SMR Regulators' Forum
Phase 2 Summary Report:

Covering Activities from November 2017 to December 2020

for:

Licensing Issues Working Group

Design and Safety Analysis Issues Working Group

Manufacturing, Construction, Commissioning, Operation Working Group

June 2021

FOREWORD

There is a sustained global interest in small modular reactors (SMRs), which have the potential to play an important role in globally sustainable energy development as part of an optimal energy mix. Such reactors have the potential to enhance energy availability and security of supply in both countries expanding their nuclear energy programmes and those embarking on a nuclear energy programme for the first time.

In recognition of this in 2015, a regulator-to-regulator mechanism, driven by its members, was established and called the SMR Regulators' Forum. The Terms of Reference for the Forum [1] are published on its dedicated web page along with information about current undertakings and accomplishments resulting from cooperative activities.

This report is a Summary document that presents an overview of collaborative work between November 2017 and February 2021 by the issue specific working groups set out by the SMR Regulators' Forum, namely the:

- *Licensing Issues Working Group*
- *Design and Safety Analysis Working Group*; and,
- *Manufacturing, Construction, Commissioning, Operations Working Group*

This report serves to point the reader to the three consolidated reports of the issue specific working groups for further information concerning findings and recommendations for the areas of interest covered.

Outputs from the Forum were and continue to be aimed at enabling regulators to collaborate more effectively, inform changes, if necessary, to their requirements and regulatory practices and provide common positions and recommendations for consideration by the IAEA. Increasingly, these cooperative activities are also being leveraged outside of the Forum's work between member regulators who are assessing the same or similar SMR concepts for potential deployment.

The following countries are members as of June 2021: Canada, China, Finland, France, Korea, Russia, Saudi Arabia, South Africa[1], United Kingdom and United States. The Joint Research Centre (JRC) of the European Commission and the OECD Nuclear Energy Agency are designated as Observers within the Forum. CORDEL of the World Nuclear Association and other Departments within the IAEA are invited to participate and provide expertise/information on a case-by-case basis.

[1] South Africa officially joined the Forum in April 2021 and is participating in Phase 3 activities.

The Forum has retained Scientific Secretariat resources from the IAEA in order to facilitate discussions, draw information from or pass information to other IAEA activities concerning SMRs and advanced reactors and manage a platform for communication with external stakeholders. The IAEA Scientific Secretariat is part of the Forum Steering Committee and also provides assistance to the Forum with communicating the work of the Forum to interested stakeholders worldwide.

For the time period 2018 to December 2020, the Steering committee of the Forum was chaired by A. Bradford of the United States of America and K. Herviou of France served as vice-chair. The IAEA Technical Officer designated Scientific Secretary of the Forum, providing ongoing support to the Forum's work was M. Santini of the Department of Nuclear Safety and Security.

The work of the Forum focuses on cross-cutting and technology-neutral issues and does not conduct technology-specific cooperation or assessments. Recognizing that regulatory requirements will differ from Member State to Member State, IAEA publications applicable to nuclear reactor installations serve as benchmarks for the discussions within the Forum and to compare practices when developing common positions.

Finally, the members of the Forum seek to conduct activities that complement, without duplication, the work of existing fora/organizations such as those under the Nuclear Energy Agency, including:

- Multinational Design Evaluation Programme – MDEP
- Committee on Nuclear Regulatory Activities - CNRA
- Generation IV International Forum - GIF
- Working Group on the Safety of Advanced Reactors – WGSAR

In many cases, work being done by these fora to support regulatory activities for new build nuclear reactor installations, even if not explicitly addressing SMRs and advanced reactor concepts, remains valid in safety discussions about these technologies.

Table of Contents

1. Background and Introductory Comments

1.1 Formation of the Three Issue-Based Working Groups for Phase 2

In January 2018, following completion of a pilot to demonstrate the ability to produce meaningful cooperative outputs, the Forum Published a Pilot Project Report [2] which established of a series of common positions and recommendations in reports for the following technical areas:

- Graded Approach Working Group: Application of the Graded Approach;
- Defence in Depth Working Group: Implications of SMR features and characteristics on Application of Defense in Depth;
- Emergency Planning Zone (EPZ) Working Group: Considerations in defining Emergency Planning Zones for SMR Facilities.

The outputs of the EPZ Working Group were carried forward into an IAEA Consolidated Research Project (CRP) to further develop qualitative and quantitative methodologies for informing the establishment of flexible and risk informed emergency planning zones for reactor facilities (including SMRs).

Several recommendations from the Graded Approach and Defence-in-Depth Working Groups to the IAEA were carried forward by the IAEA into specific projects aimed to:

- Further reinforce the concept, applicability and use of the Graded Approach within the IAEA Safety Framework
- Analyze documents such as SSR 2/1, Safety of Nuclear Power Plants: Design [8] for applicability to advanced reactor technologies and make recommendations for enhancements where applicable

The Forum discussed remaining recommendations from the Graded Approach and Defence-in-Depth Working Groups and decided to carry them forward into a three-year second phase of the Forum (2018 to 2020) along with a series of new topics. The Working Groups established for Phase 2 were:

- Licensing Issues Working Group
- Design and Safety Analysis Working Group; and,
- Manufacturing, Construction, Commissioning, Operations Working Group

The objectives of each working group are covered in Chapter 2

1.2 Constraints and Limitations Impacting Working Groups

The working groups experienced a number of constraints and limitations. They established their scope of work accordingly and implemented other appropriate mitigation measures to address these constraints and limitations. The major constraints and limitations are discussed below.

Ongoing large variety of SMR designs

The number of different SMR concepts being considered for deployment by countries around the world remains large. Some Members have actively established themselves as technology development countries (whether as direct government supported enterprises or via the private sector. Others are evaluating the potential importing of different technologies. The Forum members agreed that the Forum would remain technology-neutral to the extent practicable but draw from actual experiences which could also include sending questionnaires to existing vendors to gather information. By doing this, the Members could develop common positions and recommendations that could be applied both broadly by the IAEA and as appropriate in each individual Member's activities.

Limited operational experience, if any, exists for most SMR technologies

In many cases, the substantiation of safety claims by technology developers is still in progress. In a few limited cases, some early operational experience is emerging from technology assessment, construction and operation. However, for most designs, safety claims are either in the early stages of regulatory assessment under pre-licensing engagement processes or will not be subject to detailed assessment until the First of a Kind (FOAK) project is proposed in one of the Member's countries. Rather than treat this as an impediment to the Forum's work, much of the Phase 2 discussions examined the implications of this issue in more detail to understand what expectations would apply to address both uncertainties and potential for risks that could impact safety.

