



On the Safety of Generation IV Nuclear Systems

Tim Leahy
Risk and Safety Working Group Co-Chair

PSAM 9 Meeting
May 21, 2008
Hong Kong

Generation IV Nuclear Energy Systems

- ***Technology development guided by an extensive international collaboration led by the Generation IV International Forum***
- ***Six reactor concepts under active development***
 - ***Gas Cooled Fast Reactor***
 - ***Lead Cooled Fast Reactor***
 - ***Molten Salt Reactor***
 - ***Sodium Cooled Fast Reactor***
 - ***Supercritical Water Cooled Reactor***
 - ***Very High Temperature Reactor***
- ***Aimed at producing significant steps forward in terms of sustainability, economics, safety, and proliferation resistance***

RSWG Terms of Reference

- ***“Promote a consistent approach on safety, risk, and regulatory issues for Generation IV systems”***
- ***“RSWG will focus particularly on***
 - ***Generation IV safety goals and evaluation methodologies***
 - ***Interactions with the nuclear safety and regulatory community, IAEA, and other relevant stakeholders”***

RSWG Workscope - Highlights

- ***Promote a homogeneous approach to safety in design***
- ***Define the framework for safety evaluation methodology***
- ***Identify and encourage advanced safety assessment methodologies***
- ***Consider defense in depth and safety standards to be adopted for all Generation IV systems***
- ***Cooperate and coordinate with IAEA work on safety standards and associated safety initiatives***
- ***Interact with PRPP Working Group to assure mutual understanding of safety priorities and their implementation in PRPP and RSWG evaluation methodologies***

RSWG Work to Date

- ***Principal areas of inquiry include:***
 - ***Familiarization with Generation IV concepts, and identification of major issues that define safety bases***
 - ***“Safety Philosophy” for Generation IV systems***
 - ***Desirable level of safety for Generation IV systems***
 - ***Characteristics and attributes that may be incorporated in Generation IV systems***
 - ***Methods and tools that may be useful for developing and evaluating the Generation IV safety basis***
 - ***Additional research needed, and future activities of the RSWG***

RSWG Activities - Practical Considerations

- ***RSWG activities are informed by Generation IV Technology Roadmap and Safety Goals, historical practices, and by other recent work in the field of nuclear safety, including positions and documents prepared by national regulators and others***
- ***RSWG attempts to leverage the value of existing good work***
- ***RSWG specifically avoids “endorsement” of any specific national safety program or approach. Strong desire for RSWG work to represent an international consensus.***
- ***Emphasis on providing useful guidance to system developers. No intent to constrain or prescribe design practices.***

May 2008 Report - Major Recommendations

- ***Current nuclear systems are already very safe. Opportunities exist to achieve an even greater level of safety. “Safety is built-in, not added-on.”***
- ***Potential safety improvements must be simultaneously based on several considerations. Among these are:***
 - ***The notion of “optimal risk reduction”***
 - ***The adoption of ambitious safety objectives***
 - ***Development and integration of innovative technologies to achieve improved system reliability and safety***
 - ***Emphasis on prevention, backed up by mitigation***
 - ***Demonstrated “robustness” relative to a broad range of challenges***

Recommendations - continued

- ***An updated safety approach is needed for Generation IV systems***
 - ***Consistent with current and future regulation***
 - ***Demonstrate full implementation of defense in depth***
 - ***Based on a technology-neutral framework***
 - ***Combine deterministic and probabilistic perspectives***
 - ***Address uncertainties, in part, through demonstration***
- ***The principle of defense in depth is a keystone of nuclear safety and should be fully implemented in Generation IV systems.***

