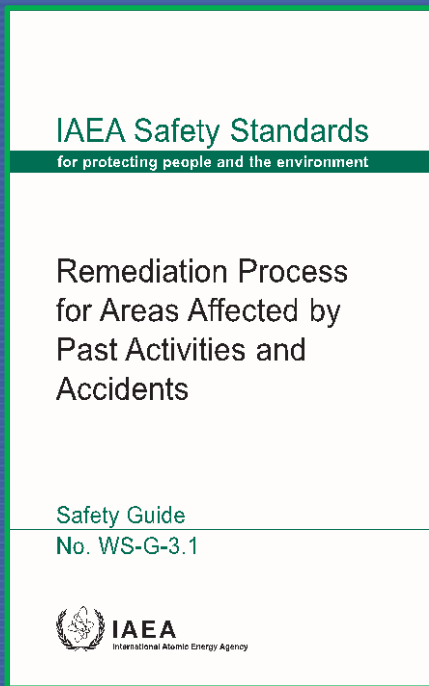
- Preliminary evaluation (characterization)
- Planning
- Implementation
- Post-remediation management



IAEA

DS468 is out for Member State comment until 2 June 2017.

Structure of DS468:



1. INTRODUCTION
 - Background
 - Objective
 - Scope
 - Structure
2. NATIONAL FRAMEWORK FOR REMEDIATION
 - Governmental, legal and regulatory framework
 - National policy
 - National strategy
 - Site-specific remediation strategy
 - Site-specific remedial action plan
 - Regulatory oversight
 - Funding of remediation
 - Involvement of interested parties *[covered throughout remediation process]*
3. APPLICATION OF THE PRINCIPLES OF RADIATION PROTECTION
 - Reference Levels
 - Justification
 - Optimization
4. THE REMEDIATION PROCESS *[flow diagram]*
5. SITE EVALUATION
 - Preliminary site evaluation
 - Detailed site survey
6. PLANNING OF REMEDIATION
 - Selection of remedial options
 - Safety and environmental assessments
 - Justification, optimization and evaluation of remedial options
 - Site-specific remedial action plan

Structure of DS468:

7. IMPLEMENTATION OF REMEDIATION

- Radiation protection during remediation
- Monitoring and ongoing surveys during remediation
- Emergency preparedness
- Dealing with abnormal events
- Security in the area
- Release of areas
- Unrestricted use
- Restricted use
- Restricted access
- Final remediation report
- Record keeping and information management

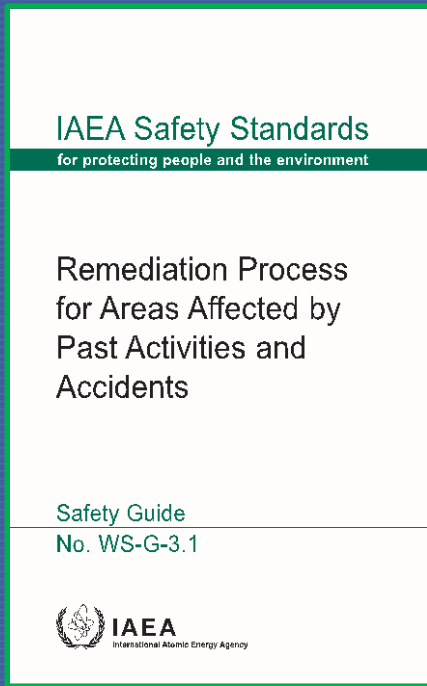
7. MANAGEMENT OF RESIDUAL MATERIALS GENERATED DURING REMEDIATION

- General approach
- Clearance
- Recycling and reuse of residual materials
- Management of remediation radioactive waste

8. POST-REMEDIATION MANAGEMENT

- Removal of restrictions
- Record keeping and information management
- Interested parties aftercare and public communication
- Monitoring and surveillance programme

REFERENCES



Structure of DS468: ANNEXES (no Appendices)

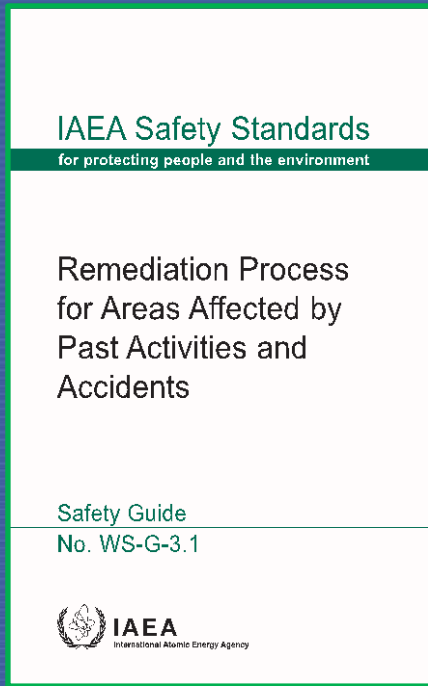
ANNEX I: EXAMPLE TABLE OF CONTENTS FOR A
SITE REMEDIATION PLAN

ANNEX II: DOSE ASSESSMENT FOR REMEDIATION
PURPOSES

ANNEX III: OPTIMIZATION OF SITE REMEDIATION:
PRACTICAL ASPECTS AND EXAMPLE *[including
example of establishment of Reference Levels]*

ANNEX IV: SELF HELP

ANNEX V: RELEVANT LITERATURE



Development of Underlying Technical Basis for Implementation of DS468

Technical Meeting on Remediation Techniques and Strategies in Post-Accident Situations 13–17 June 2016



Objectives of the Technical Meeting

- Sharing knowledge and experiences of Member States on a wide spectrum of aspects related to remediation and recovery of contaminated areas.
- Addressing the requirements of the IAEA Safety Standards, and in particular of the General Safety Requirements, Part 3 on Radiation Protection and Safety of Radiation Sources.