Limited time and resources for interactions with other organizations

Members of the Forum had limited direct interactions with other organizations such as the World Nuclear Association (WNA) Cooperation in Reactor Design and Licensing (CORDEL) working group during Phase 2. Limited direct interactions were largely due to travel and meeting limitations in order to accomplish an aggressive Forum work schedule. However, these organizations (such as CORDEL, NEA) and other groups of the IAEA, such as the Nuclear Energy Department, are invited regularly to present their initiatives on SMRs to the Forum to augment the synergy of the collective work on SMRs and minimize duplication.

Additionally, the Forum members took many opportunities to describe the work being done by the Working Groups to conferences, IAEA projects and meetings with key organizations such as the NEA ensure work was not duplicated and regulatory messaging remains consistent.

1.3 Working SMR Definition Underpinning the Activities of the Forum

The SMR Regulators' Forum considered the following factors/features in recognition that SMR concepts vary widely but have several of these characteristics:

- Nuclear reactors typically <300 MWe or <1000 MWt per reactor;
- Designed for commercial use, i.e., electricity, production, desalination, process heat (as opposed to research and test reactors);
- Designed to allow addition of multiple reactors in close proximity to the same infrastructure (modular reactors);
- May be light or non-light water cooled; and
- Use novel designs that have not been widely analysed or licensed by regulators.

IAEA publications on SMR designs served as references for the discussions. However, it is also important to understand that although these concepts may start off as smaller designs, it is entirely possible that some developers will eventually propose to scale these concepts up based on operating experience and leverage many of the safety features and principles derived from the smaller facilities. Many of the observations and common positions expressed in the Phase 2 reports would likely also apply to scaled-up technologies.

2. Phase 2 Common Positions

In Sections 2.1 to 2.3, for each of the Working Groups, web-links for each of the published reports have been provided to avoid duplication of the reports in this document. The common positions developed by each working group are reproduced and have been adopted as the common positions of the SMR Regulators' Forum by the Steering Committee.

Recommendations from the Forum are documented in Chapter 3.

2.1 Licensing Issues Working Group

The fundamental principles and objectives underpinning a systematic, high quality and traceable licensing process for a nuclear facility are well documented in IAEA safety standards and guides and all of these principles continue to apply to the licensing of regulated activities associated with the siting, manufacturing, construction, commissioning and operation of SMR facilities. At the core of licensing is the fact that:

- The licensee is responsible for the safe conduct of licensed activities regardless of where they are performed.
- Safety and control provisions have both a design and licensee management system component that need to be established consistent with requirements for defense in depth.
- Safety and control provisions should be commensurate with importance to safety; however, safety must still be demonstrated, and provisions must take account of and compensate for uncertainties.
- Regulatory assessment as well as regulatory compliance verification assurance activities must consider the above on a case by case basis for each project.

Licensing Issues Working Group – Phase 2 Report

Chapter 1: Key regulatory interventions

This chapter discusses the licensing processes and challenges arising from the various potential SMR deployment models as well as the potential key regulatory interventions within the process for the regulation of the said deployment.

Chapter 2: First of a Kind (FOAK) vs Nth of a Kind (NOAK) Designs

This chapter discusses potential issues related to the licensing process within a Member State for a FOAK SMR project, and how the safety case may differ from that of NOAK SMR projects (serial production).

Chapter 3: Licensing of multiple module/unit facilities

This chapter discusses how multi-unit/modules potential features such as a) ownership model, b) single license for several nuclear cores, c) sharing of systems important to safety, d) sharing of personnel, e) common control rooms, may or may not have an impact on the licensing process of an SMR.

Forum Common Positions - Key Regulatory Interventions

- "Key regulatory intervention" (KRI) is a term which describes a strategic regulatory point of interest during the lifecycle of an SMR. A KRI could range from a higher level of regulatory involvement or scrutiny to pause the licensee's activities until the regulatory authority has issued an authorization to continue work.
- Regulators need to ensure the licensing process facilitates efficient validation of safety, which in turn facilitates efficient progression of regulatory activities. The steps (e.g., construction, operation, decommissioning) of the licensing process should be discrete and follow a logical order.
- Experience has shown that licensing stages may overlap; i.e., one stage may start before the previous one is fully completed.
- Regulators have shown that effective pre-licensing interactions can be a positive practice for both reactor vendors and regulators.
- Regulators should ensure that applicants/licensees have the capabilities to work with vendors to understand where KRIs may emerge.
- Regulators should consider implementing KRIs for areas known to be of higher safety risk. That is, if not resolved properly by the licensee, they could evolve into safety issues or latent flaws that could challenge operational safety
- The modularity, transportability, and modularity of SMRs may result in a regulator implementing KRIs that might not be considered or relevant in traditional nuclear power plant facilities

Forum Common Positions - FOAK vs NOAK designs

- Regulators need to consider the deployment of SMRs and would benefit by understanding what is different about FOAK designs and how they would evolve towards NOAK designs. This is especially true for emerging countries
- Regulators need to be mindful that there are many new players in the SMR market, some of whom might not have the experience (both vendors and licensees) expected of more mature nuclear proponents.
- Regulators should not lower standards for FOAK deployments. Additional demonstration requirements are expected.
- Regulators must also consider the amount of experience they have with respect to technologies that are being assessed/deployed. Targeted training programs to help develop regulatory knowledge should be considered if needed.

- Regulatory bodies need to have enough flexibility to ensure safety throughout the lifecycle of any design type – especially for SMRs that will be taking an FOAK design and evolving it to an NOAK design.
- Regulators need to be able to take into account lessons learned across all SMR stages (e.g., design, construction, operation, decommissioning) in a manner which keeps pace with evolving techniques
- Regulatory bodies need to provide stability in their regulatory frameworks as a design evolves from FOAK to NOAK. The best way to keep pace with SMR evolving is to apply high level safety principles in a manner which utilizes a graded approach
- Regulators should recognize that FOAK designs might have to employ additional features in order to provide enough margin to overcome unknowns in their design.
- Regulators should consider whether FOAK designs require additional instrumentation, start-up control, operational controls, commissioning tests, or controls during early operations.
- Regulators need to carefully consider how incremental design changes module by module can impact safety as an FOAK design evolves to an NOAK design
- Regulators need to strike a balance between pragmatically allowing designs to evolve while maintaining safety.

Forum Common Positions - Licensing of new build projects with multiple module/unit facilities

SMR ownership / licensee models:

- Regulators should ensure that the Licensee has relevant capability as defined in the licence.
- Regulators need to ensure that any adjacent facilities / sites have a co-operation agreement in-place for the management arrangements covering emergency response or security, etc.
- The Regulatory Body would expect a single licensee, even though the ownership of a number of reactors (or % share) could be owned / funded by different organisations.
- Regulators need to have means in place to ensure that the licensee have appropriate control and oversight of their staff and key contractors.
- Regulators need to ensure that Licensees have clear contractual arrangements in place for shared personnel in order to ensure that shared personnel do not compromise the safety of a licensed facility.

