INTERNATIONAL HARMONIZATION OF NUCLEAR POWER SAFETY: ROLE OF SAFETY GOALS

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BACKGROUND

- Nuclear Energy is a long term commitment
  - Over 100 years, need continuity and open attitude to change, close attention to experience and results from safety research
- Nuclear map is changing
  - New countries accessing nuclear power
  - New designs being launched (EPR, AP-1000, APWR, SBWR, SMRs)
  - International partnerships on safety matters (MDEP, NEA, IAEA)

EXPECTATION OF HIGHER LEVEL OF SAFETY

- All countries expect that a higher level of safety will be achieved for new designs of nuclear power plants with particular emphasis on further efforts to prevent and mitigate severe accidents
- Clarity in Establishing safety requirements and international harmonization desirable

NEED FOR INTERNATIONAL HARMONIZATION

- Given the changes in landscape and the expectations regarding higher levels of safety two elements are important
  1. Clear understanding of the expectations by all stakeholders
  2. Additional effort to achieve international harmonization on what level of safety needs to be achieved

DEFENSE IN DEPTH SAFETY PHILOSOPHY, CORNERSTONE OF SAFETY

- All countries use a form of defense-in-depth (D-I-D) safety philosophy in making decisions on nuclear safety
- D-I-D philosophy has resulted in good safety record
- Some weaknesses in application of D-I-D identified from experience and research studies
- INSAG-12 provides good perspective on D-I-D (five levels)

LESSONS LEARNED FROM EXPERIENCE AND RESEARCH STUDIES

- Traditional Design Basis Accidents alone insufficient
- Design Extension conditions (e.g. SBO, ATWS)
- PRA to systematically develop accident scenarios
- How to decide on what can be excluded
- How to integrate probabilistic and deterministic elements

RELEVANT IAEA, NEA AND USNRC INITIATIVES

- INSAG-25 Integrated Risk Informed Decisions (expands on earlier efforts such as the USNRC RG1.174)
- IAEA Safety of Nuclear Power Plants: Design; No. SSR-2/1, 2012
- USNRC Safety Goals
- MDEP Safety Goals Subcommittee report
- MDEP Position Paper
- IAEA Safety Goals Activity
- USNRC RMTF

