OECD WGRISK – Recently Ongoing and Potential Future International Risk-related Activities

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Abstract: The overall objective of the OECD Nuclear Energy Agency (NEA) CSNI (Committee on the Safety of Nuclear Installations) Working Group on Risk Assessment (WGRISK) is to permanently enhance the understanding of Probabilistic Risk Assessment (PRA, synonymously used for PSA) and facilitate the use and application of probabilistic approaches as an important tool for nuclear safety assessment. WGRISK therefore carries out activities to exchange risk related information between PRA experts in member countries and to advance the use of this tool for improving safety.
The following WGRISK activities are currently ongoing: The task "Human Reliability Analysis in External Events PSA – Survey of Methods and Practice" close to completion, the task "Status of Site Level PSA (including Multi-unit PSA) Developments" ongoing in its second phase, the joint task of WGRISK and the NEA Database Projects on the "*Use of OECD/NEA Database Project Operating Experience Data for Probabilistic Safety Assessment*", where a common Workshop took place in spring 2018, and the task "Development and Comparison of Digital I&C Modelling Approaches for PSA (DIGMAP)"started most recently in 2017. Three further tasks are close to completion, the report on "Use and Development of PSA in Member and Non-member Countries" being updated nearly every five years and updates of two WGRISK Technical Opinion Papers (TOPs) on Fire PSA and Seismic PSA highlighting the actual status of PSA for these two types of hazards.

Keywords: Probabilistic Risk Assessment, Probabilistic Safety Analysis, WGRISK, Use and Application of PSA, Methods and Data, Human Reliability, Site Level PSA, External Events PSA, Fire PSA, Seismic PSA

1. INTRODUCTION

The OECD (Organisation for Economic Co-operation and Development) Nuclear Energy Agency (NEA) Committee on the Safety of Nuclear Installations (CSNI), in close conjunction with the Committee on Nuclear Regulatory Activities (CNRA), maintains a joint strategic plan and mandates [1] in order to identify main challenges and focus areas. One important challenge identified in this CSNI/CNRA Strategic Plan is the safe operation of current, new, and advanced nuclear facilities, including improving the use of risk-informed regulatory strategies, updated with operating experience and safety research results, to evaluate, measure, and enhance the safety performance of nuclear installations.

The main objective of the CSNI Working Group on Risk Assessment (WGRISK) is to continuously advance the understanding of probabilistic risk assessment (PRA, synonymously used for PSA) and to facilitate its utilization for improving the safety of nuclear installations. Due to its disciplined,

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integrated and systematic approach, PSA is meanwhile considered as a necessary complement to traditional deterministic safety analysis. In support of this goal, WGRISK carries out various activities to exchange risk related information between experts in member countries and to advance the use of these tools for improving safety.

This paper presents a brief overview of the recent work of WGRISK covering some important ongoing activities (hereafter called "*tasks*") and perspectives. These tasks are:

- Task 2014(1) "Human Reliability Analysis in External Events PSA – Survey of Methods and Practice", started in 2015 for developing and analyzing the results of a questionnaire survey on the methods and analysis practices used in existing PSAs for external event initiators;
- Task 2015(1) "Status of Site Level PSA (Including Multi-unit PSA) Developments", started in summer 2015 aiming at exchanging information, how multi-unit multi-source issues are addressed in risk assessment;
- Task 2017(1) "Use of OECD/NEA Database Project Operating Experience Data for Probabilistic Safety Assessment", recently started as a follow-up on a former WGRISK task in collaboration with the NEA joint Database Projects to conduct a joint workshop;
- Task 2017(1) "Development and Comparison of Digital I&C Modelling Approaches for PSA (DIGMAP)", started in late 2017 aiming at a comparison of different approaches for modeling digital I&C systems important to safety within PSA.

Three further tasks are close to completion:

- Task 2015(3) "Use and Development of PSA in Member and Non-member Countries", started in late 2015 as regular update prepared approximately every five years; this report will present the status of PSA developments and applications particularly focusing on lessons learned from post-Fukushima investigations and effects on PSA.
- Task 2016(1) "Update of the CSNI Technical Opinion Paper (TOP) No. 1: Fire Probabilistic Safety Assessment for Nuclear Power Plants", started in early 2017 highlighting the actual status of Fire PSA from the perspective of risk assessment experts; and
- Task 2017(3) "Update of the CSNI Technical Opinion Paper (TOP) No. 2: Seismic Probabilistic Safety Assessment for Nuclear Facilities", started in mid-2017 for providing the WGRISK expert perspectives on the actual status of Seismic PSA.