Shared safety systems in Multi-module/unit:

- Regulatory bodies must ensure safety functions are demonstrated to be available for all modules/units when needed.
- When an of structures systems and components (SSCs), important for safety is shared, regulatory bodies must ensure that the risk contribution to the overall plant is considered.

- Regulators must ensure that the safety case demonstrates that there is enough ultimate heat sink capacity to perform required safety functions for abnormal and accident conditions for the combined heat loads from all modules/units.

Shared personnel:

- Regulatory bodies must require that processes are in place to ensure that shared personnel or services are available when required for safety reasons.
- Regulators must verify that controls are in place to ensure shared personnel are familiar with all the different designs and procedures they work with (i.e. be competent in what they do).
- Regulatory bodies should require demonstration that emergency plans cover the entire site and include multi-unit events.
- Regulatory bodies should require demonstration that security plans cover the entire site and consider multiple reactor designs.
- Regulatory bodies should ensure that there are provisions for site-wide drills for security and emergency response that are graded to the overall risk of the site.

Shared control rooms:

- Regulators should assess in the licensing process the justification for the amount of control room staff, sufficient consideration of Human Factors Engineering (HFE), and the licensee's configuration control process (including training of staff or updating procedures when the configuration changes).
- Regulators must ensure that licensees demonstrate that the proposed operating models are capable of meeting all safety requirements.
- The regulatory body should include configuration control in its inspection program.
- Regulators should encourage training utilizing a simulator and be flexible on the location of such simulator facilities.
- Regulators should ensure that the loss of the common control room is considered in the licencing basis.
- Regulators must ensure that human error is accounted for in the licensing basis.

2.2 Design and Safety Analysis Issues Working Group

In conducting follow-up actions from the two-year pilot phase reports of the Defence-in-Depth Working Group [3]one of the key areas of work was associated with the use of novel approaches to address defence in depth provisions in SMR designs. The significant use of passive and inherent features to support safety performance, although highly promising, presents challenges to regulatory assessment including issues such as:

- Confirming sufficient independence of provisions supporting the 5 levels of Defense in Depth
- Judging the adequacy of supporting information supporting the safety and performance claims

- Understand the levels of reliability and resiliency of safety provisions under all plant states

Multiple unit NPP facilities with shared structures systems and components exist already and there are significant lessons that can be drawn from these facilities when designing and developing a concept of operations for multiple module SMRs. Of particular importance is the consideration of common cause events or the impacts of an incident unit on safety in adjacent units.

Design and Safety Analysis Working Group –Phase 2 Report

Chapter 1: Multi-unit, multi-module aspects of SMRs

This chapter presents common positions on the design and safety analysis aspects specific to multi-unit/multi-module SMR facilities.

Chapter 2: Considerations in the use of passive and inherent safety features in SMR designs

This chapter presents common regulatory positions on the regulatory assessment of passive and inherent safety features for SMRs. Although the inclusion of passive and inherent safety features within designs is not exclusive to SMRs, the subject is of particular importance for SMRs because of the extent to which such features are deployed in SMR design proposals.

Chapter 3: Aspects of beyond design basis analysis relevant to SMRs

This chapter presents common positions on the consideration of safety features at Level 4 defence-in-depth (design extension conditions, severe accidents and the concept of 'practical elimination' as introduced in SSR 2/1 (2012)) for SMRs.

Forum Common Positions - Multi-unit, multi-module aspects of SMRs

Terminology and definitions

- The Forum acknowledges that SMR designers use the term "modular" to denote both "modular design approaches" and/or "modular construction approaches". However, irrespective of how the modules/units are defined for any particular design, it is most important to:
  - Clearly define terminology in each instance that terms are used

- o Understand safety and regulatory implications of sharing the structures, systems and components and/or infrastructure. In these cases, it is important to ensure that the safety of the nuclear power plant is not negatively impacted by the adoption of a modular reactor deployment.
- o Recognize that multi-unit/multi-module SMR designs may have certain potential operational and safety benefits, such as interconnections between units/modules to strengthen the availability and reliability of support services (electric power, compressed air, water) or qualified personnel.

Defence-in-Depth

- It will be important to consider the impact of multi-unit/module issues at all levels of DiD.

Internal and external hazards

- For sequential deployment or maintenance of units, consideration should be given to ensuring that a hazard in units/modules under construction, in maintenance or in operation would not have any safety consequences for neighbouring operating units or the safety consequences are properly considered. The current requirements usually refer specifically to "units", however the working group considers that its underlying principles are applicable to all SMR designs containing multiple reactor cores, regardless of the nomenclature adopted (i.e. "multiple unit' or "multi module")

Selection of initiating events

- The Forum acknowledges that multi-unit/module SMRs may use shared systems to a greater extent than multi-unit NPPs because of their compact configuration and close proximity, therefore the selection of initiating events should consider these aspects of a design.

Shared Structures, Systems and Components (SSCs)

- For SMR designs which shared SSCs, the safety assessment should consider all relevant safety implications, in recognition that sharing may introduce risk significant vulnerabilities in the design.

Risk Assessment for multi-unit/multi-module sites

- It would be beneficial for both designers and regulators to think beyond the single unit mindset. This might involve extending their considerations to whole site risk including developing methods of aggregating risk from differing on site sources (e.g.

new and old reactors, spent fuel pools). Furthermore, the proper balance between deterministic and probabilistic safety approaches should be achieved.

Human Factors and Emergency Preparedness

- The presence of multiple modules/units at the site could exacerbate challenges that the plant personnel would face during an accident. The events and consequences of an accident at one unit may affect the accident progression or hamper accident management activities at the neighbouring unit; available resources (personnel, equipment, and consumable resources) would need to be shared among several units. These challenges should be identified, and the available resources and mitigation strategies shown to be adequate.

Forum Common Positions - Considerations in the use of passive and inherent safety features in SMR designs

Identifying and Addressing Uncertainties in Performance claims for FOAK Facilities

- A facility safety case, in particular for a FOAK facility, is expected to systematically identify, account for and address uncertainties in performance claims for passive and inherent features through a strategy that considers aspects such as:
    - results from substantiation activities (e.g. use of sufficiently validated computer models, experimental prototypical systems, integrated test facilities)
    - compensatory design enhancements (if required),
    - control provisions expected to be implemented by the operator; and,
    - any additional activities necessary to demonstrate and/or support functional performance claims and gather experience data.

- The greater the combination of interfacing inherent and passive design features the more complex the performance uncertainties become. In such cases, design substantiation should pay particular attention to the need for integrated testing activities both during the design process and in the commissioning program for the FOAK facility.

Assessment of Reliability for Passive Systems in the Presence of Weak Driving Forces

- Designers should establish clear criteria for characterising the strength of driving forces in features that support safety functions with a particular emphasis on understanding conditions that may weaken those forces to the point where their effectiveness or predictability is significantly impacted. This information should be used to identify and understand failure modes that could, in principle, impact the delivery of a safety function with sufficient reliability. Designers should ensure that all parameters potentially affecting the delivery of a safety function are taken into account within the safety demonstration.