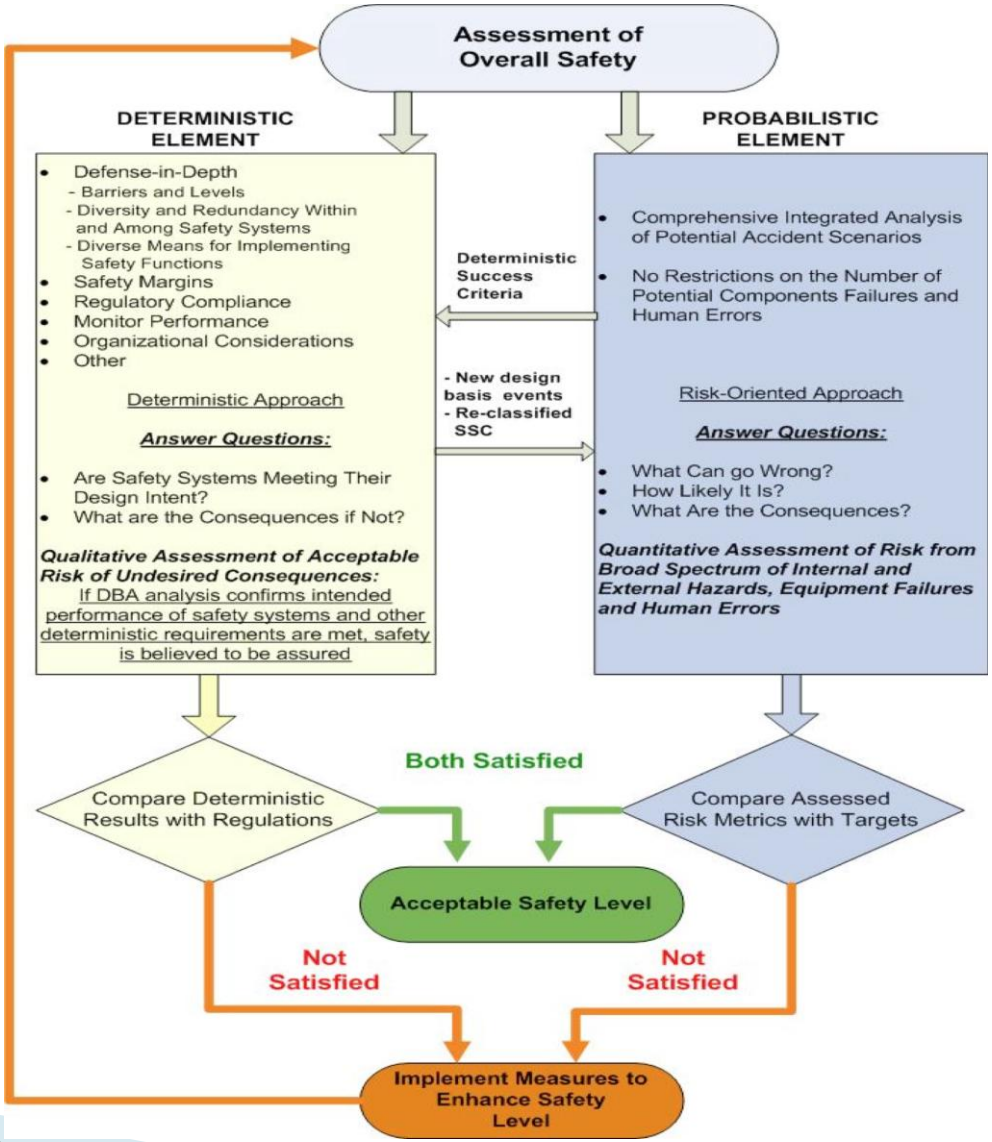
INSAG-25: A FRAMEWORK FOR INTEGRATED RISK-INFORMED DECISION MAKING PROCESS

- The IAEA fundamental principles and requirements encourage consideration of risk information along with deterministic safety analyses
- INSAG-25 describes a process for integration of operating experience, deterministic considerations, probabilistic analyses, consideration of uncertainties and other factors and serves to help ensure coherent and balanced decisions

INSAG-25

- The numerical results of analyses, deterministic and probabilistic, are influenced by input assumptions and associated uncertainties, and other limitations.
  - Both epistemic and aleatory uncertainties are important.
  - For Safety decisions, It is preferable to consider the numerical results as distributions

INSAG-25 INTEGRATION PROCESS



IAEA SAFETY OF NUCLEAR POWER PLANTS: DESIGN; NO. SSR-2/1, 2012

- **Requirement 20: Design extension conditions**
  - **A set of design extension conditions shall be derived on the basis of engineering judgment, deterministic assessments and probabilistic assessments for the purpose of further improving the safety of the nuclear power plant by enhancing the plant's capabilities to withstand, without unacceptable radiological consequences, accidents that are either more severe than design basis accidents or that involve additional failures. These design extension conditions shall be used to identify the additional accident scenarios to be addressed in the design and to plan practicable provisions for the prevention of such accidents or mitigation of their consequences if they do occur.**
  - **5.31. The design shall be such that design extension conditions that could lead to significant radioactive releases are practically eliminated (see footnote). If not, for design extension conditions that cannot be practically eliminated, only protective measures that are of limited scope in terms of area and time shall be necessary for protection of the public, and sufficient time shall be made available to implement these measures.**
- Footnote: The possibility of certain conditions occurring is considered to have been practically eliminated if it is physically impossible for the conditions to occur or if the conditions can be considered with a high level of confidence to be extremely unlikely to arise.

