SSM funding of R&D activities related to Probabilistic Safety Assessment

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Abstract: The Swedish Radiation Safety Authority (SSM) has a yearly research budget at approximately 80 M€. This budget is used to support SSM supervision by direct and indirect funded research activities and by sponsoring of academic institutions. Some funding is provided to different co-operation groups that in turn identifies and prioritise R&D projects. The use of co-operation groups mean that an individually small budget will be effective when combined with funding from other organisations, utilities and in-kind contributions. Examples of co-founders are The Nordic Safety Council (NKS), Energiforsk, Halden, the Finnish State Nuclear Waste Management Fund VYR, utilities, private companies and Universities.

This paper will present the SSM research structure and some of the recent (5-10 years) direct and indirectly sponsored activities, with a focus on PSA and PSA related activities. This include Nordic PSA Group projects and the Swedish National Fire Safety Group projects.

Main research areas covered are: Dependent failures including Common cause failures, Human reliability, PRA quality, defence in depth, Seismic, Uncertainties, Result presentation, Source Term Predictions, and Reliability Data analysis.

Keywords: PSA, PRA, R&D.

1. INTRODUCTION

The Swedish Radiation Safety Authority (SSM) has a yearly research budget at approximately 80 MSEK (~8 M€). This budget is used to support SSM supervision by direct and indirect funded research activities and by sponsoring of academic institutions. Some funding is provided to different co-operation groups that in turn identifies and priorities R&D projects. The picture with different funding paths, where also SSM money is used either directly or via a funded cooperation organization is a challenge for both funding applications and for the funding organizations creating sometimes an additional administrative burden.

This paper presents different organizations involved in funding nuclear safety R&D individually or together with SSM, see section 2. Section 3 continues with describing some of the funded research activities. The focus is on PSA and PSA related activities.

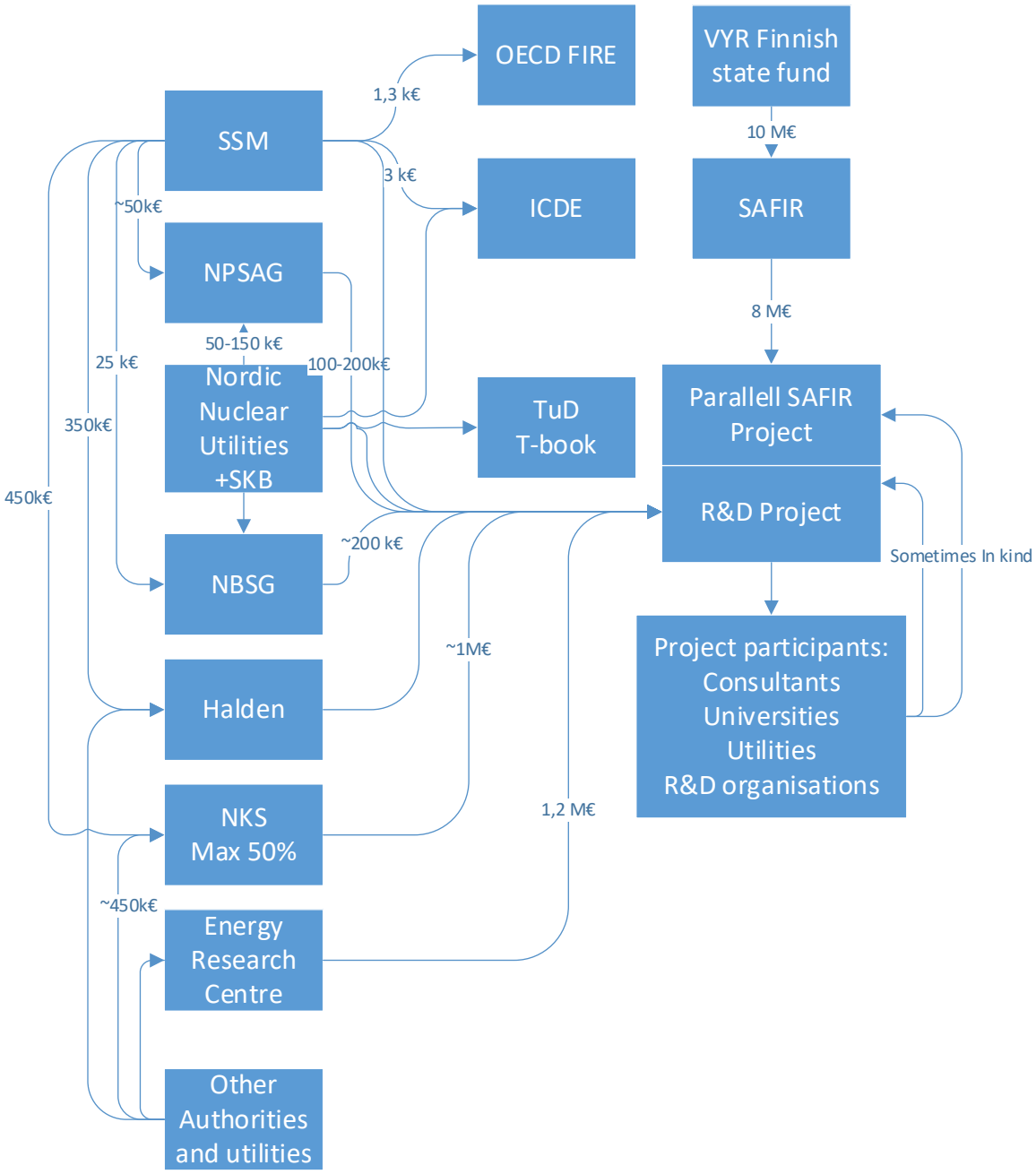
2. FUNDING AND CO-ORDINATION ORGANISATIONS