Optimization of the Use of Passive and Active Features in the Design Process

- Subject to a prioritisation which favours first inherent characteristics and then passive features or continuously operating systems over systems that need to be brought into service (SSR-2/1 [8] Req 16), any combination of active and passive safety systems can be acceptable provided defence in depth and safety design principles are met. The designer should document the approach for establishing optimization in the use of passive and active features in consideration of the availability of supporting information to substantiate safety claims and to support the conduct of safety classification.

Applicability of the Single Failure Criterion to Provisions that Include Passive Features and Inherent Characteristics

- Designers should apply the single failure criteria in safety evaluations of passive safety systems deployed within SMRs. Non-applications of the single failure criteria may be considered for passive systems if it is not reasonably practicable to achieve compliance, for instance via the incorporation of redundancy into a design, however this should be accompanied by a demonstration that adequate reliability can otherwise be achieved. Particularly in circumstances where driving forces are weak, analyses should account for all potential system failure modes and consider how these may evolve in time in order that the worst-case single failure mode is captured.

Requirements for Diversity and the Treatment of Common Cause Failures

- Designs should incorporate redundancy, diversity and, where practicable, physical separation for safety systems to mitigate common cause failures. Particular attention should be paid to functional diversity where exclusively passive safety systems are deployed in SMR designs. There may be some benefit in using combinations of passive and active systems to ensure a safety function is delivered as this may provide additional diversification to improve resilience to common cause failures.

Forum Common Positions - Aspects of Beyond Design Basis Analysis relevant to SMRs

Challenges with Characterising Severe Accidents for Novel SMR Concepts

- For novel design characteristics of SMRs, there is a need to identify criteria against which some event sequences and accidents scenarios are judged to be severe, taking account of the potential for barrier failure with radioactive release or fuel relocation. Both designers and regulators will have a role in defining such criteria. This is particularly important for SMR designs in which the concept of "core melt" is claimed not to apply. The potential for severe consequences to arise from actions required to clean-up following an accident, including the case of multi-module units and/or in co-located facilities[2] should also be considered.

The Role of DiD in Preventing and Mitigating Severe Accidents

- SMR designers need to identify, from the outset, how defence-in-depth principles, based on the provision of multiple independent barriers to accident progression, are applied within the safety provisions and information substantiating those provisions. The progression of faults/accidents should be analysed assuming failure or degradation of the primary barriers (levels 1-3 DiD) to fission product release in order to establish a facility's vulnerability to severe accidents. All areas of a facility having the potential for severe accidents must be assessed.

- SMR designers need to systematically identify credible severe accident scenarios for their designs including very low frequency events. Severe accident scenarios are expected to consider the consequences of accidents that result from credible failures of the level 1-3 of defence in depth. Where claims are being made that severe accidents will be precluded by design provisions, such conclusions need to document how accidents based on unmitigated consequences associated with a fault have been characterised and analyzed. Any assumptions with respect to the maintenance of barrier integrity should be robustly justified.

Design Extension Conditions

- Safety features at level 4 DiD are necessary to assure fundamental safety functions, particularly confinement/containment of radionuclides, in all credible severe accident scenarios so far as is reasonably practicable. The inclusion of additional features for accidents scenarios involving multiple failures needs to be considered to improve resilience to common cause failure.

Practical Elimination of Event Sequences and Accident Scenarios that Could Lead to a Large or Early Release

- A systematic and defensible demonstration that event sequences that could lead to a large or early release have been practically eliminated (SSR-2/1 [8], Sections 2.11 and 2.13) needs to involve a complementary and iterative use of deterministic and

[2] For example, some molten salt designs incorporate co-located fuel processing facilities which should be assessed for their severe accident potential

probabilistic analyses coupled with use of experiential information[3]. For the FOAK facility the demonstration of practical elimination will need to take account of the absence of OPEX.

2.3 Manufacturing, Construction, Commissioning, Operations Issues Working Group

The Manufacturing, Construction, Commissioning, Operations Issues Working Group was established to, among other things:

- Build on already existing body of knowledge being generated from new build power plant OPEX by further examining the implications that SMR characteristics such as modularity present to manufacturing, construction, commissioning and operation
- Construction: Document regulatory views of SMR specific construction issues and implications in licensee oversight and regulatory inspection programs
- Commissioning: Document regulatory views of expected SMR commissioning issues and implications in licensee oversight and regulatory inspections programs
- Operation: Document the implications on in service inspection programs from, for example, compact system design, sealed vessels or inaccessible systems.

Manufacturing, Construction, Commissioning and Operation Working Group – Phase 2 Report

Chapter 1: Manufacturability, supply chain management and commissioning of SMRs

This chapter discusses the concept of modularity and presents common regulatory positions on manufacturing, construction, and FOAK commissioning for SMRs.

Chapter 2: Collection and Use of Experience in the Lifecycle of Small Modular Reactor facilities

This chapter presents common regulatory positions on the use of experience in activities related to the entire lifecycle of SMRs in order to enhance nuclear safety and improve performance. A primary focus in this chapter is on activities associated with design, manufacturing, construction, commissioning and operations.

[3] Information derived from OPEX, R&D activities, computer modelling etc.

Chapter 3: Conduct of Maintenance in an SMR

This chapter presents common positions associated with the need to address the conduct of maintenance as early as possible to enable effective operation and maintenance activities through design features.

Chapter 4: Conduct of Co-activities and Combined Activities on a Multiple Unit Small Modular Reactor Facility Site

This chapter discusses safety considerations that need to be considered up front in the design of SSCs as well as in the overall program for conducting construction, operation and maintenance.

Forum Common Positions - Manufacturability, supply chain management and commissioning of SMRs

Modularity

- The terms "module" and "modularity" may mean something different depending on the design and business model for the SMR in question. All parties need to be attentive to what is included in the terms for the particular SMR being considered.

- There are safety implications that arise from the use of modularity in building and operating SMRs, and the end-user (Licensee) needs to have the ability to address those implications to secure nuclear safety

Manufacturability

Manufacturability has implications for demonstrating compliance with requirements, long- term maintainability and operability of structures, systems and components. There are safety implications that arise from these facts. The Licensee is responsible for addressing these aspects.

- The Licensee needs to mobilize adequate competence skills early in the design stage to verify that the SMR design will fulfil safety requirements. Suppliers need to be involved at an early stage in the manufacturability, inspectability, operability, and maintainability assessments of modules for the purpose of specification.

- When assessing alternative or novel configurations of SSCs, such as compact modular assemblies, licensees should work directly with the SMR designers and their vendor to evaluate and address appropriate provisions to enable access for required inspections, operations, and maintenance of SSCs. These provisions should also enable licensee to conduct specific oversight activities during manufacturing and construction such as witnessing key quality assurance activities during manufacturing or conducting receipt inspections at the site.