2. TASK ON HUMAN RELIABILIY ANALYSIS IN EXTERNAL EVENTS PSA – SURVEY OF METHODS AND PRACTICE

The objectives of this task are to identify and examine the key assumptions of the analyses and applied methods in external events PSA. An initial overview of the state of practice was developed from the responses to a survey questionnaire, distributed in the member countries. Given that the location of nuclear power plants (NPPs) generally determines the external event initiators that are more significant in terms of hazard frequencies and plant risk, the questionnaire addressed seismic, external flooding, and severe weather initiators. Note that severe weather initiators themselves are a class rather than a uniform set of initiators, again due to geographical reasons; consequently, the survey responders could provide a response for the severe weather phenomena relevant for the plant concerned. The selection of these initiators for the survey considered the extent of experience with PSA for these initiators as well as aiming to have some diversity among the initiators.

Eleven organizations from nine countries provided responses. There were eight responses completed for human reliability analysis (HRA) in scenarios initiated by earthquake, nine related to severe weather, but only three responses for external flooding. In several cases, the initiator is screened out, typically due to the usually applied criteria based on the hazard frequency and on safety margins. As the task is intended to inform a comparative analysis and discussion of the differences in the HRA

methods and their applications in these PSA rather than to develop a comprehensive overview of practices throughout the worldwide industry, this initial set of responses is adequate.

The survey responses have been analyzed in terms of the observed differences in methods and assumptions. In some cases, these can be attributed to the specificity of the indicator; in others, similar performance issues are treated differently across external hazards or across analyses. These survey findings will be examined next in an extended task group meeting, with the aim to contribute to the harmonization of HRA methods and analysis practices for external hazards, not only for a given initiator but also across initiators, to the extent that the performance conditions and influences are shared among initiators. Furthermore, selected experiences with these hazards at nuclear power plants will be brought into this discussion, as evidence to support building consensus in these applications of HRA, where operating experience is particularly limited. The task report will be ready for approval by WGRISK in early 2019 and is intended to be endorsed by CSNI for publication in June 2019.

3. TASK ON SITE LEVEL PSA (INCLUDING MULTI-UNIT PSA) DEVELOPMENTS

The task "Status of Site Level PSA (Including Multi-unit PSA) Developments", which also started in 2015, aiming at exchanging information, how multiple reactor and multiple radioactive source issues are addressed in risk analyses carried out in member countries, identifying their challenges and ongoing research activities for Site Level PSA. The task was subdivided into two phases.

- **Phase 1** of the task consisted of the preparation of surveys on member countries' practices and research activities on Site Level PSA, preparation of draft reports on specific focus areas, and the identification of technical topics to be addressed in Phase 2 of the task. The initial survey conducted at the beginning of this phase has led to the identification of three focus areas:

  - Focus Area 1: Risk Aggregation;
  - Focus Area 2: Multi-source Interactions or Dependencies;
  - Focus Area 3: Site-Based Risk Metrics and Safety Goals.

  This initial survey was then followed by more detailed questionnaires related to the identified three focus areas. Phase 1 is meanwhile completed; its outcome includes the collection of WGRISK member countries' responses about their practices in each of the three focus areas. Responses were received from 18 countries – some of which have provided answers to all the three focus areas questionnaires – whereas others have only provided answers to specific questionnaires that are of particular interest to them.

  The results of the survey on Risk Aggregation Practices (Focus Area 1), when compared to the probabilistic safety goals established for each country, indicated that even though there are varying practices in different countries, there is an increasing interest in assessing and understanding the total aggregated risk from internal and external hazards involving all major radiological sources at a nuclear installation at different plant operating states. Aggregation methods vary from simple addition of single hazards risks, to the development of a master fault tree that integrates the contribution from different hazard groups.

  The results of the survey regarding Focus Area 2 indicate that from viewpoint of the most countries the four types of dependencies identified in IAEA SSG-3 [2] are sufficient to be modeled within Site-Level PSA, whereas other countries have developed new classification schemes. Common challenges identified as important for Multi-Unit Human Reliability Analysis (HRA) are: extreme conditions, prioritization/limitation of resources, and stress level. Regarding the questionnaire on Focus Area 3, most of the countries indicated that safety goals are used as indicators, and there are no different Level 1 and Level 2 PSA safety goals established for sites or for individual units.

- **Phase 2** of this task aims at organizing an international workshop on "Site-Level PSA Developments (Including Multi-Unit Issues)", in July 2018, which will expand on the different technical challenges identified as part of Phase 1 of this task. The workshop structure with in total four sessions mainly covers the above mentioned three focus areas, but also some more general presentations on Site Level PSA methods and applications. The final panel sessions – planned as a facilitated discussion of the session chairs with the plenary – is intended to summarize insights from the technical topics and to develop recommendations for future activities and needs for further enhancements with respect to Site Level PSA.

The final task report, which will include a summary of the results from Phase 1 as well as a summary of the Phase 2 workshop, is intended to be approved by WGRISK in March 2019 for endorsement by CSNI and publication in June 2019.

