Recent Tasks of the OECD Nuclear Energy Agency Working Group WGRISK – An Overview

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Abstract: Overall objective of the OECD Nuclear Energy Agency (NEA) Committee on the Safety of Nuclear Installations (CSNI) Working Group on Risk Assessment (WGRISK) is to permanently advance and extend the understanding of probabilistic safety assessment (PSA[*]) and facilitate its use and application as an important tool for nuclear safety assessment. WGRISK therefore conducts various activities for risk-related information exchange between member countries´ experts enhancing the use of this tool for improving safety.

This paper presents an overview on the following ongoing and envisioned activities of the WGRISK:

- "Symposium on PSA for Reactors of Singular Designs", where a symposium is planned in June 2022 for exchanging experiences from and practices for performing PSAs for reactor facilities such as first-of-a-kind, prototype or demonstration, and research reactors,
- "DIGMORE – A Realistic Comparative Application of Digital I&C (DI&C) Modelling Approaches for PSA" aiming on supporting the improvement of the probabilistic assessment methodology by providing guidance for PSAs with respect to DI&C systems (including relevant aspects of their hardware and software),
- "Use and Development of PSA – Status Report", a standard WGRISK task conducted about every five years in order to provide a report on the status of actual developments and applications of the PSA tool in member countries, and
- "Treatment of Uncertainties for Novel Aspects of Risk Analyses" intended to be started in summer 2022 in order to get a better understanding how – in light of several types of new and advanced reactors being built in WGRISK member countries or new and more complex PSA applications that involve novel methods and approaches – uncertainties in probabilistic risk assessment for novel aspects of risk analyses are considered and treated.

1. INTRODUCTION

The overall objective of the OECD/NEA CSNI Working Group WGRISK is to advance and extend the understanding of PSA and to facilitate its use and application as a highly important tool for assessing nuclear safety. WGRISK therefore conducts a variety of activities for risk related information exchange between member countries` experts enhancing the use of this tool in order to improve safety.

Two ongoing activities were started in 2019 (see separate papers with details):

[*] In this paper, consistent with usage across various countries, the abbreviations PSA (Probabilistic Safety Assessment) and PRA (Probabilistic Risk Assessment) are used interchangeably.

- "Dynamic PSA – Preparing for the Future" addressing the potential for dynamic PSA in risk-informed decision-making (RIDM) as well as feasibility and practical challenges for increased adoption of dynamic PSA, and
- "Combinations of External Hazards – Hazard and Impact Assessment and Probabilistic Safety Analysis (PSA) for Nuclear Installations" as a joint activity of WGRISK and the Working Group on External Events (WGEV) addressing the state-of-the-art in considering combinations of external hazards in the design and safety assessment of nuclear installations.

In 2020, another ongoing activity titled "Symposium on PSA for Reactors of Singular Designs" was initiated. This symposium is planned in June 2022 for exchanging experiences from and practices for performing PSAs for reactor facilities such as first-of-a-kind, prototype or demonstration and research reactors.

In the recent past, WGRISK has successfully completed an activity on "Comparative Application of Digital I&C (DI&C) Modelling Approaches for PSA (DIGMAP)". A follow-on activity titled "DIGMORE – A Realistic Comparative Application of DI&C Modelling Approaches for PSA" initiated in 2021 is aiming on supporting the improvement of the probabilistic assessment methodology by providing guidance for PSA with respect to DI&C systems including relevant aspects of their hardware and software.

Other currently ongoing or in 2022 to be started activities are the following:

- "Use and Development of Probabilistic Safety Assessment in Member and Non-member Countries – Status Report", a standard WGRISK task conducted about every five years in order to provide a report on the status of actual developments and applications of the PSA tool in member countries,
- "Treatment of Uncertainties for Novel Aspects of Risk Analyses" intended to be started in summer 2022 in order to get a better understanding how – in light of several types of new and advanced reactors being built in WGRISK member countries or new and more complex PSA applications that involve novel methods and approaches – uncertainties in probabilistic risk assessment for novel aspects of risk analyses are considered and treated, and
- "Level 3 PSA Modelling Benchmark", which shall particularly help better understanding the impacts of consequence modelling techniques and assumptions, model uncertainties in relation to those in the overall PSA, and differences in the variety of models.

In the following, some information on and first insights of the most recent WGRISK activities are given.