Member State Participation in Technical Meeting

- No. of Member States: 33
- No. of Participants: 50 (>100 nominations)



- Operators
- Regulators
- Technical support organisations

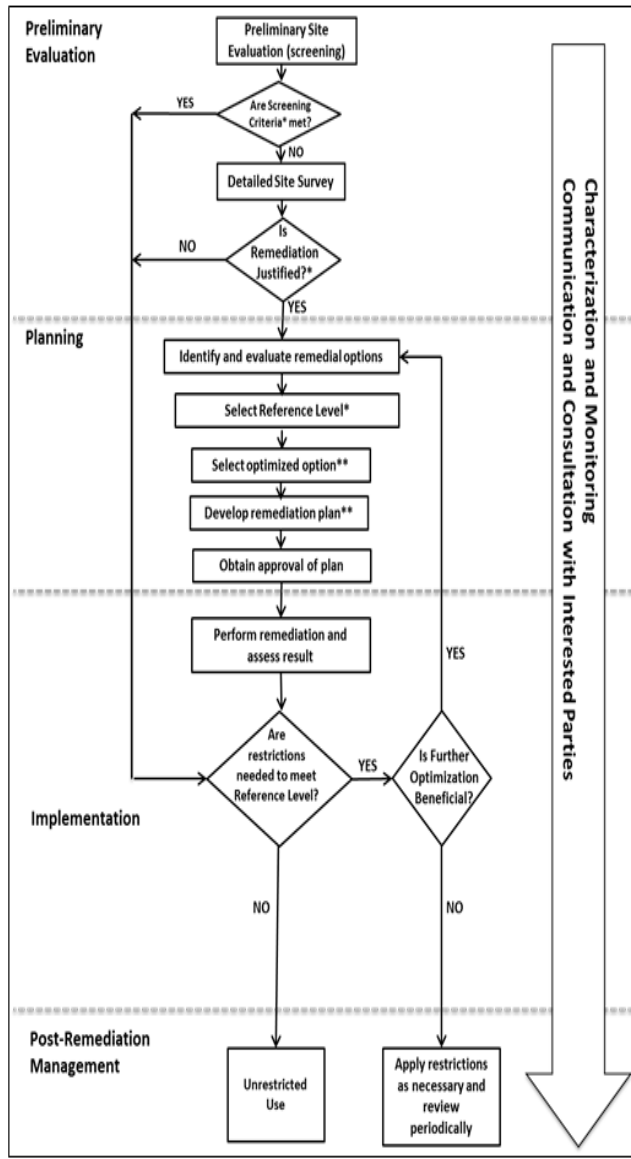
Participants originated from countries ranging from those with significant nuclear technology practice and experience in post-accident management, to those with experience in post-accident management as 3rd parties, to those with mining experience, to those working to gain additional expertise.

- Number of presentations: 33

Working Agenda:

1. PRELIMINARY SITE EVALUATION FOR REMEDIATION PLANNING
2. REMEDIATION PLANNING
3. IMPLEMENTATION OF REMEDIATION
4. POST-REMEDIATION MANAGEMENT AND INSTITUTIONAL CONTROL
5. CASE STUDIES

DISCUSSION of “*Questions for Discussion*”
PLENARY SESSION AND WRAP-UP
GROUP DISCUSSION of possible PATH-FORWARD



Topics of Interest Identified by Meeting Participants

- How to demonstrate compliance with remediation criteria
- How to build trust so that stakeholders can be effectively risk informed
- Decommissioning planning, with or without accident
- Accident management and remediation in recovery stages
- Meaning of “Adequate Preparedness”
- Optimised analysis of remediation
- Information to support EU projects
- Support for regulatory development relevant to planning of remediation
- Strategy for crisis communication
- Mitigation of long-term Chernobyl impacts
- Data for model validation
- Selection of numerical values for Reference Levels
- Transition from emergency to existing situation
- Transition to final recovery reaching the selected site end state
- Waste management in post-accident situations
- Dose assessment for workers and the public

Outcomes and conclusions

- The meeting participants provided useful feedback on the “Questions for Discussion” and a great number of detailed aspects to be considered for further improvement have been identified.
 - Overly conservative/cautious dose assessments do more harm than good! **Direct resources at improved monitoring strategies to inform realistic dose assessments and subsequent recovery strategies, following an accident.**
 - **Enhance resilience** in recovery/remediation by improved preparation and planning; proactive_approaches needed not reactive ones.
 - Consider establishing an International Recovery Handbook User’s Group to maintain state-of-the-art knowledge and to develop simpler User Interfaces
 - **Without demonstrating their practicability and/or applicability this doesn’t solve the problems of reality.**

Developing Effective Risk Communications throughout Integrating Perceived Risk and Actual Risk in Public Communications

Improving public communication by addressing the perceived risks and actual risks of local residents of the affected communities will improve public acceptance for existing remediation and waste management measures, foster a return to normal life by residents and returning evacuees by reducing fears, stress and anxiety, and help to build mutual understanding and trust that will contribute to future success of the revitalizing efforts related to remediation and waste management.

Population-based estimates of dose/risk are difficult to convert into precise statements of individual risk – however, if perceived risks go unaddressed, then the public remains unconvinced of the safety, and public confidence in the authorities is lost.

The IPARSC Project offers to assist Member States in the assessment of risk perceptions of residents, and provides guidance on developing risk communication.