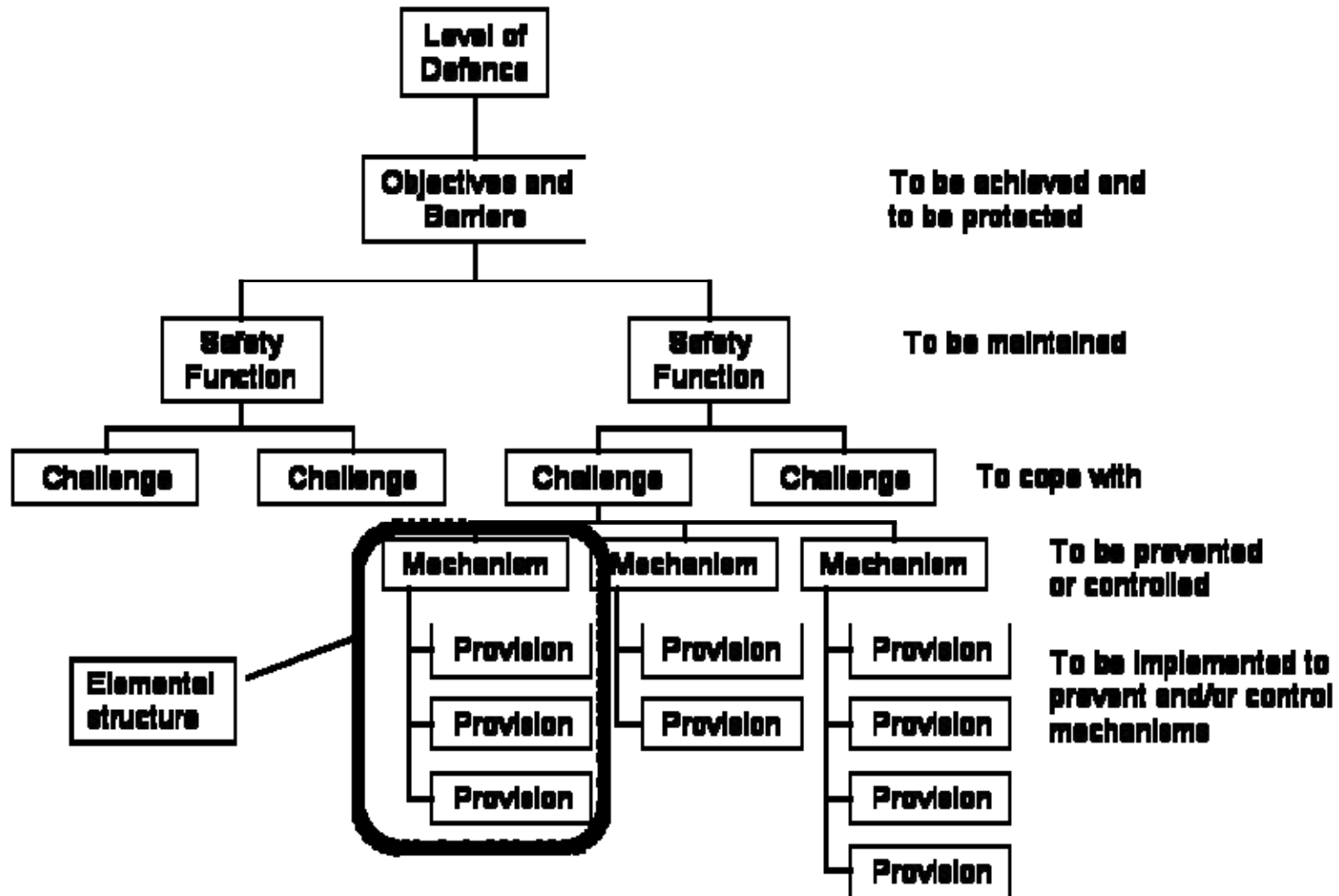
Recommendations – Continued

- ***Generation IV system designs should be “driven by a risk-informed approach”***
- ***While demonstration and prototyping are an important part of establishing Generation IV safety bases, modeling and simulation should play a large role in design and evaluation***
- ***Generation IV design bases must address a full range of safety significant conditions***
 - ***“Spectrum of design basis accidents”***
 - ***Demonstration of “practical elimination” and low “residual risk”***

Approach for Evaluation of Generation IV Safety

- ***PSA should be used extensively, in conjunction with deterministic methods***
- ***Current PSA methods and practices updated with improved failure rate data bases and models for treatment of passive reliability issues, dynamic phenomena, digital instrumentation and control, etc.***
- ***Use of Objective Provision Tree to identify and document provision of “lines of protection”***

The Objective Provision Tree



Achieving Extremely High System Reliability

- ***Explicit consideration of all aspects of defense in depth***
- ***Advanced instrumentation and control for improved process control, on-line condition monitoring, system prognostics, and better informed test and maintenance***
- ***Increased use of passive systems, as appropriate, and other “naturally safe” design provisions such as improved materials, gravity, convection, conduction, negative reactivity feedback, thermal inertia, and similar features***
- ***Reduced reliance on human interventions, and increased tolerance for human errors***
- ***Reducing uncertainties through both analytical and empirical demonstration, and provision of safety margins where uncertainties remain***

Ongoing and Future RSWG Activities

- ***Development, documentation, and demonstration of a framework and methodology for assessing the safety of Generation IV nuclear systems***
- ***Identification of cross-cutting R&D needed to fully establish safety basis of Generation IV systems***
- ***Interactions with IAEA, INPRO, GNEP, and others to ensure a homogeneous and effective approach to safety of advanced nuclear technologies***