4. TASK ON USE OF OECD/NEA DATABSE PROJECT OPERATING EXPERIENCE DATA FOR PSA

In collaboration with the NEA joint Database Projects ICDE (International Common Cause Failure Data Exchange), FIRE (Fire Incidents Record Exchange) and CODAP (Component Operational Experience, Degradation, and Ageing Programme), WGRISK has recently started a new activity on the "Use of OECD/NEA Database Project Operating Experience Data for Probabilistic Safety Assessment". The objective of this task is to conduct a joint workshop in order to accomplish the following objectives: (1) Identify, update, characterize, and share current uses of Database Project products and data in support of PSA for nuclear power plants; (2) In collaboration with the Database Projects, identify and characterize new operating experience data needs for Probabilistic Safety Assessment; and (3) Demonstrate the value of the Database Project products to PSA and continue to strengthen the coordination between Database Project activities and end users. This task is a follow-up on a former task which culminated in the publication of NEA/CSNI/R(2014)2, "*Use of OECD/NEA Data Project Products in Probabilistic Safety Assessment*" [3].

The joint workshop was conducted in late April 2018 with nearly 30 participants, including chairs and operating agents from all three Database Projects, WGRISK and further interested experts from member countries. The eight technical presentations covered presentations of the data collection experience and challenges in the different databases as well as information on the use and application of Database products in PSA so far. Moreover, some needs of potential users including PSA analysts were pointed out and discussed.

The task report, which will also cover the presentations of the workshop, will summarize the outcome of the workshop, focusing on insights and recommendations not only from WGRISK perspective but also covering the interests and viewpoints of the Database Projects members. Approval by WGRISK and the Database Projects is intended for early spring 2019 and endorsement by CSNI for publication in summer 2019 at the latest.

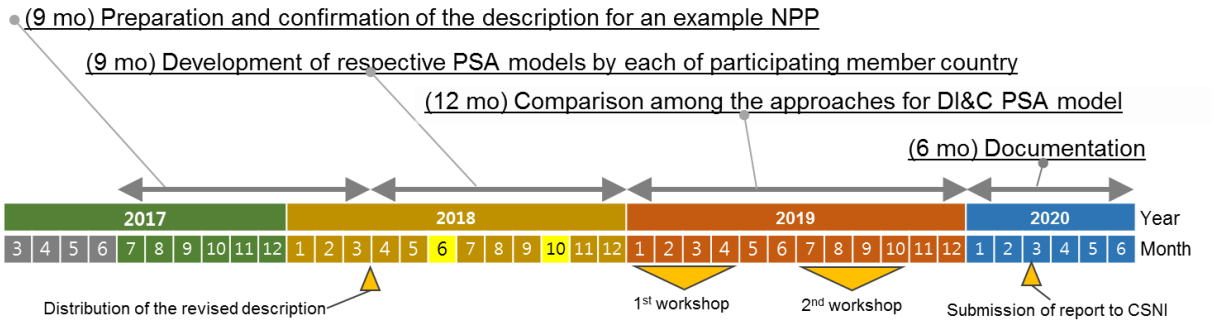
5. TASK ON DEVELOPMENT AND COMPARISON OF DIGITAL I&C MODELLING APPROACHES FOR PSA (DIGMAP)

Reflecting the current situation where there is no specific guidance being internationally agreed on for modeling digital I&C systems in PSA, the WGRISK task DIGMAP was started in 2017 to compare different modeling approaches and identify possible methods and issues for further development. A simplified boiling water reactor (BWR) design equipped with digital features is used as a common reference plant for the task. Each participating country develops its own PSA model based on the plant description. Through comparison, valuable insights on different modeling approaches regarding digital features (such as software, fault-tolerant techniques, and network communication) for future modeling methods development will be gained. Eight countries are currently participating in this task: Korea and Finland (as task leads), Czech Republic, France, Germany, The Netherlands and United Kingdom (as

core task group), and Canada (as observer). The intended duration of the task is three years (until 2020).

The reference plant description was developed for the study based on the DIGREL PSA model of a simplified fictive BWR [4] provided by Finland. The plant design and description were modified in order to focus specifically on modeling issues concerning digital I&C and were otherwise simplified to minimize other modeling efforts. After finalization of the plant description in early 2018, the work for the rest of the year focuses on PSA modeling by each task participant (cf. Figure 1). Two online meetings are planned for 2018 to discuss any matters requiring consensus and coordination in PSA model development. In 2019, two workshops are planned for comparison of PSA models: one to share PSA models and set a comparison framework and a second one to capture differences among approaches proposed by each participant and identify issues for further development. The final report is aimed to be endorsed by CSNI in June 2020.