2.1 Overview

Figure 1 shows an overview of SSM and other organizations involved in identifying, prioritizing and selecting projects for funding. SSM R&D budget can go directly to different projects where SSM is the only financing source. However, there are also many examples where SSM's contribution is only a small part of the total, e.g. Halden that receives some contribution from SSM and the major part from other organizations. Halden in turn has its own R&D priorities. Further, SSM provides funding to several co-operation groups that has a role to identify, prioritize and select projects for funding. In these cases, SSM funding together with funding by other members in these groups makes it possible both to have larger projects, and to involve more actively other organizations and people in the processes contributing to a broader acceptability. Examples of co-operation groups are The Nordic Safety Council (NKS), the Nordic PSA group (NPSAG) and Energiforsk. It also happens that

individual organizations that are taking part in the active execution of the projects provides in-kind contributions not covered by the external financing.

Figure 1. Overview of R&D funding flow



2.2. Swedish Radiation Safety Authority (SSM)

Research funded by SSM has the objective to provide new knowledge that can support SSM to be an efficient and authoritative regulator for radiation safety, and contribute to keep and develop the competence needed to bring new and use available knowledge, both at the authority and nationally. R&D can support planning and prioritisation of supervision activities and decisions on supervision findings.

SSM has an R&D budget at approximately 80 MSEK (~8 M€) per year, of which about 60 MSEK (~6M€) is used in projects related to nuclear safety as well as radiation protection. Research is mainly

carried out by universities and businesses. The research projects are classified in the following areas including the approximate percentage of funding of the total SSM budget:

Table 1: SSM R&D areas

	Area	Funding (%)
1	Man, technology and organisation (MTO)	4
2	Reactor safety	24
3	Structural integrity	16
4	Safety analysis	4
5	Decommissioning and radioactive waste	3
6	Measuring techniques	7
7	Radiation protection	28
8	Other	10

The percentage of funding per area has remained about the same over the past several years. Note that research in reactor safety, even though specified as area 2, is also a part of research in other areas, in particular area 1, 3 and 4. This mean that reactor safety accounts for approximately 50% of the total budget, i.e. about 4 M€ per year. All project proposals are evaluated by SSM experts regarding scientific level, competence, and relevance using a scale from 1-5.

2.3. SAFIR

The reason to have some information about SAFIR in this paper is that certain projects are executed in co-operation between Sweden and Finland, not the least in the reactor safety areas.

The Ministry of Employment and the Economy (MEE) in Finland has initiated a four-year national technical and scientific research programme on the safety of nuclear power plants to take place between 2015 and 2018, SAFIR2018. SAFIR2018 is a continuation of earlier government-led nuclear safety programmes that have proven their worth in maintaining and developing know-how. The safety research programme is based on Chapter 7a ("Ensuring availability of expertise") of the Finnish Nuclear Energy Act. In essence, the programme covers plant safety and systems engineering, reactor safety and structural safety and materials.