- As standard practice, industry stakeholders and, where applicable, regulators, should work with the standard development organizations to address potential gaps in existing standards related to manufacturing and construction issues.

- If there are aspects of SMR manufacture that are not covered by an appropriate existing standard, then the SMR intelligent customer should set a tailored standard for that aspect with appropriate surveillance, third party oversight and witnessing, proportionate to the risk to nuclear safety. Good engineering practices should be used in the derivation of tailored standards, consistent with the regulatory requirements.

- Manufacturing processes, if not implemented correctly for safety significant modules, could result in potential latent issues. Hence, the development and implementation of manufacturing processes need to contain sufficient control measures to prevent latent issues.

- Configuration management and stability needs to be verified from the FOAK manufactured SMR to the NOAK SMR (including situations that involve changes in manufacturing facilities or vendors).

- SMR manufacturers need to demonstrate the capacity and capability to address nuclear safety requirements.

- Site construction and commissioning of SMRs is a licensee activity. Licensees need to exercise oversight of in-factory manufacturing and testing to achieve an assembled SMR that is safe and meets all regulatory requirements

- Special attention needs to be paid to factory-fuelled and sealed transportable reactor modules. This is because introducing nuclear material in the factory triggers a step change in nuclear safety risk and therefore the licensing and regulatory approach need to be commensurate with any other facility that handles fissile material.

<u>Supply Chain Management</u>

- The Licensee needs to identify and demonstrate how to mitigate risks arising from a more diverse, new and potentially global supply chain, particularly risks from counterfeit, fraudulent and suspect items (CFSI).

- It is the responsibility of the Licensee to establish adequate Supply Chain Management (SCM) arrangements to ensure delivery of products and services safely and right the first time [5].

- The Licensee needs to have both an organisation that is capable of providing intelligent customer capability, and a supporting management system.

- The Licensee needs to instil an appropriate nuclear safety culture amongst its suppliers and contractors, at all tiers in the supply chain [6].

- The Licensee for the SMR needs to incorporate appropriate practices, codes and standards.

- The Licensee and its associated supply chain organizations, including the SMR vendor and suppliers, will need to be capable of managing deviations and non-conformances in a way that takes into account the characteristics of SMR build, and encourages reporting, collaboration and continuous improvement.

- The Licensee will be expected to use safety classification to support the justification of appropriate quality requirements applied to structures, systems and components for SMRs.

- Licensees are responsible for pre-qualification of their suppliers. Hence, they should recognize that supply chain companies for SMRs who have experience with modular design, manufacturing, and construction, may not have experience of the nuclear sector.

Commissioning

- The Licensee needs to demonstrate how the commissioning programme takes into account any uncertainties due to the lack of OPEX.

- If multiple units/modules are located in one facility or some units/modules will be added later on:
  - there will be common SSC that may require certain commissioning activities to take place as the first modules are installed and placed into service;
  - due consideration needs to be made to common system performance when adding units or modules and whether additional or new or repeated commissioning tests may be needed (a common plant HVAC system, for example, is important to environmental qualification);
  - commissioning may have the objective to demonstrate/verify the compatibility with the existing plant.

- The Licensee is responsible for:
  - quality, transparency and independence of persons or entities directly responsible for performing the tests (the persons implementing this process should have the appropriate expertise in terms of manufacturing, detailed design and operation of the module to meet this objective).
  - conducting a review of deviations and of how these deviations are handled;

  - the decision on the continuation of the tests, or the definition of any subsequent test programme.

- Given the importance of the Commissioning program in future plant operations, the Licensee is responsible for the conduct of the program and is expected to specify where the tests will be performed and justify the representativeness of those tests regarding the on-site configuration. A further set of on-site commissioning tests will have to be performed to check that the results obtained off-site are valid for the plant

- When commissioning tests are performed in the manufacturing premises, the Licensee needs to be involved for the purpose of gaining experience for the future operation.

- The licensee will need to justify the representativeness of full-scale replica tests results and FPOT tests if wanting to take credit for those tests in the commissioning phase, and detail the commissioning tests to be performed on the licensed plant to check their full applicability.

<u>International cooperation</u>

- Information exchange about SMR activities may be affected by international agreements on intellectual property rights.

Forum Common Positions - Collection and Use of Experience in the Lifecycle of Small Modular Reactor facilities

<u>Importance of Experience to the safety of SMRs</u>

- Management at the highest level should embrace and promote the use of experience by all levels of the organization, for all safety significant applications as part of an overall defence in depth strategy. The collection, evaluation (including analysis where appropriate), sharing and use of significant experience throughout the SMR lifecycle by all stakeholders is critical to safety, continual improvement and public confidence. The overall responsibility for the use and oversight of experience lies with the licensees who should impose it on all their contractors and sub-contractors performing safety significant activities. In order to make decisions, regulators independently assess safety claims being made by the licensee and verify that the safety and control provisions both meet regulatory requirements and provide a high degree of confidence that they are effective.

SMR Experience Infrastructure

- The infrastructure to manage the body of experience information for an SMR concept needs to be systematically established up-front to consider diverse experience types and anticipate and address diverse stakeholder needs which may potentially extend across international boundaries. This includes the need for mechanisms to provide appropriate and timely access to specific information for the purposes of enabling technical cooperation activities and decision-making.

Enabling access to experience data and intellectual property by stakeholders

- Designers and licensees need to establish agreements amongst stakeholders in advance, to enable sharing of nuclear safety significant experience while still assuring the protection of intellectual property.

- The organizations' measures for experience should establish roles and provisions that promote the use and sharing of experience by all stakeholders.

Establishing systematic measures for the use of experience

- SMR stakeholders should establish systematic experience measures early in the lifecycle to be used during the entire lifecycle of the SMR. The measures should adopt and follow IAEA safety standards and guides with the ultimate goals of preventing significant events and improving performance. The measures should be disseminated into appropriate tools (for example, processes, procedures, checklists, independent reviews and training), to cover all safety significant activities by all levels of the organization.

Implementing experience measures

- SMR stakeholders should establish common and effective communication channels and tools and use experience in all important safety applications. This includes access to common experience databases, technical publications, generic communications, root cause evaluations, safety evaluations, industry and regulatory groups and other fora, the sharing of data, and technical staff cooperation in evaluating complex experience. Staff training is also part of the implementation of measures.

Assessing the effectiveness of the experience measures

- SMR stakeholders should perform both periodic and reactive internal and external assessments of their experience measures including self-assessments, internal and external audits and benchmarking against IAEA safety standards and industry practices, to ensure that the use of experience continues to meet internal and industry objectives. Reactive assessments of experience for preventable significant failures should be required by the corrective action programme and actions should be taken to improve the experience measures as required. An assessment of how experience information is being systematically leveraged or developed by the licensee should be part of the regulatory assessment.