2. SYMPOSIUM ON PSA FOR REACTORS OF SINGULAR DESIGNS

The use of PSA in the assessment of risk and the safety improvements of nuclear power plants (NPPs) has provided significant benefits in the past decades. However, there are significant challenges in conducting PSA for reactors of singular designs, where there are novel design features, lack of operating experience and data, or new materials, processes, or phenomena to consider within the context of PSA.

The term "reactors of singular designs" is broad and can include research reactors, demonstration reactors, prototype reactors, first of a kind (FOAK) reactors, small modular reactors (SMRs), and to some extent also Generation IV reactors of singular designs.

The WGRISK, jointly with the International Atomic Energy Agency (IAEA), has planned a forum for sharing knowledge and experience related to the challenges of conducting PSA for such unique reactors. A PSA Symposium, jointly organized by WGRISK and IAEA, shall be hosted by the Office for Nuclear Regulation (ONR) in the United Kingdom in June 2022. The following topics are intended to be addressed by the Symposium:

- Experience of conducting PSA for reactors of singular designs (including supporting analysis),
- Differences and challenges of PSA for singular design reactors compared to classic PSA (including supporting analysis),
- Operational experience from reactors of singular designs,
- Lessons learned and recommendations for development of PSA and use of risk-informed decision-making processes for reactors of singular designs.

The scope of the symposium covers all aspects of PSA, from small-scale probabilistic investigations and risk-informed applications up to full-scope PSA covering Level 1, 2 and 3, all plant operational states (POS), plant internal events as well as risk aggregation from internal and external hazards. Analysis conducted to support the development of the PSA is also within the scope (success criteria, reliability data, severe accident analysis, hazard analysis, etc.).

The symposium is planned to foster discussion and information sharing in the international PSA community. Participation is planned from all sectors of the global nuclear industry, including regulators, vendors, academics, and technical support organizations (TSOs).

The focus of the symposium with approximately 20 presentations from researchers and PSA practitioners in OECD/NEA member countries and from the IAEA is on the following three topics grouped as respective sessions followed by panel discussions: (i) PSA for research reactors, a majority of these representing unique designs, (ii) methodologies and experiences from conducting PSA for unique reactor designs, and (iii) challenges for unique reactor PSA.

The expected result of the symposium is a common understanding of possible benefits and application areas, challenges, and possible solution paths in the field of PSA for reactors of singular designs. A CSNI report will be prepared by the WGRISK, summarizing the contents of the symposium and any key areas of learning identified.

3. DIGMORE – A REALISTIC COMPARATIVE APPLICATION OF GIGITAL I&C (DI&C) MODELLING APPROACHES FOR PSA

In the recent past, WGRISK has successfully completed an activity on "Comparative Application of Digital I&C *M*odelling *A*pproaches for *P*SA (DIGMAP)" [1]. A follow-on activity titled "DIGMORE – A Realistic Comparative Application of DI&C Modelling Approaches for PSA". aiming on supporting the improvement of the probabilistic assessment methodology by providing guidance for PSAs with respect to DI&C systems (including relevant aspects of their hardware and software).

Currently, most I&C systems in NPPs worldwide are being digitalized due to the obsolescence of safety-grade analogue components. This shift entails the adoption of new features that do not exist in analogue systems. Although some features are expected to contribute to the enhancement of both efficiency and economy, from a safety point of view, the risk caused by the new features needs to be analyzed in an appropriate framework in order to ensure the dependability of the entire NPP. Moreover, different concepts of backup functions are used in new NPPs to control the failures in digital control technology. This can lead to new, unexpected interactions in the entire I&C architecture of the plant in the course of an incident. However, guidance or consensus on PSA methods for the newly adopted digital features is not yet available. Therefore, a continued comparative application of various approaches for modelling DI&C in PSA will be an important step towards establishing internationally well-agreed methods for DI&C modelling with respect to nuclear safety.

The major goals of DIGMORE are to get an in-depth understanding of possible impacts of interactions within the entire DI&C architectures on PSA models, i.e., a more comprehensive approach which includes an extension of the former DIGMAP test case to consider, e.g., various backup features of NPP DI&C architectures for critical safety functions, the probable impact of malfunctions of priority modules/logics and accident sequences, to compare the results from DIGMAP and DIGMORE, especially

concerning different approaches to implement modern defense-in-depth and diversity (3D) strategies in the I&C architecture of the plant (e.g., automatic programmable backup I&C systems versus automatic PLD-based I&C backup systems versus automatic or manual hardwired I&C backup systems). and to give recommendations for the development of PSA models as a basis for a future development of corresponding guidelines.