Stakeholder Involvement

- Protection decisions are generally NOT taken by Radiation Protection specialists; instead, the Radiation Protection expert is an advisor and a councillor rather than a decision maker.
- The “most effective” stakeholder interactions are by RP experts trained in public interactions, not by communications experts trained in RP.
- Trust is a necessary and central component of successful stakeholder involvement for stakeholders to build trust in government, government must have trust in stakeholders.
- **Training opportunities of experts in public interactions (communication and consultation), to facilitate effective, non-confrontational exchanges would be of great use.**



PRELIMINARY SITE EVALUATION FOR REMEDIATION PLANNING

- Many countries identified the complexity as well as the resources associated with the implementation of the necessary technical and organizational arrangements in the preparedness stage.
- In most of the countries plans and regulation for initiation and conduct of remediation activities are not available.
 - The need for further work in this area both at national and international level was recognized > **Undertake national assessments of recovery capability and focus resources where significant gaps are identified**
 - Wider dissemination of good practice (eg. ICRIN, CODIRPA ...) would be highly desirable - how to achieve this?

REMEDIATION PLANNING

- Little/no experience is available for deriving Reference Levels available in most countries. Only few countries represented have yet completed the required process to define RLs or operational levels during planning.
- There is a continuing debate about fixed vs. dynamic Reference Levels and about 1 mSv as a long term goal.
- Considerations of radiological protection umbrella versus societal umbrella have to be applied;
- Inconsistencies between ICRP 82 and 103 have been identified (10 or 20 mSv?); **ICRP TG93 must provide more clarification in the updated guidance.**

IMPLEMENTATION OF REMEDIATION

- Remediation and waste management have a strong dependency on many components, e.g., radionuclide characteristics, scale of contamination, tolerability, environmental conditions and infrastructure capabilities...
- Waste is one of the key challenges following a nuclear accident
 - **It is important to direct resources at developing practical means to reduce volumes of waste (realistic dose assessments, segregation and sorting of waste).**
- Options to enhancing resilience include effort to improve assessments of e.g. individual dose from air dose rates, taking into account lifestyle and location as well as to increase understanding of transport and accumulation of radionuclides in the environment: river basins; forests; reservoirs; marine environment.

IMPLEMENTATION OF REMEDIATION

Demonstration of compliance with remediation criteria

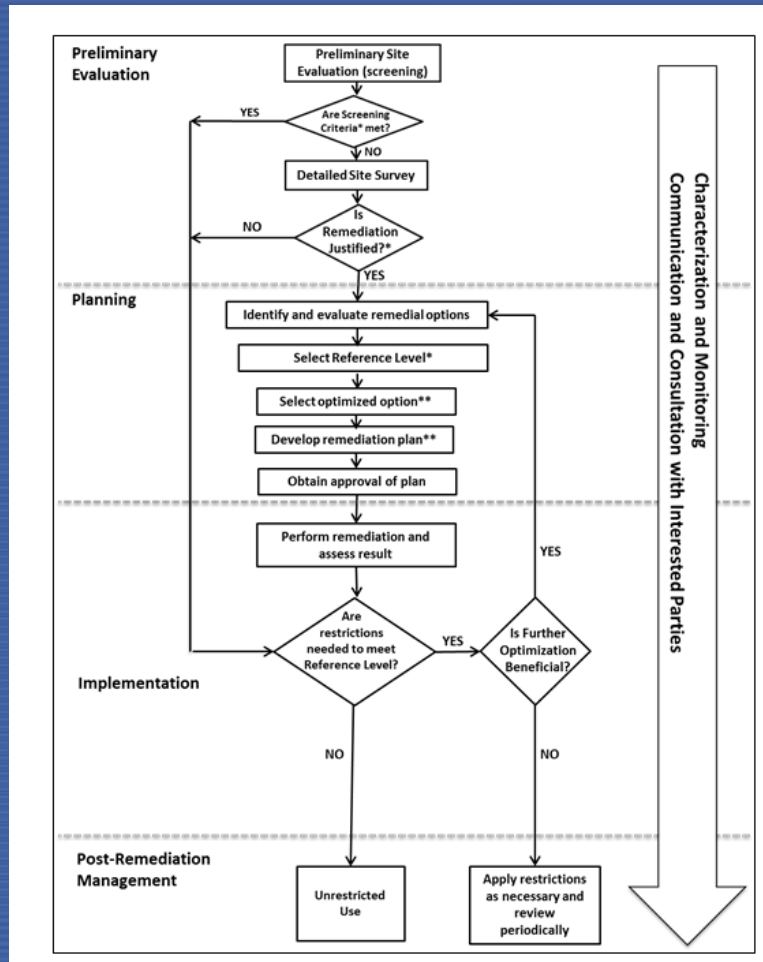
- Models, measurements; interpreting and combining results in assessment of doses, while addressing uncertainties. Application of criteria derived from Reference Levels.
- Converting stakeholder concerns into something that can be included into protection objectives: making a first assessment using a combination of established psychometric and other methodologies to better support the characterisation and quantification of risk perception. (Part of an overall process to build trust ... for the stakeholders to be able to see their concerns are addressed in the protection objectives).

Some issues for the revision of WS-G-3.1

- Take into account recent changes to related safety requirements (e.g., GSR Part 3).
- Elaborate further on waste and materials management, including topics such as clearance, recycle and reuse.
- Incorporate recent experience from remediation (contaminated sites and post-accident situations).
- Issues connected with transition from an emergency to an existing exposure situation.
- Radiation protection criteria and application of the optimization process to existing exposure situations in the context of remediation.
- Strengthen discussion on involvement of interested parties.
- Advance planning.