Forum Common Positions - Conduct of Maintenance

Conduct of Maintenance

- The operating organization (Licensee) is expected to understand and approve where, how and by whom any maintenance activities are going to be done.

- The designer and operating organization should collaborate as early as possible to:
  - enable effective operation and maintenance activities through design features;
  - apply requirements for maintenance, inspection and testing in line with the national expectations of the country where the SMR is deployed;
  - consider how the design of the SMR, and any modular, factory-based approach to building the SMR, may affect subsequent maintenance activities; and
  - strike a balance between minimising risks arising during maintenance activities (to people, plant and the environment), with ease of SMR build and aspects of the design.

- Modular construction does not necessarily mean modular maintenance unless that was the original design intent. The degree of modularity (at the outset), and the approach to the content of modules, must include thinking about future maintenance requirements, as well as the conduct of operations.

Forum Common Positions - Conduct of Co-activities and Combined Activities on a Multiple Unit Small Modular Reactor Facility Site

Safety Case for multiple unit SMR facilities

- The facility Safety Case must consider all co-activities being performed at an SMR facility.

- Activities that are potentially vulnerable to co-activity risks should be systematically identified and analysed. The results of the analysis should be reflected in the safety case for the entire facility and be included in the deployment plan.

- The design of structures, systems and components for a multiple unit facility should take due account of the sequence and timing of activities and co-activities associated with construction, commissioning and operations.

- With any increase in co-activities, a "step-wise" increase is needed in risk control features and organisational capability to match and should be anticipated in the deployment plan. Licensee capability needs to be maintained throughout any later deployment of extra modules.

Safety Culture and the conduct of co-activities in a multiple unit facility

- Activities between co-located units should be effectively managed by the Licensee(s) within a strong and facility-wide safety culture environment:
    - All workers should be made aware when they are conducting work in a co-activity environment and provided with the necessary tools to understand and complete their tasks within the constraints under which their work is to be conducted. For example, technical processes for activities should be sufficiently detailed to assist the workers to perform their activities to a high degree of quality.
    - The perimeters of responsibilities should be clearly established and documented, between the Licensee and parties with key responsibilities in the execution of construction, commissioning and maintenance support.
    - An integrated set of processes and tools should be implemented to systematically identify potential co-activities, characterize potential risks and establish effective means, including "back-out" provisions to prevent and mitigate potential events that could impact on safety.
    - Particular attention could be necessary when a new module is to be installed or commissioned, or a module is underdoing maintenance in close proximity to operating units.
    - A coordinator should be assigned to manage the interface between the Licensee and the companies involved in the installation/commissioning of a new module or significant maintenance on an existing unit.
    - Another coordinator should be assigned to manage the day-to-day interface between operators and the team in charge of the installation/testing.

- The preparation of co-activities, especially before installing or withdrawing a unit or other major modular equipment, requires early systematic planning activities that involve operations staff to anticipate and prevent events that could impact on nuclear safety. Planning activities should anticipate the complexities and potential hazards of co-activities and provide realistic allowances for the impact of any delays and slippages in planning to avoid any adverse effect on quality.

- A facility operating experience program should include the study of co-activities and the analysis of lessons learned. The first unit to be installed and commissioned should be used to gather necessary operating experience to validate and verify work processes for use in subsequent units. Sufficient schedule time should be provided to accommodate these activities.

Conduct of Operations and Maintenance in a Multiple Unit Control Room

- The operations and maintenance program should give due regard for human factors considerations of multiple unit operation in a single control room.

The Commissioning Program and Plan for a Multiple Unit Facility

- The commissioning program for a multiple unit facility should encompass the entire facility in a holistic manner and incorporate the gathering and use of operating experience as new units are installed into the facility.

- In particular, commissioning activities and results for common (for example, shared) systems need to be revisited as activities within the facilities evolve, in particular as new units are added to the facility, to demonstrate that common systems remain fit for service to support safety functions credited in the safety analysis.

  The commissioning activities for newly installed units should consider past commissioning activities in the facility while at the same time ensure that sufficient testing activities are performed to demonstrate that the new units are fit for service to support safety functions.

Configuration Management in Multiple Unit Facilities

- In a multiple unit facility, a strong and systematic facility wide configuration management program is particularly important over the life of the facility to prevent the potential for human induced events and introduction of latent safety issues into the design of the facility.

- Workers planning to conduct activities should be made aware of configuration differences between units through the configuration management program and the potential safety implications of those differences. Awareness of configuration differences should be addressed through worker training as well as in all tools used to conduct work.

3. Conclusions and Recommendations

Although many developers and promoters of SMR technologies are positioning the deployment of standardized SMR technological concepts with enhanced safety and economic performance as a near-term objective, the deployment of the 'first few of a kind' of any SMR concept represents a learning process for both licensees and regulators. This learning process will take time and must address the need to ensure a high degree of confidence in safety provisions while accumulating operating experience from integrated facilities in a real-world setting. Lessons learned from these first facilities will result in refinements to planning and conduct of licensed activities including:

- Design approaches and the proven practices (e.g. technical standards) that support them
- Manufacturing
- Construction and commissioning
- Conduct of Operations and Maintenance

A number of organizations have expressed the need to amend certain requirements and guidance in the IAEA safety framework to give credit for the improved safety performance of SMRs. However, to do this requires a sufficient evidence base, including operating experience, to justify any amendments. In many cases, there is insufficient evidence to support significant changes to safety requirements and guidance. As experience and lessons learned are accumulated, the IAEA can apply a systematic approach to incorporate them into the safety framework

However, the Forum maintains that the existing safety requirements are a time-tested benchmark for comparison when developing safety provisions for SMR technologies and they do not present an impediment to the deployment and effective regulation of SMR projects. However, there is a need to have appropriate skills to interpret and apply them in an intelligent manner to ensure safety will not be compromised. This applies to all stakeholders in the development and deployments of SMR technologies such as designers, manufacturers, constructors, licensees and regulators.

The objectives of the three Issue Based Working Groups were selected primarily to support the near-term activities being conducted in the Forum's representative member countries. The discussions in the Working Groups have not only resulted in pragmatic common positions that can be used for cooperative activities between regulators but have also led to recommendations for further activities to be conducted in Phase 3 from 2021 to 2023. These are discussed in Section 4.

