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The opinions expressed below are my personal views and they do not reflect expressed or implied positions of Generation IV Forum's Risk and Safety Working Group or the Canadian Nuclear Safety Commission.

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1. As per your presentation, ISAM methodology is largely based on existing tools that combine probabilistic and deterministic perspectives to allow for graded approaches to technical issues of varying complexity and importance. In reference to SMR and advanced reactors (AR), please provide an example where ISAM is helpful in developing graded approaches for regulatory requirements for SMRs and ARs ?

The ISAM tools will be able to identify robustness (and vulnerabilities, if there are any) of each barrier. As a hypothetical example, if an advanced reactor fuel is demonstrated to contain all of its fission products within the fuel matrix in any postulated accident initiating events, the stringency of barrier application and robustness would be shown to be less.

2. Another question on the same subject matter, safety classification of SSC for NPP in compliance with IAEA Safety Standard SSG-30 is an important licensing consideration for identifying systems important to safety, in what way you think that ISAM methodology may contribute to a consistent approach of safety classification per IAEA SSG-30 for SMRs and ARs?

When ISAM tools are applied consistently across different technologies, the importance of systems, structures and components (SSC) to safety will be identified. Once the importance of SSCs to safety is identified, the IAEA Standard Series SSG-30 can be used for safety classification. Another useful guide for safety classification is IAEA-TECDOC-1787.

3. Kindly explain the role of ISAM in PSA, LPSA and in the online Risk monitoring. Thank you

In ISAM, there are five different tools available for use during the pre-conceptual design phase to licensing and operation. One of the five tools discussed in ISAM is PSA. ISAM does not use any other tools such as LPSA and online risk monitoring.

4. Does the integrated safety assessment take into account the security related issues?

Although ISAM does not take into account security related issues explicitly, when Qualitative Safety Review tool is applied at Level 1, safety and security needs can be harmonized.

5. What is your opinion on transitioning back to the regulatory framework put in place during Gen I – objective based rather than strict regulatory guidelines? Similar to the ONR's goal-based regime.

The high level objective based regulation would be difficult to implement today given the societal expectations. The objective based framework made sense during GEN I, but today with several decades of operating experience, we know more of the risks and vulnerabilities.

6. Any comments on the differences and commonalities between ISAM and the Risk-informed Performance-Based approach developed by the USNRC under the Licensing Modernization Project would be interesting.

RSWG is currently reviewing Risk-Informed and Performance Based Approach for event selection and component safety classification. I do not know enough to comment anything on the approach now.

7. I am curious about how the safety assessment methodology can be applied to the diversity of SMR designs under consideration in Canada--and what R&D and experimental data are needed to substantiate the assessment in each case.

The ISAM tools rely heavily on data from R&D. These tools, especially the PIRT, can identify the importance of phenomena and its knowledge level. Based on the outcome of PIRT, R&D needs can be identified. Similarly the use of other tools will be able to establish robustness of the technology. The ISAM tools have been applied to most of the GIF technologies and results are encouraging.

8. How coherent is the CNSCs approach with that of the US and UK?

I do not know enough on the regulatory frameworks in the UK or US to comment.

9. How is research direction and funding in Canada regarding Gen 4 reactor technology?

Canada is participating in SCWR, MSR, and VHTR technologies. Canada has invested reasonably well in Gen IV reactor technologies. Private sector is also investing in Gen IV R&D in Canada.

10. Will Canada develop a reactor or validate existing design?

Canada is promoting an innovative environment for advanced reactor development as evidenced by this virtual technical speaker series and other activities. Canada is developing several advanced reactor designs such as MSR, SCWR, etc. through public sector and private sector initiatives. I do not understand what is meant by "validating an existing design".

11. Are we working on Safeguard Standardization efficiencies; anything we can look forward to in this world?

I do not know enough on safeguards standardisation to comment on.

12. How do we ensure generic water cooled reactor Opex Lessons are incorporated into SMRs? Systematically speaking

The objective of ISAM is, "safety is built in rather than added on". To build safety into the design, OPEX plays an important role. Perhaps a review of OPEX from water cooled reactors and its relevance to the new design can be assessed through a PIRT process to determine the relevancy and value. This will then set the stage for a OPEX risk informed design.

13. What is the ISAM relationship with an assessment of Defence-in-Depth (e.g., overlap to some extent (how?), complement each-other, different)?

ISAM is a set of tools applied to a reactor design following the defence-in-depth principles. When the tools are used, it should give the assurance how well the defence-in-depth principles are applied at each level of defence and whether there are any vulnerabilities that the designer should be aware of for further improvement.

14. How the SMR ISAM safety measures can be interconnected to the Oil and Gas ESD (emergency shutdown) system and has been any risk assessment and classification done in any plant in this subject?

I am only aware of ISAM applications to Gen IV designs. I do not know enough about Oil and Gas ESD to say anything on the interconnection between the two.

15. Why have reactor designs not been standardize? What is the cost to build and operate various sizes of reactors e.g. 5 MWe, 50MWe, 100 MWe, 200 MWe? Is the cost per MWe to build and maintain essentially the same or are there economies of scale?