Short-term Path-forward by IAEA to Achieve Longer-term Goal

- The information gained during the TM, along with information through other IAEA initiatives, is being digested and condensed.
- This evaluation will then be captured in a document that will give practical guidance for each of the steps of remediation as outlined in DS468 – the Draft Safety Guide on Remediation.
- In the longer term, this summary document will serve as a basis to develop more detailed technical documents to provide advice, approaches, experiences and lessons learned, based on international experience and good practice.



IAEA Model Validation Programmes

Objectives

To improve capabilities in the field of environmental dose assessment by means of acquisition of improved data for:

- Model testing and comparison
- Reaching consensus on modeling philosophies
- Approaches and parameter values
- Development of improved methods
- Information exchange



Previous International IAEA Model Testing Programmes

- **1985-1991: BIOMOVs**
 - BIoSpheric Model Validation Study, sponsored by SSI (Sweden)
- **1988-1994: VAMP**
 - Validation of Model Predictions, prompted by Chernobyl
- **1991-1996: BIOMOVs II**
 - BIoSpheric Model Validation Study, with SSI, Sweden
- **1996-2001: BIOMASS**
 - BIoSphere Modelling and ASsessment, 1996-2001
- **2003-2007: EMRAS I**
2009-2011: EMRAS II
 - Environmental Modelling for Radiation Safety, 2003-2007
- **2012-2015: MODARIA I**
 - Modelling and Data for Radiological Impact Assessment

MODARIA I (2012-2015)

Working Groups



IAEA

International Atomic Energy Agency

MODARIA I Working Groups

Theme A: Remediation of Contaminated Areas

WG 1 Remediation strategies and decision aiding techniques

- Decision theory and decision process
 - Limitation of science
 - Different countries, different decision processes, different decisions
- Engagement of interested parties
- Remediation planning

WG 2 Exposures in contaminated urban environments and effect of remedial measures

- To test and improve assessment models applied to contamination in urban environments
- Dispersion and deposition
- Short- and long-term redistribution following deposition events
- Effectiveness of potential countermeasures or remediation efforts

Theme A: Remediation of Contaminated Areas

WG3: Modelling radiological impacts arising from NORM and radioactively contaminated legacy sites

- Assessments to fulfil the regulatory requirements of IAEA Standards
- Development of the MORMALYSA assessment tool for affected sites
 - Enhanced levels of NORM : e.g. U-mining
 - Enhanced levels of man-made RN, e.g. accidents, legacies, unregulated past practices
- Model-model and model-data comparison exercises

WG4: Analysis of radio-ecological data

- IAEA TRS-472 animal database revision (goat and cow milk)
 - Relationship between gut absorption and transfer parameters
 - Transfer to meat in semi-natural environments in Japan
- K_d datasets of soil and freshwater systems
- Derivation of conservative values for SRS-19 revision

Theme B: Uncertainties and Variability

WG 5: Uncertainty and variability analysis for assessments for routine discharges

- **Influence of national regulatory requirements**
- **Realism of models**
 - Sources of uncertainty and methods for their quantification
 - Environmental monitoring data in uncertainty analysis processes
 - Sensitivity analysis to identify key parameters
- **Distributions of parameters used in the different scenarios and codes**
 - Influence of correlations between different parameters
- **Comparison exercises with the different codes in the defined scenarios**

Theme B: Uncertainties and Variability

WG 6 Environmental change in long term safety assessments of radioactive waste disposal facilities

- Projections of **long-term climate and landscape change** (reference futures)
 - Results for a **range of CO₂ emission scenarios** as a common starting point for assessments for international use
 - Method for downscaling to regional/site level
- Quantitative **modelling of landscape evolution**
 - Linked with climate modelling
 - Modelling **radionuclide transport through a changing landscape**
- Enable **consistent treatment of long-term environmental change** across different national radioactive waste disposal programmes

Theme B: Uncertainties and Variability

WG 7 Models for accidental tritium releases

- Development and application of **environmental tritium transfer** models
- Analysis of the **tritium transfer in terrestrial ecosystems**
 - Dry/wet deposition
 - Deposition during day/night,
 - Summer/winter
- **Inter-comparison of models** on specific scenarios
- Identification of knowledge gaps and assessment of their significance

Theme C: Exposures and Effects on Biota

WG8: Modelling exposures to biota

- Modelling exposure in spatially heterogeneous environments
- Comparison of **simple and complex dosimetric models**
- Development of **dynamic models**: Scenario for Fukushima marine environment
 - Biological half-life data for wildlife
- **Guidance on assessment for biota**: 'Lessons learnt' documentation

WG9: Radiation effects on populations of wildlife species

- Explore **effects on populations**
 - Acute vs chronic exposure
 - Laboratory vs field conditions
- Review of **existing population models** focussing on the field of application
- **Population modelling** methodologies - conceptual and mathematical description
- Applicability of population modelling in a radiation protection **regulatory context**

Theme D: Marine Modelling

WG 10: Modelling of marine dispersion and transfer of radionuclides accidentally released from land-based facilities

- **Fukushima releases in the Pacific Ocean**
 - Intercomparison of hydrodynamic sub-models
 - Intercomparison of dispersion models
- **The Baltic Sea: modelling Chernobyl fallout, 4 models involved**
 - NRPA box model
 - POSEIDON box model
 - USEV hydrodynamic model
 - THREETOX hydrodynamic model
- Results compared with HELCOM database measurements

MODARIA Participants:

Typically, ~150 participants from more than 40 Member States, with representation from:

- Operators
- Regulators
- State Agencies
- Technical Support Organisations
- Universities
- National Research Institutes

Dissemination of Results

- **IAEA Publications**

- Each working group prepared an IAEA (TECDOCS)
- Technical Report series (TRS) in some cases

- **Papers in peer reviewed Scientific Journals**

- Publication of results is encouraged
- Large number of individual papers published on initiative of the WG from results obtained during BIOMASS, EMRAS I, EMRAS II, MODARIA

MODARIA II Programme 2016-2019



IAEA

International Atomic Energy Agency

Development of the MODARIA II Programme

- **Brainstorming session** during the last Technical Meeting of MODARIA I (11 Nov 2015)
 - 17 proposals
- **Consultants' Meeting** in Vienna (29 Feb to 2 March 2016)
 - Analyze the proposals in view of:
 - The Member States' needs to implement the IAEA Safety Standards
 - To develop assessment capabilities
 - To ensure appropriate control of exposures to the public

MODARIA II Proposal:

- **Suggestions during the brainstorming session were largely integrated** into the MODARIA II programme
- **MODARIA II will have 7 Working Groups**
 - Integrating activities of Decision Making (WG 1) and Remediation (WG3)
 - Joining the work on Modelling exposures to biota (WG 8) and Modelling effects to biota (WG9)
 - Integrating the work on Tritium modelling (WG 7) into Modelling Discharges (WG 5)

*Proposals for Topics for the
IAEA's Environmental Network
MODARIA II:
“Modelling and Data for
Radiological Impact Assessments”*

July 2016

MODARIA II Working Groups:

WG 1: Assessment and Decision Making of Existing Exposure Situations for NORM and Nuclear Legacy Sites

- WG Leader: Ming Zhu (USA)
- Scientific Secretary : Tamara Yankovich
- **Methods and tools for radiological impact assessments** and application to specific situations
- Methodologies for **decision analyses for remediation and closure** of NORM and legacy sites
- **Communication** and engagement with relevant interested parties
- **Training** for end users for the use of the NORMALYSA software

WG 2: Assessment of exposures and doses plus effectiveness of countermeasures in urban environments

- WG Leader: Kathy Thiessen (USA)
- Scientific Secretary : Tamara Yankovich
- **Experience in Japan** following the accident at the Fukushima
- Modelling the **dispersion and redistribution** of radionuclides in an **urban environment**
- Effectiveness and impact of **remedial measures for urban environments**



There is room for new scenarios to cover predictions of deposition and dose for different types of accidents under MODARIA II.

MODARIA II Working Groups:

WG 3: Assessment and control of exposures to the public and biota for planned releases to the environment

- WG Leader: Juan Carlos Mora (Spain)
- Scientific Secretary: Diego Telleria
 - Develop and apply an **integrated approach** to assess the impact of releases to the environment on both **humans and biota** from ionizing radiation.
 - Assessment of impacts from **short-term tritium releases**

WG 4: Transfer processes and data for radiological impact assessment, including radionuclide transfer in tropical and sub-tropical environments

- WG Leader: Brenda Howard (UK)
- Scientific Secretary: Gerhard Proehl
 - **Transfer parameters in Japan** determined after the Accident at the Fukushima NPP
 - Analysis and **updating key parameters** for use in radiological impact assessment
 - Assessment **models and data for tropical, semi-tropical and arid** environments

MODARIA II Working Groups:

WG 5: Modelling radiation exposures and effects on wildlife

- WG Leader: Nick Beresford (UK), Jordi Vives i Battle (Belgium), [F Alonzo, (France)]
- Scientific Secretary: Diego Telleria
- Development of **simplified approaches for biota** dose assessment (“graded approaches”)
- Modelling possible **effects to populations and need to fulfil regulatory requirements**
- **Uncertainties** associated with the different approaches and models

WG 6: Biosphere modelling for long-term safety assessments of waste disposal facilities

- WG Leader: Tobias Lindborg, Sweden
- Scientific Secretary: Gerhard Proehl
- Systematic, transparent and robust conceptual **framework for biosphere assessments** for radioactive waste disposal facilities
- Scientific basis of **long-term dose assessments and complementary plausible assumptions**
- Update/extension of the **BIOMASS-6 methodology, including numerical values** and models to assess the long-term dose to hypothetical members of the public

MODARIA II Working Groups:

WG 7: Assessment of fate and transport of radionuclides released in the marine environment

- WG Leader: Raul Perianez, Spain
- Scientific Secretary: Paul McGuinnity
- Improvement of **fate and transport models** including processes not yet implemented
- **Reliability of models** for predicting dispersion under different situations (short term or long term)
- **Limitations of the models** to predict radionuclide dispersion in emergency situations



IAEA

There is room for new scenarios to cover predictions of deposition and dose for different types of accidents under MODARIA II.

Mode of Operation

- **MODARIA II will run from 2016-2019**
 - Final Technical Meeting in October/November 2019
- **One joint Technical Meeting per year of all working groups in Vienna**
 - Enable cooperation between working groups to address cross-cutting topics
- **Interim Meetings**
 - Held half-way between the Plenaries by each Working Group
 - Held in Vienna or other places

Further Information

**IAEA.org**
International Atomic Energy Agency

NS IAEA Search this site

About Us
Who We Are

Our Work
What We Do

News Centre
Latest from IAEA

Publications
Books and Reports

Nucleus
Specialized Resources

Nuclear Safety & Security

Nuclear Applications

Nuclear Energy

Nuclear Safety & Security

Safeguards

Technical Cooperation

Nuclear Safety & Security

Safety & Security Framework

Technical Areas

Services for Member States

Safety & Security Publications

Conventions & Codes

Education & Training

Meetings

Special projects

Good 4 3 2 1 0 Poor

Rate this page

MODARIA II

Modelling and Data for Radiological Impact Assessments

First Technical Meeting for MODARIA II

The [first Technical Meeting \(TM\)](#) for the MODARIA II programme will be held at the IAEA's headquarters in Vienna from **31 October to 4 November 2016**, during which the MODARIA II programme will be formally launched.