The Forum has the following recommendations, aimed mainly to support the IAEA work:

Recommendation #1: Potential gaps in existing safety standards and guides. Potential enhancements

The Forum recommends that the IAEA engage with the Forum to review the identified common positions against existing requirements and guidance and decide where potential gaps may exist of enhancements may be necessary. Enhancements may be of particular interest for embarking countries as they establish their regulatory frameworks and licensing processes. Examples of areas where enhancements are recommended are:

- Considerations/practices important to conduct of operations and maintenance in multiple unit/module facilities
- Further elaboration on multiple unit/module risk considerations (risk aggregation on a site-wide basis)
- Consideration of risks from non-electrical uses of SMRs or co-location with industrial facilities

Recommendation #2: Promotion of pre-licensing engagement with designers and vendors by regulators

The Forum notes that pre-licensing engagement with regulatory authorities either by a technology developer or a future applicant is critical to developing a thorough working understanding of how requirements and guidance would apply to SMR activities. The Forum recommends that the IAEA consider further promoting and reinforcing the use of such practices, in particular with the view of enabling the establishment of international regulatory cooperative activities. The forum recommends promoting the early cooperation between regulators. (e.g. on an issue by issue basis for specific technology assessments) to promote common understanding and convergence of regulatory practices.

Recommendation #3: Oversight of the activities of the supply chain for the facility

Given the significant increase in intent to use the global supply chain (goods and services) in the "factory" manufacturing of modular facilities, particularly where integrated systems are replacing on-site construction and commissioning activities, the Forum recommends that IAEA reinforce the roles and expectations in overseeing the activities of the supply chain for the facility. This includes reinforcing the principles of the Informed Customer[4] [7].

Recommendation #4: On use of Experience

The most effective way to produce new experience tools and measures is to work with existing organizations as early in the project lifecycle as practicable to promote, establish and implement them. As a result, the Forum recommends that the IAEA take advantage of

[4] According to the IAEA Safety Glossary [4], *informed customer' capability* is the capability of an organization to have a clear knowledge and understanding of the product being supplied or the service being provided.)

the memorandum of cooperation with WANO to develop guidance for establishing experience infrastructure appropriate for deployment of SMRs. In particular:

- Infrastructure should consider the need for regulatory and licensee readiness programmes, particularly for nations embarking in a new nuclear power programme.

- Infrastructure should consider SMR specificities that extend beyond operations and maintenance and include elements of manufacturing, construction and commissioning that may introduce challenges to lifecycle operation. For example, one noteworthy area is to examine experience interfaces between modular manufacturing organizations, which seek to produce standardized products, and the need to address site-based installation and commissioning activities in different countries.

- Existing experience infrastructure such as the International Reporting System for Operating Experience (IRS) should be evaluated to ensure that it adequately accommodates SMR experience needs.

Recommendation #5: Clarifications on the difference between Passive and Inherent Safety Features

In view of the wide variety of passive systems that may be deployed in a single SMR, the Forum recommends the IAEA provide guidance that recognises that a spectrum of passivity is possible. The Forum suggests that this could include the development of requirements in a more granular way, based on the categorisation proposed in the IAEA document "Safety Related Terms For Advanced Nuclear Plants" (TECDOC-626 [8]) and separately addressing expectations for substantiation with respect to inherent system characteristics, passive system features and any active elements that may be involved in system actuation.

Recommendation #6: Assessment of Reliability for Passive Systems in the Presence of Weak Driving Forces

Current regulatory guidance from member states set quantitative expectations for the reliability of passive safety systems despite there being no accepted general methodology for conducting such an assessment. The Forum recommends that the IAEA promotes continued research in this area. This is of particular importance for SMRs which may incorporate exclusively passive safety features. The Forum recommends continued work on the development of assessment methodologies building upon the work of the IAEA document "Progress in Methodologies for the Assessment of Passive Safety System Reliability in Advanced Reactors" (TECDOC-1752 [9]).

Recommendation #7: Applicability of the Single Failure Criterion to Provisions that Include Passive Features and Inherent Characteristics

Where a passive flow is evolving, the parameters most affecting the flow could change radically such that single failures relevant to each stage of a transient might not be easily determined. In such situations iterative evaluation of transient scenarios may be necessary to identify worst case failures. The Forum recommends that the IAEA promotes further work in this area as it does not appear that this issue has received significant attention.

Recommendation #8: Challenges with Characterising Severe Accidents for Novel SMR Concepts

The forum recommends the IAEA explores clarifying the definition of a severe accident for advanced reactor technologies. The DSA Working Group considers that the definition needs to be technology neutral and more readily adaptable to the assessment of SMRs for which the traditional definition of core melt does not apply.

In addition, the Forum concluded that further work is required on some topics for the issue specific working groups:

Conclusion #1: Regulatory oversight related to long lead items

To support supply chain discussions, in particular for FOAK Facilities, the Manufacturing, Construction, Commissioning, Operation Working Group should pursue work to clarify key principles and practices important to procurement of goods and services that may have a long lead timeline. (these are commonly known as Long Lead Items) The Forum recognizes that the way SMRs may be deployed will lead to increased use of regulatory processes for long lead procurement which are often not part of the licensing process.

Conclusion #2: On sharing of experience

The Forum concludes that the Licensing Issues Working Group should address in their next phase of work how national regulators might need to use existing international cooperation mechanisms to share experience and enable mutual recognition of each other's activities, through developing common positions.

4. Forum Activities Planned for Phase 3 (2021-2023)

During Phase 3 (Third Phase) from January 2021 to December 2023, the working groups will consider the following topics:

4.1 Licensing Issues Working Group

- Framework for mutual recognition of regulators' assessment/Joint assessments/ Collaboration
    - The high-level enablers or challenges to development of framework
    - Fundamental and technical expectations and their timeframe
    - How a regulator could utilize assessment performed by a regulator of another state
    - What kind of joint assessments could be carried out?
    - How the IAEA can help, (for example, SSG-16 [11], enabling infrastructure for newcomers)

- Legal constraints between member states considering mutual recognition. Possible areas for discussion:
    - What is not covered in international/local frameworks for international deployment?
    - Any legal implications of international supply chain
    - Are legal issues with sharing information or technologies covered?
    - What elements of collaboration could be identified for further work under the legal? framework umbrella? Do the recommendations that the licensing groups come up with have any legal implications to them.

- Lessons learned from MDEP efforts in both design and issue specific working groups

- Licensing process[5] - Impact of the licensee's core safety capabilities to oversee the construction and operation of SMR facilities. SMR supply chain impacts on organizational capabilities of new build stakeholders with respect to stakeholders' capabilities. The difference for SMRs is that many of the potential licensees are smaller than more traditional plant licensees and may not have the depth and breadth of knowledge. With this in mind, what additional issues should a regulator consider?

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[5] Similar topical area being looked at by MCCO-WG but from a different perspective of conducting authorized activities.