In my opinion, the evolution of six different technologies is not conducive to standardization. Cost to build varies, depending on the technology, the location, etc. There is economy of scale and vendors will be able to provide the cost per MWe.

16. Is the public aware enough about the inherent safety features of the proposed Gen. IV Reactors?

I think the effort by G4SR, GIF, etc. is increasing public awareness of Gen IV system safety features. More public awareness is required.

17. Can we integrate safety assessment with failure mode and effect analysis for SMRs?

Yes, it is possible. There are papers available demonstrating this. Some US universities have published on this application.

18. Could FMEA be sufficient instead of PRA for Gen IV type of designs?

I doubt FEMA would be sufficient. The purpose of using tools such as ISAM (i.e., PSA) is to identify design vulnerabilities for making risk informed design decisions. FEMA alone may not be adequate, however, it will provide useful information to be used in PRA.

19. What is the knowledge on SMRs at the CNSC?

We have trained and experienced specialists with sufficient knowledge. We are a continuously learning organisation.

20. At which degree the methodology is applicable for Licensing purposes?

The tools in ISAM methodology have been used for licensing in a number of countries. These tools are not new.

21. Does ISAM treat passive systems and inherent characteristics differently from active systems?

No, they are treated alike. ISAM looks at the outcome, i.e., the coolability (beside others like control and contain) of the core in a postulated accident with respect to maintaining barrier effectiveness.

22. Is a Safety Case documented for each design? If not, why not? It "appears" you are quickly engaged in details rather than holistic view.

Yes, a safety case is documented for each design.

23. Describe how your hazard log / risk register is used as an integral part of system safety design

The presentation gave a few examples of risk identification via fault tree analysis (like a risk register) and this would, along with DPA, would form an integral part of demonstrating safe design.

24. Question: Would appreciate if Dr. Nithenandan can clarify the terms "pre-conceptual", "conceptual", "final" design stages, as different people have different understandings of the level of design in each of those categories. Thanks.

The term pre-conceptual refers to a preliminary mostly qualitative stage of a design. When more quantitative information is added (such as coolant, moderator, fuel type, power, flow, etc.), the design becomes a conceptual design. The final design is an information rich state of the design ready for licensing assessments and construction.

25. The QSR it was shown that it is appropriate for "pre-conceptual" and "conceptual" design stages/phases. The on slide 18 (or 17?) it says that the QSR needs as input a "detailed knowledge of design". The "detailed" knowledge of the design is normally achieved in later phases (e.g., final, or at best "conceptual"), surely not in pre-conceptual phase. Would appreciate a clarification about this. Thanks.

The use of the term "detailed" in this context refers to the best/current information available at that stage of design. QSR is used iteratively from pre-conceptual stage to the early stage of final design. The degree of detail in the information supplied to the tool increases as design matures. The QSR sheets (shown in examples) prepared during the pre-conceptual stage can be continuously updated as design matures.

26. The process doesn't seem to follow a systematic engineering process where first all requirements are established (safety, operational, RP, environmental, etc), then refined and finalized, and then systematically turned into a design at several hierarchical levels of detail with verification at each step.

The information presented was confined to the application of ISAM. I agree that a design must follow as you state, "other systematic engineering process" to establish the requirements of safety, operational, radiation protection, environmental, etc. These processes are completed before the application of ISAM at every hierarchical levels.

27. It seems to encourage going straight to design but seems to leave out the essential step of requirements definition. Please clarify.

The purpose of the presentation is to describe ISAM tools. The requirement definition, as you say, must be performed before pre-conceptual design and the application of ISAM tools.

28. From the presentation, it is understood that ISAM is very much technology dependent. Can it be possible to make technology neutral ISAM for Nuclear Facilities, including NPP with global safety objectives?

As my examples showed, the ISAM tools have been used for a number of different technologies. Among the six Gen IV systems most of them have used these tools successfully. The lessons learned form these applications have been used in refining the tools. In my opinion, it can be used for meeting global safety objectives.

29. How ISAM will useful for Life extension of NPPs or Safety Enhancements of Operating NPPs?

Although I have not seen one yet, but it is possible to use these tools.

30. How ISAM will useful for Life extension of NPPs or Safety Enhancements of Operating NPPs?

ISAM will be useful in identifying vulnerabilities, strengths, and R&D needs in life extension projects.

31. from Julian Stanciu to all panelists: 11:29 AM Excellent presentation! Very informative and well delivered. How can we obtain a copy of it?

Thank you. Please contact G4SR administration.

32. from Krishna Kumar to all panelists: 11:29 AM Can we decide the practical elimination phenomenon/event sequences, which can be excluded from the design using this methodology?

ISAM is a tool for identifying design strengths and vulnerabilities. This information can be used to demonstrate practical elimination.

33. from Julian Stanciu to all panelists: 11:31 AM Is the CNSC updating the Reg. Docs. (2.5.2, 2.4.1, 2.4.2, etc.) to align them to the IAEA standards as presented here?

CNSC is committed to continuously improving our regulatory documents.