The objectives of the meeting are summarized in the [Prospectus and Notes Verbale](#) (in all official languages) which were recently circulated to all Member States.

Should you wish to take part in the TM, a [Participation Form](#) (Form A) must be completed and then forwarded to the competent official authority (Ministry of Foreign Affairs, Permanent Mission to the IAEA, or National Atomic Energy Authority) of your respective country, for onward transmission to the IAEA.

Please note that your participation will only be registered when we receive your fully endorsed Participation Form, completed in your name. After the deadline for receipt through official channels (**19 September 2016**) has passed, you will subsequently receive a formal invitation to attend the meeting.

For further information please contact [MODARIA](#)

Background of the MODARIA II programme

The assessments of radiological impacts to people and the environment arising from radionuclides being discharged or already existent in the environment are necessary to prove compliance with regulatory standards, to support decisions during and after nuclear emergencies

Resources

[MODARIA II](#)

[EMRAS II](#)

[Environmental Assessment](#)

Page links

[Background](#)

[Objectives](#)

[Organization of the MODARIA Programme](#)

[MODARIA Working Groups](#)

[First Technical Meeting](#)

[Second Technical Meeting](#)

[Third Technical Meeting](#)



IAEA

<https://www-ns.iaea.org/projects/modaria/default.asp?l=116>

Next MODARIA II Technical Meeting

2nd Technical Meeting will be held in
Vienna, Austria from

30 October – 3 November 2017

Please email me if interested (t.yankovich@iaea.org)



Relevant Safety Standards under Development

- **DS468:** Revision of Safety Guide WS-G-3.1 on *Remediation Process for Areas Affected by Past Activities and Accidents* (update of WS-G-3.1) (**Web-site where draft can be found** - <http://www-ns.iaea.org/downloads/standards/drafts/ds468.pdf>).
- **DS499:** Specific Safety Guide: Application of the Concept of Exemption including Criteria for Trade in Contaminated Commodities (NEW IAEA Safety Standard).
- **DS500:** Safety Guide on Implementation of the Clearance Concept (update of RS-G-1.7).
- **DS505:** Source Monitoring, Environmental Monitoring and Individual Monitoring for Protection of the Public and the Environment (update of RS-G-1.8)
- You can monitor the following web-site for IAEA Safety Standards under development: <http://www-ns.iaea.org/standards/documents/drafts-ms-posted.asp?s=11&l=85>

Under Development:

TECDOC on Considerations for the Application of the IAEA Safety Requirements for Design of NPPs

Contact: Ms Cornelia Spitzer
IAEA Safety Assessment Section
Division of Installation Safety
(C.Spitzer@iaea.org)



IAEA

International Atomic Energy Agency

Presented at NUSSC

Objectives / Scope

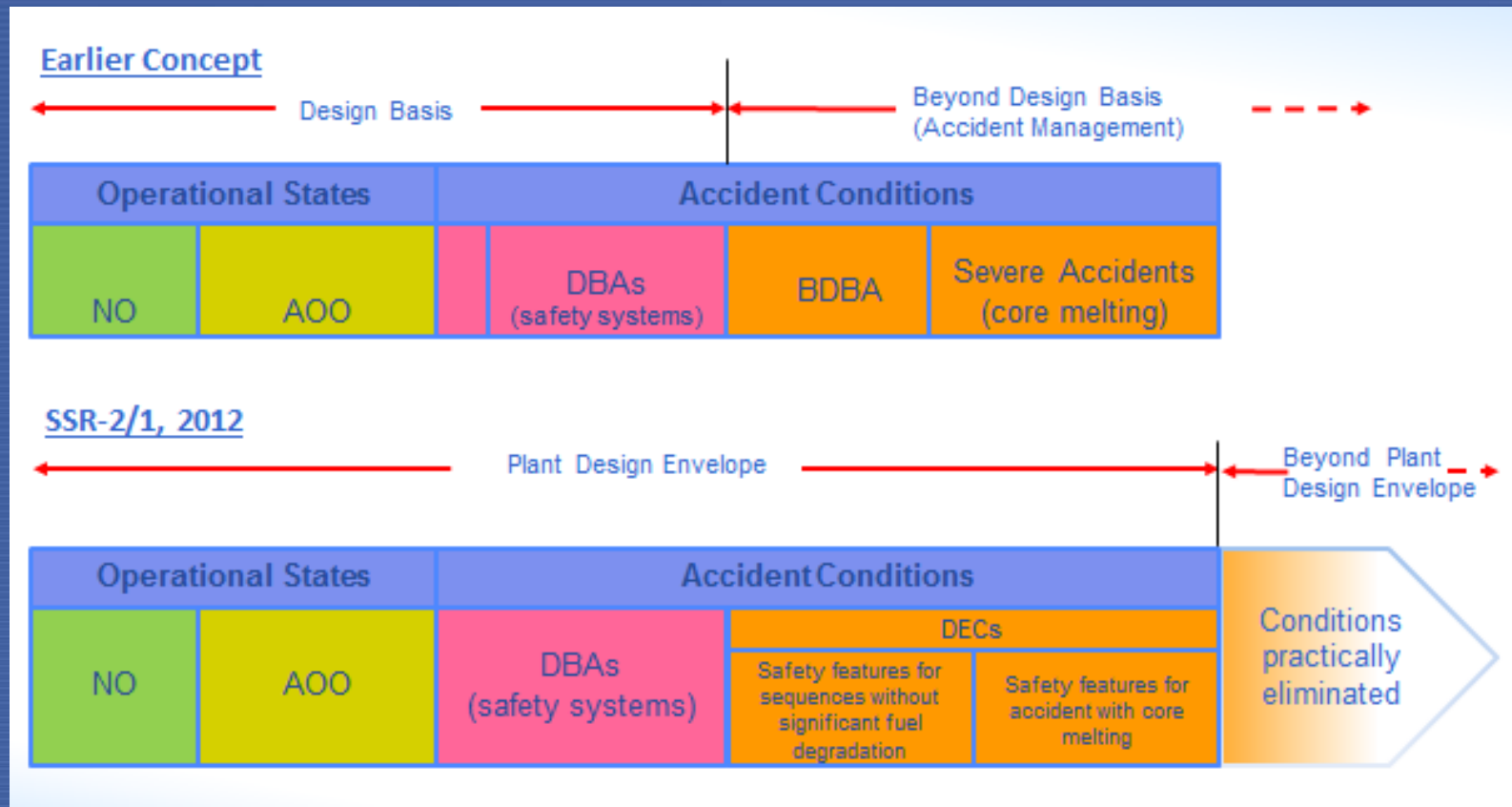
- TECDOC is aimed at facilitating the understanding and provide more explicit information on selected topics in SSR-2/1:
- IAEA Safety Standards
for protecting people and the environment