The following important steps are needed within the DIGMORE activity:

In a first step, a reference case is currently being developed taking into account the entire architecture of the DI&C system, including, e.g., priority modules, backup systems, signals from the operational I&C system as well as extended accident sequences and spurious actuation scenarios based on accessible, generic information provided by the task participants. In further steps, the DIGMORE participants will develop and describe individual DI&C models, which then will be discussed and compared. For this purpose, task workshops are foreseen. In this context, the characteristics of DI&C features, such as software and hardware, fault-tolerant techniques, network communication, and automatic testing need to be carefully considered based on the experience from the DIGMAP case study. Finally, it is also intended to establish guidance for PSA with respect to DI&C systems. The task results will be published within a CSNI report.

4. USE AND DEVELOPMENT OF PSA – STATUS REPORT

The WGRISK routinely shares information regarding PSA methodologies used to identify NPP risk contributors and assess their importance as well as applications of PSA results. To this end, WGRISK has periodically summarized the current status of PSA programs in member and some non-member countries in a PSA "Use and Development" report. This report, intended to be updated approx. every five years to ensure that the content remains timely and relevant, provides descriptions of the current status of PSA programs in member countries, including basic background information, guidelines, various PSA applications, major results from recent studies, PSA based plant modifications, and research and development topics. Feedback received by WGRISK indicates that these reports are widely used to benchmark PSA programs and identify emerging trends in PSA developments and applications.

The objective of this task is to update the previous status report [2] with an increased emphasis on new PSA developments and applications to reflect current issues and applications.

In a first step of the task, the structure and format of the report have already been further enhanced in order to better communicate information and insights, considering the experience of using the previous versions of the report. A template of the report structure with guidance on the expectations to the member countries´ inputs has been distributed to WWGRISK members for providing input until fall 2022. Besides an introduction and two chapters at the end summarizing some overall insights and providing conclusions, the report structure covers the following topics:

- PSA framework and environment,
- Safety goals, criteria, and risk metrics,
- Status and scope of ongoing PSA studies in different countries,
- PSA methods, tools, and data,
- Notable results from PSAs,
- PSA applications and risk-informed decision-making,
- Future developments and research,
- International activities.

The deliverable will be a final CSNI task report (status report) providing descriptions of the current status of PSA programs in WGRISK member countries as well as in and participating non-member countries including basic background information, guidelines, various PSA applications, major results from recent studies, PSA based plant modifications and research and development topics.

5. TASKS BEING STARTED

Two new tasks have been proposed to start in 2022 after endorsement by the CSNI.

5.1. Treatment of Uncertainties for Novel Aspects of Risk Analyses

As PSA tools have matured, risk-informed decisions have evolved from relatively simple to complex actions requiring a more integrated and holistic view of nuclear plant risk. Most current reactor designs have a significant base of experience in design, operation, and analysis. There is also a large base of experience in performing PSAs for current reactor designs and treating uncertainties within these PSAs. With interest in expanding the use of risk-informed decision-making, new and more complex PSA applications have emerged for which consensus PSA modelling approaches (e.g., assumptions related to modelling of portable equipment or flexible coping strategies) may be unavailable. Although these more complex uses of PSA can further improve safety and operational flexibilities, they have also pushed the limits of state-of-the-art PSA modelling and highlighted the inherent uncertainties in PSA modelling.

Furthermore, new and advanced reactors have significantly different design and operational features and a much smaller base of experience in treating uncertainties in PSAs. Because of the novel aspects of risk analyses for new and advanced reactors or more complex PSA applications, there is likely more uncertainty in these PSAs, which is likely to derive from different areas. Modern PSA approaches and tools are capable of supporting many of these new and complex applications, and previous research activities have produced several guidance documents and risk communication guidelines related to the treatment of uncertainties. Nonetheless, the PSA practitioners and decision-makers may need to increase their capabilities and skills for dealing with PSA uncertainties related to novel aspects of risk analyses. Such additional capabilities will be beneficial to integrate the existing foundation into coherent and practical guidelines for making decisions on treating uncertainties in support of emerging PSA applications.