Figure 1. Milestones of the WGRISK task DIGMAP



6. FURTHER ONGOING TASKS

Three further tasks are close to completion. The report on "Use and Development of PSA in Member and Non-member Countries" is updated approximately every five years. The latest update of the report from 2012 [5] started in late 2015 and will present the status of PSA developments and applications in WGRISK member countries and some non-member countries through IAEA. This update will particularly focus on lessons learned from post-Fukushima investigations and their effects on PSA.

Answers were received from twenty-two countries. A small writing group was set-up for summarizing this large amount of information, with the following structure:

- Countries PSA framework and environment;
- Numerical safety criteria;
- Countries status and scope of ongoing PSA studies;
- PSA methodology and data;
- Notable results of PSA;
- PSA applications and decision making;
- Future development and research;
- International activities

The major preliminary insights of this updated report are as follows:

Continuing the trend discussed in previous versions of this report, the use and development of PSA continues to grow internationally. Multiple characteristics and indicators, including the importance of a PSA framework, the number of studies carried out, the scope of PSA studies, the number of risk-informed applications (for design and operation safety improvements), and the volume of ongoing

PSA R&D (research and development), exhibit an increasing trend. For example, in recent years, a number of countries have instituted new regulatory requirements to the effect that a plant's Periodic Safety Review (PSR) must now include an up-to-date PSA.

The development of new and advanced designs has led to a more rapid development in certain topical areas. Among others, these include the definition of a more formal framework concerning the requirement of a PSA and the scope required, more precise safety goals, efforts relating to the importance of external hazards and to specific problems such as the reliability of digital I&C systems and the reliability of passive systems. When considering the scope of recent PSA, a tendency towards harmonization clearly appears.

There are a number of important ongoing PSA activities related to the Fukushima Dai-ichi reactor accidents. Some of these activities (e.g., whole site PSA) involve unresolved issues that were recognized before March 2011 but were not the subject of major projects. Other activities (e.g., External Hazards PSA) were already being addressed by development efforts. In both cases, the general interest has increased substantially after the accidents.

Two additional tasks are updates of WGRISK Technical Opinion Papers (TOPs) on Fire PSA and Seismic PSA from the early 2000s highlighting the actual status of PSA for these two types of hazards. The TOP on Fire PSA is intended to be published after CSNI endorsement in 2018 and the one on Seismic PSA in 2019.

The updated TOP on Fire PSA contains viewpoints and perspectives resulting from work of the corresponding members of this task. It is also based on results of an international WGRISK Workshop on Fire PRA [6]. The technical opinions also consider the operating experience regarding fires in NPPs, in particular from those fire events collected and analyzed within the OECD FIRE Database Project. Moreover, results from the fire related experimental NEA Projects "Propagation d'un incendie pour des scénarios multi-locaux élémentaire" (PRISME) and PRISME 2 for fire behavior and spreading in nuclear specific complex geometries under different conditions and High Energy Arcing Faults (OECD HEAF) covering high energy arcing faults with the potential of ensuing fires have been considered.

This TOP clearly demonstrates that fire continues to be an important risk contributor for nuclear installations in member countries. Fire PSA methods, models, tools, and data continue to improve and the practice of Fire PSA continues to mature. Moreover, Fire PSA is a valuable tool providing useful results and insights in support of risk-informed decision making. It is important to note that knowledge of the uncertainties and potential biases in Fire PSA results can and should be addressed.

The TOP on Seismic PSA (SPSA) provides a technical opinion of risk analysts and experts from WGRISK member countries on the current state-of-the-art in seismic probabilistic safety assessment. The main elements of the content of the TOP are: probabilistic seismic hazard analysis, fragility analysis, and development and quantification of the SPSA model. Important applications of a SPSA are also discussed in this TOP. SPSA provides a broad scope of insights relating to plant safety. The inclusion of SPSA in a risk assessment results in a more complete risk picture, and thus enables more meaningful PSA applications.

7. CONCLUSION AND OUTLOOK

The ongoing WGRISK activities cover a variety of different issues identified by WGRISK members for common work. Hence, the corresponding tasks cover hot topics such as a more comprehensive and systematic treatment of area events from external and internal hazards in PSA including human reliability, the modelling of the risk from plant sites with multiple reactors and/or multiple nuclear sources, or the different modelling approaches for digital I&C, which will be even more important for new 6 installations, methods and application of Dynamic PSA for more complex event sequences,

information exchange on data updates, and – as a task becoming more important in the future – PSA for small modular reactors (SMR).

Additional ideas for future activities include information exchange on PSA applications in support of risk-informed decision making (RIDM) and safety management, on the status of PSA for research reactors, risk assessment for the spent fuel pool (SFP) and PSA for a variety of external hazards such as harsh weather conditions.

It shall be emphasized that the reports by WGRISK are generally available to the public (including non-members of NEA) and can be found on the OECD/NEA website (e.g., http://www.oecd-nea.org/nsd/docs/indexcsni.html).

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