Safety of
Nuclear Power Plants:
Design

Specific Safety Requirements
No. SSR-2/1 (Rev. 1)

 IAEA
International Atomic Energy Agency
- Plant States considered in the design
 - Design Extension Conditions without and with fuel damage
 - Design basis of plant equipment
 - Defence in Depth (DiD) strategy for reactor and spent fuel pools (SFP)
 - Independence of the levels of DiD and prevention of common cause failures (CCFs)
 - Reliability of the heat transfer to the ultimate heat sink
 - Concept of “practical elimination” of early or large releases
 - Design margins and prevention of cliff-edge effects
 - Design for external hazards
 - Use of mobile sources of electric power and coolant

Novel Design Safety Principles



NO: Normal Operation; **AOO:** Anticipated Operational Occurrence;
DBAs: Design-basis Accidents; **BDBA:** Beyond Design-basis Accidents;
DECs: Design Extension Conditions



IAEA

Contact: C.Spitzer@iaea.org

Design Basis for SSCs

← Plant design envelope →				
Operational states		Accident conditions		
NO	AOO	DBAs	Design Extension Conditions	
			Without significant fuel degradation	With core melting (severe accidents)
Loads and conditions generated by External & Internal Hazards (for each plant state)				
Criteria for functionality, capability, margins, layout and reliability (for each plant state)				
Design basis of equipment for Operational states	Design Basis of Safety Systems including SSCs necessary to control DBAs and some AOOs		Design Basis of safety features for DEC including SSCs necessary to control DEC Features to prevent core melt	Features to mitigate core melt (Containment systems)

NO: Normal Operation; **AOO:** Anticipated Operational Occurrence;

DBAs: Design-basis Accidents; **BDBA:** Beyond Design-basis Accidents;

DECs: Design Extension Conditions; **SSCs:** structures, systems and components



IAEA

Contact: C.Spitzer@iaea.org

Defence in Depth ↔ Plant States

Level of defence Approach 1	Objective	Essential design means	Essential operational means	Level of defence Approach 2
Level 1	Prevention of abnormal operation and failures	Conservative design and high quality in construction of normal operation systems, including monitoring and control systems	Operational rules and normal operating procedures	Level 1
Level 2	Control of abnormal operation and detection of failures	Limitation and protection systems and other surveillance features	Abnormal operating procedures/emergency operating procedures	Level 2
3a	Control of design basis accidents	Engineered safety features (safety systems)	Emergency operating procedures	Level 3
Level 3 3b	Control of design extension conditions to prevent core melting	Safety features for design extension conditions without core melting	Emergency operating procedures	4a
Level 4	Control of design extension conditions to mitigate the consequences of severe accidents	Safety features for design extension conditions with core melting. Technical Support Centre	Complementary emergency operating procedures/ severe accident management guidelines	Level 4 4b
Level 5	Mitigation of radiological consequences of significant releases of radioactive materials	On-site and off-site emergency response facilities	On-site and off-site emergency plans	Level 5