- Work with MCCO-WG, but focus on technical assessment of licensee capabilities (compare practices based on experience)
- What requirements should there be for knowledge transfer from the vendor to the licensee for things like maintenance, future design changes, aging management, and operation limitations
- What is the 'company' that is going to oversee the construction: core competencies of the licensee to oversee the construction and operation of the reactor: How is this measured during a licensing evaluation?
- Also consider smaller deployments with outsourced monitoring and maintenance
- o Consider whether regulators should come up with some pre-licensing engagement guidelines in order that a proponent would be better prepared to enter a licensing process

4.2 Design and Safety Analysis Working Group

- Integrate Security by Design considerations into design and safety analysis considerations (speak to interface with safety)
    - Determine what documents and guidelines exist and find if gaps exist related to SMRs and current expectations for integration of safety and security considerations in design assessments
    - Identify common features of SMRs that may be the focus of attention for integrating safety and security considerations (e.g. underground siting, sealed cores, unmanned operation, transport of factory fuelled modules etc.)
    - Identify the barriers to integrating regulatory considerations of security and safety for SMRs, including any trade-offs specific to SMRs. Are there limits to the level of integration that can be achieved or is desirable?
    - Consider whether design optimisation across both security and safety functions is a realistic goal?
    - Is the adoption of common non-prescriptive/outcome-based regulatory regimes for both safety and security a pre-requisite to the effective integration of these functions?
    - Share practical experience on judging how security by design may be achieved (Sharing of practical examples of effective integration of security considerations during early stage plant design for SMRs)
    - What additional staff training might be needed to support integration of safety and security regulatory functions?
    - How the integration of security by design considerations into design and safety analysis is different for SMRs than NPPs? For example, consider application of the Graded Approach or defence-in-depth (DiD).

- Containment/confinement – New-design-for-containment approaches and impacts on DiD.
    - The current expectations for delivery of the confinement function, and approaches to physical containment (e.g. expectations for leak tightness)
    - Identified gaps in regulatory guidance with respects to SMRs including Gen IV SMRs and proposed ways forward from which common positions can be established.
    - Sharing of regulatory approaches to ensuring the achievement of an appropriate balance between safety features at levels 1-3 and level 4 of DiD for SMRs
    - The identification of postulated 'limiting' scenarios informing containment design for SMRs

- Regulators' expectations on multiple independent, physical barriers to the release of radioactive material
    - "Low leakage" vs leak tight concepts
    - Difference between containment means and containment SSCs
    - Address FOAK uncertainties
    - How can the IAEA help? Can the IAEA Safety Reports on applicability of the IAEA selected Safety Guides for Design be useful?
    - Can the IAEA Report on Safety Assessment of SMR be useful?

- Safeguards by design (may only include input presented by Safeguards Department) – This area of work of the WG is assigned lower priority that the two previous items. The Secretariat will promote interactions with the IAEA Safeguards Department on its initiatives on safeguards by design.
    - Practical examples of safeguards-by-design in the context of SMRs including Gen-IV types.
    - What are the barriers to integrating safeguards considerations at the design stage for SMRs?
    - The role of international regulators in supporting safeguards by design (IAEA, Euratom, Brazilian-Argentine Agency for Accounting and Control of Nuclear Material)
    - Identification of SMR specific considerations. Identification of SMR features that may be the focus of attention for safeguards considerations (e.g. sealed cores, liquid fuels)
    - Proposed verification activities for accountancy, physical inventory and facility design for SMRs
    - Novel or specific safeguards containment/surveillance/remote monitoring equipment/measures for SMRs

  - Can the IAEA publication on "Safety, Security and Safeguards by Design" (planned by IAEA Nuclear Safety, Nuclear Energy and Safeguards Departments) be useful?

4.3 Manufacturing, Construction, Commissioning, Operation Working Group

- Implications of SMRs in long lead SSC procurement. This topic may include:
  - Differences in the meaning of "long-lead" for SMR with respect to large nuclear power plants. Just-in-time manufacturing for SMRs.
  - How the different regulators regulate long-lead procurement;
  - Degree of involvement by the regulator and where the risks lie to the future licensee;
  - The impact of time passing on the code that was used for the long lead item ("code effective" dates and reconciliations with later versions of the codes used);
  - What does the "off the shelf manufacturing" business model for SMRs mean for regulators?
  - What are the implications from the use of innovative processes, such as additive manufacturing, for SMR components?
  - If one regulator "accepts" an approach, what is the basis for another regulator to do so as well? (this is part of the Licensing WG scope)
  - Fleetwide considerations for long lead items

- Conduct of authorized activities impact on organizational stakeholders' capabilities (Designers, Vendors, Manufacturers, Supply chains, Operators). This topic may include:
  - Licensee will likely be a smaller organisation for an SMR (than an NPP), and therefore more reliant on supply chain organisations and contractors;
  - Vendors are smaller organisations and more reliant on their suppliers;
  - Licensees and vendors may be new to nuclear, with implications for capability.
  - Experience of people in any organisation in nuclear likely to be spread thinly;
  - Likely to be more businesses involved in any function ("fragmentation") and possibility of lack of control by Licensee due to more interfaces between organisations for the Licensee to manage;
  - Likely globalisation of SMR supply chain leading to misunderstandings due to cultural differences between countries and legislation differences;
  - Tools to measure capability will be more important for SMRs than for NPPs. How to measure a Licensee's ability to measure organisational capabilities in their suppliers?

  - Learning from experience on capability.

- Configuration management. This is a topic brought forward from Phase 2. This topic may include:
  - Implications of configuration management;
  - Consideration of ANSI/EIA-649-1998 [10];
  - Engineering changes control – different tools to apply a graded approach to maintain the configuration within the safety case;
  - Time between the implementation of modifications for one plant, i.e. several modules may impact the operability of the plant or shared systems.

- Design of SMRs to allow straightforward de-commissioning and waste management.

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6. Abbreviations Used in This Report

CNRA:	Committee on Nuclear Regulatory Activities – NEA/OECD
CORDEL:	Cooperation in Reactor Design Evaluation and Licensing - World Nuclear Association
CRP:	IAEA Consolidated Research Project
CFSI:	Counterfeit, Fraudulent and Suspect Items
DID:	Defence in Depth
EPZ:	Emergency Planning Zone
FOAK:	First of a Kind
FPOT:	First Plant Only Tests
GIF:	Generation IV International Forum
HFE:	Human Factors Engineering
HVAC:	Heating, ventilation, and air conditioning
JRC:	The Joint Research Centre of the European Commission
KRI:	Key Regulatory Intervention
IAEA:	International Atomic Energy Agency
MCCO-WG:	Manufacturing, Construction, Commissioning, Operations Working Group
MDEP:	Multinational Design Evaluation Programme
MWe:	Mega-Watt, electrical
MWt:	Mega-Watt, thermal
NEA:	Nuclear Energy Agency of the Organisation for Economic Co-operation and Development
NOAK:	Nth of a Kind (where N is any number above 1)
NPP:	Nuclear Power Plant
OPEX:	Operating experience (from events)
SCM:	Supply Chain Management
SMR:	Small Modular Reactors
SSC:	Structures Systems and Components
WGSAR:	Working Group on the Safety of Advanced Reactors

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