The WGRISK identified the potential benefits of a new task to assess the established tools for treating uncertainty for novel aspects of risk analyses and develop a common understanding of current practice, possible benefits of additional criteria, challenges and opportunities, and potential follow-on activities. The goals of the new task are to assess how members currently treat uncertainties in risk analyses and risk-informed decision-making for novel aspects of risk analyses and survey member views as to potential improvements in treatment where a relative lack of operational experience exists. While it is anticipated to observe more challenges related to the lack of operational experience in the treatment of uncertainties for new and advanced reactors, unique or novel aspects of risk analyses or RIDM for the traditional reactor designs and operations are included in the scope of this task. The PSA community would benefit from the task by discussing current practice and consideration of developing additional criteria for this area. WGRISK, whose members represent a wide range of views, is well-suited to facilitate such discussions, identify follow-on activities, and prepare member countries for the future.

It is expected that the task will involve (i) developing an overview of tools, research, or applications related to the treatment of completeness, modelling, and parametric uncertainties in PSAs and risk-informed decision making, (ii) identifying decision-making cases where the specific methods for treatment of uncertainties provided additional insights to a decision or the lack of methods posed challenges to decision-making, (iii) identifying the practical challenges, and (iv) developing a preliminary outline of an application benchmark as groundwork for a potential follow-on WGRISK task. To achieve these objectives, this task will solicit input from PSA experts and decision-makers who are well-versed in the treatment of uncertainties for nuclear power plants. This activity considers all scopes of NPP PSAs, the associated nuclear safety issues, and the diverse decisions made by stakeholders, including licensees and regulatory bodies. The scope includes the consideration of uncertainty in all PSA Levels, any plant operational modes, internal events, internal and external hazards as well as diverse concerns such as spent fuel pools (SFPs), equipment recovery, portable equipment deployment, accident management, and site-level risk.

The conclusions of the task will be mainly based on the results of a WGRISK member country survey and follow-on workshops. The activity is expected to develop a WGRISK Technical Note summarizing the task survey results, a Task Report documenting the results of the activity and providing recommendations for future activities, and conference papers providing intermediate project results and facilitating discussions with other members of the PSA community.

5.2. Level 3 PSA Modelling Benchmark

PSA is an important tool in the design, evaluation, and regulation of nuclear installations. One aspect of PSA is the evaluation of offsite consequences. Models developed for offsite consequence analysis describe the transport and dispersion of radionuclides released and predict the resulting interaction with and influence on the environment and people. The predicted consequences can include early fatalities and injuries, latent cancer fatalities, genetic effects, land contamination, and the magnitude of economic impacts. In recent years new and modernized Level 3 PSA tools have been developed. The WGRISK identified a need to understand the capabilities of these tools, understand the uncertainties and provide a forum for discussion between national experts.

The objectives of the Level 3 PSA modelling benchmarking task are:

- to provide a forum for discussion and understanding of impacts of consequence modelling techniques and assumptions,
- to better understand uncertainties in the models in relation to the uncertainties in the overall PSA, and
- to better understand and tolerate differences in the various (national) models.

Since most Level 3 PSA codes are set up in line with national regulation, national living habits and national climatic conditions, the benchmark will be defined in a way that allows some tolerance against these differences. It is expected that the benchmark will cover two to three accident source terms, and five to six calculation endpoints.

The activity will be executed in three phases: 1) the participants will define the benchmark problems, 2) the participants will do the calculations, and 3) the results will be compared, and conclusions will be drawn.

Benchmark cases are expected to be defined in 2023, with workshops in 2023 and 2024. A CSNI task report is planned to be published in 2025.

6. CONCLUSION

The WGRISK continues to support its mission of providing a forum for information exchange that advances the understanding and utilization of PSA by effectively five undergoing tasks and initiating two new activities related to the treatment of uncertainties for novel aspects of risk analyses and a Level 3 PSA modelling benchmark. These activities will allow continued engagement of PSA experts and leaders on a wide range of issues related to PSA methods, models, tools, and data to support assessing and managing the risk of nuclear installations.

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[1] Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA), Committee on the Safety of Nuclear Installations (CSNI). "*Digital I&C PSA – Comparative Application of Digital I&C Modelling Approaches for PSA", NEA/CSNI/R(2021)14*, OECD/NEA; Paris, France, (in publication 2022).

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