Defence in Depth ↔ Plant States

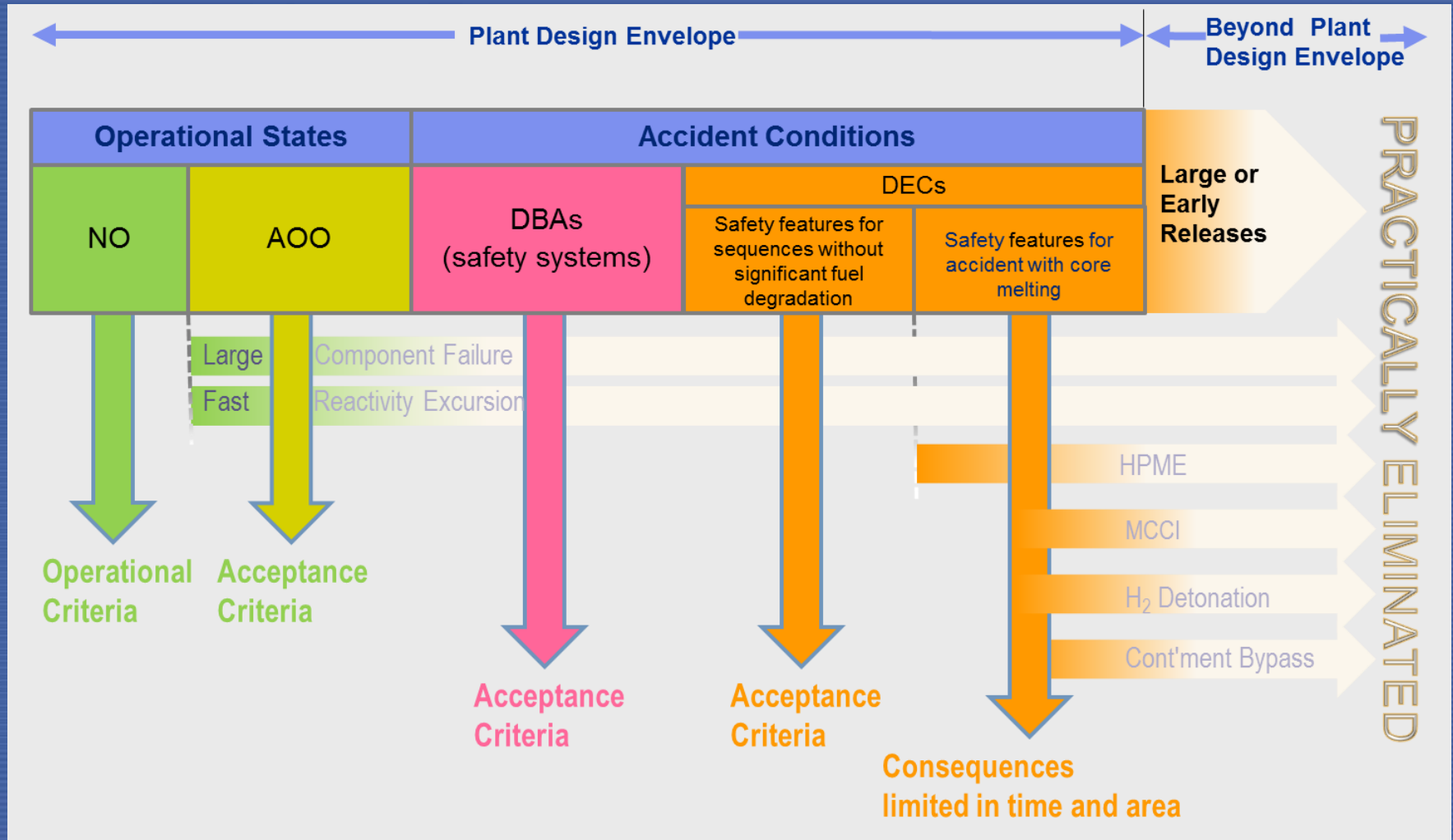
- **Approach 1**, i.e. the association of Design Extension Conditions (DECs) without core melting to level 3, has the advantage that each level has clear objectives regarding the progression of the accident and the protection of the barriers , i.e. level 3 to prevent damage to the reactor core and level 4 to mitigate severe accidents for preventing off site contamination
- **Approach 2**, i.e. the grouping of DECs without core melting and with core melting in level 4, facilitates however the differentiation between the set of rules for design and safety assessment to be applied for DECs from those for Design-basis Accidents (DBA)

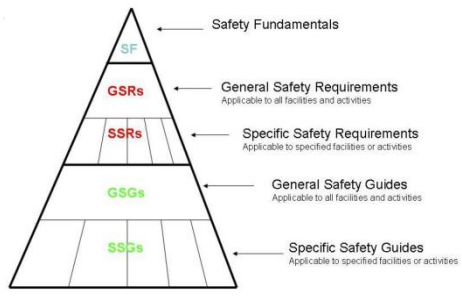
Practical Elimination

The hypothetical accident conditions that require a specific demonstration of their “practical elimination” include at least the following categories:

1. Events that could lead to prompt reactor core damage and consequent early containment failure
 - a. Failure of a large component in the reactor coolant system
 - b. Uncontrolled reactivity accidents
2. Very energetic phenomena in severe accident conditions
 - a. Core meltdown at high pressure (Direct Containment Heating)
 - b. Steam explosion
 - c. Hydrogen explosion
 - d. Containment boundary melt-through
 - e. Containment failure due to fast over-pressurization
3. Non confined severe fuel damage
 - a. Severe accident with containment by pass.
 - b. Significant fuel damage in a storage pool

Updated Safety Demonstration





Summary:

- The IAEA is responsible for activities of coordination, information sharing and development of safety standards.
- Activities are carried out in a harmonized manner, with consideration of those undertaken by other organizations.
- Needs for the underlying technical basis for higher-level documents can drive the need for coordination programmes, which can then later inform higher-level initiatives.
- For example, international model validation programmes provide a forum for evaluation of tools and standardization of approaches to assess potential risk. Findings from such studies can then be considered in IAEA safety guidance, with active participation by IAEA Member States.
- The outputs of such activities form the technical basis that informs higher-level IAEA Safety Standards and as input to conventions.
- **These efforts can be significantly leverages and strengthened through partnerships with other networks with similar objectives.**



IAEA

Tamara Yankovich (t.yankovich@iaea.org)