USNRC SAFETY GOALS

- Fundamental Requirements Based on DID Philosophy
- Experience, Particularly Post-TMI, Identified Need for Probabilistic Goals for More Coherent Decision-Making
- Qualitative and Quantitative Goals Developed

USNRC SAFETY GOALS
QUALITATIVE GOALS

Individual Members of the Public Should be Provided a level of Protection Such That Individuals Bear no Significant Additional Risk to Life and Health

Societal Risk to Health and Safety from NPP Operation Should be Comparable to or Less than the Risks of Generating Electricity by Viable Competing Technologies and should not be a Significant Addition to Other Societal Risks

QUANTITATIVE HEALTH OBJECTIVES

The Risk to an Average Individual in the Vicinity of a NPP of Prompt Fatalities that Might Result from Reactor Accidents Should Not Exceed 0.1% of the Sum of Prompt Fatalities Risks Resulting from Other Accidents to Which the Members of the US Population are Exposed (5E-7/RY)

The Risk to the Population in the Area near a NPP of Cancer Fatalities that Might Result from NPP Operation Should Not Exceed 0.1% of the Sum of Cancer Fatality Risks Resulting from All Other Causes (2E-6/RY)

For LWRs Surrogate Objectives for CDF and LERF Developed

Expect New Designs of NPPs to Achieve a Higher Level of Safety

MDEP SAFETY GOALS SUBCOMMITTEE REPORT

- MDEP Safety Goals Subcommittee to survey practices and propose structure for safety goals
- Survey of high level goals:
  - Most countries require that NPP should add only insignificantly to risks to population: expressed in terms of deaths or cancer incidence. These cover workers, discharges to environment and accidents.
  - Many goals relate to effects on individuals but all countries also recognise effects are wider such as use of land or food production.

THE STRUCTURE AND APPLICATION OF HIGH LEVEL SAFETY GOALS (SAHLSG)

Hierarchical Structure of Safety Goals

- It is proposed that:
  - the DID structure is extended to integrate the elements of safety to protect health and safety during normal operation and accident conditions for the whole plant lifecycle.
- This structure should comprise a hierarchy:
  - a top level safety goal,
  - a set of high level safety goals to meet the top level safety goal, and
  - lower level goals/targets, derived from the higher level for application to design and operation.

Hierarchical Structure of Safety Goals and Targets

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- *Proposed high level safety goals*

- **Top-level Safety Goal**

- *Provide a level of safety such that the risks to people and environment from the whole lifecycle of a nuclear power plant is only a small fraction of the risks from other hazards to which these are otherwise subjected.*

- *Proposed high level safety goals*
  - **High level DID goals**

1. *Occupational and public **dose limits during normal operation**, should conform to the **IAEA Basic Safety Standard**, which is derived largely from the ICRP recommendations.*
2. ***Prevention should be the focus** by designing for fault tolerance through using good engineering principles.*
3. *Within the **design basis**, there should be **no offsite effects** and **no significant onsite doses for workers**, **as far as practical**.*
4. *Large **offsite releases** due to accidents, should be **as infrequent as practical.***
5. ***Any offsite releases** that could occur should only require **limited offsite emergency response.***

- ***Safety Goals: Safety Targets***

- ***Safety Goals*** *are generally qualitative, or define upper limits, setting out what has to be achieved*
- ***Targets*** *are usually quantitative and developed from the Safety Goals, setting out the measure of achievement*
- *Further development to technology specific targets should therefore be consistent and coherent*

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- ***Goals*** *should be achieved*
- ***Targets:***
- *failure to meet must be robustly justified,*
- *failure to do better must be explained.*

MDEP POSITION PAPER ON SAFETY GOALS

- The Position paper describes the hierarchical structure of Safety Goals developed in the report
- It provides some examples of applications to current/recent designs and suggests how the structure can be applied to future designs
- It provides the basis for further work both within MDEP and in other fora in which MDEP participates.

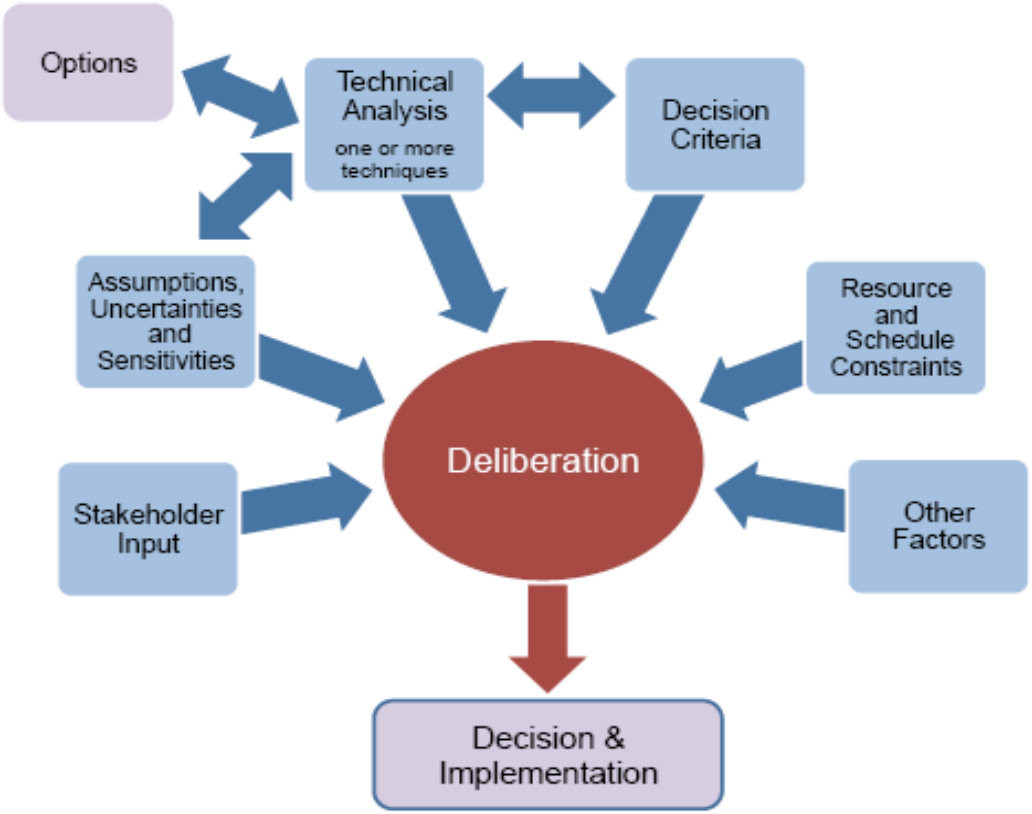
THE MDEP STC POSITION HAS FOUR ELEMENTS:

1. An expectation that higher levels of safety will be achieved in the design and operation of new reactors.
2. Support for the structure of safety goals and targets, as set out, for consideration of its members, IAEA and other organisations in moving towards international harmonisation of regulatory requirements;
3. Strong support for the use of integrated decision-making for design evaluation and operational safety;
4. Recognition of the need to develop the process, and for continued interactions with other organisations, to further harmonise regulatory requirements

IAEA SAFETY GOALS ACTIVITY

- Survey of many countries practices and plans for further development of the hierarchical approach.
- Separate paper by IAEA at this conference

USNRC: A Proposed Risk Management Regulatory Framework, NUREG-2150 April 2012



CONCLUSION

- A hierarchical approach, similar to the one proposed by the MDEP subcommittee, with quantitative safety targets would;
  - Require effort to standardize robust methods
  - Clarify application of “Practically Eliminate” criterion and lead to Consistent Treatment of Design Extension conditions
  - Support a more Consistent use of “Defense-in-Depth” safety philosophy
- Appropriate treatment of land contamination and other environmental impacts needs further work.