The programme is funded by the Finnish State Nuclear Waste Management Fund (VYR), as well as other key organisations operating in the area of nuclear energy that independently decide on their funding. The annual funding of SAFIR2014 (predecessor to SAFIR2018) has been approximately 10 million euros per year. SAFIR2018 continues at the same level but with increased international funding.

SAFIR2018 total funding in 2015-2016 was 15,5 M€ and the main funding organisations were the Finnish State Nuclear Waste Management Fund (VYR) with 9,3 M€ and VTT (Technical Research Centre of Finland) with 3,5 M€.

Website: http://safir2018.vtt.fi/index.htm.

2.4. Nordic PSA Group and Utilities

The Nordic PSA Group (NPSAG) is a common forum for discussion of issues related to probabilistic safety assessment (PSA) of nuclear power plants, with focus on research and development needs.

The group follows and discusses current issues related to PSA nationally and internationally, as well as PSA activities at the participating utilities. The group initiates and co-ordinates research and development activities and discusses how new knowledge shall be used. Over the years, international contacts have increased, especially with partners in Europe (initiated by BWR Owners Group (BWROG) and EU-research contacts). This is in line with the group's aim to create a common and lasting basis for the performance of PSA and for risk informed applications of PSA in Europe.

NPSAG only has a limited fixed budget for secretary services and for meeting arrangements. Project proposals are financed by a budget shared by members dependent on their individual interest.

Current full members are the NPPs Forsmark, Ringhals, Oskarshamn, Olkiluoto and Fennovoima. In addition, SSM and STUK (regulators in Sweden and Finland), and the Swedish Nuclear Fuel and Waste Management Co (SKB) are associate members.

NPSAG members meet about three times a year, organizes a seminar to present recent R&D results and report member activities. NPSAG also co-ordinates so called "Castle meetings" about every second year, a conference to communicate and discuss R&D results.

The project portfolio for 2017 was approximately 120 k€ and for 2018 will be about 210 k€ (incl. NKS funding of about 0,75 M€).

Web site: www.npsag.org.

2.5. NKS

NKS (Nordic Nuclear Safety Research) is a forum for Nordic cooperation and competence in nuclear safety, including emergency preparedness, serving as an umbrella for Nordic initiatives and interests. It runs joint activities of interest to financing organizations and other end users producing seminars, exercises, scientific articles, technical reports and other types of reference material. The work is financed and supported by Nordic authorities, companies and other organizations. The results, which should be practical and directly applicable, are used by participating organizations in their decision-making processes and information activities.

NKS with its program for nuclear safety including emergency preparedness is of common benefit for all five Nordic countries. The hallmark of NKS is a spirit of sharing – all results are available free of charge on the NKS web site, not only to the NKS family but also worldwide providing an international benefit of the NKS work.

NKS activities are divided into two program areas:

- NKS-R: Reactor safety; Nuclear power plant life management and extension; Decommissioning and handling of generated waste; Organizational issues.
- NKS-B: Nuclear and radiological emergency preparedness; Measurement strategy, Technology and quality assurance; Radioecology and environmental assessments; Management of radioactive waste and discharges.

NKS-R covers the following topics:

- Thermal hydraulics
- Severe accidents
- Reactor physics
- Risk analysis & probabilistic methods
- Organizational issues and safety culture
- Decommissioning, including decommissioning waste
- Plant life management and extension

Table 2: NKS Owners and Financiers

Area	Funding (%)
Danish Emergency Management Agency (DEMA, Denmark)	Fennovoima Oy (Finland)
The Ministry of Economic Affairs and Employment (TEM, Finland)	Fortum Power and Heat Ltd. (Finland) TVO (Finland)
Icelandic Radiation Safety Authority (GR, Iceland)	Institute for Energy Technology (IFE, Norway)
Norwegian Radiation Protection Authority (NRPA, Norway)	Forsmark Kraftgrupp AB (Sweden)
Swedish Radiation Safety Authority (SSM, Sweden)	OKG AB (Sweden)
	Ringhals AB (Sweden)
	SKB

SSM contribution to NKS is approximately 450 k€ per year, which is about 50 % of the total budget. In 2017 the contributions of the owners and additional financiers were more than 1.1 million euros. To this should be added contributions in kind by participating organizations, worth approximately the same amount (NKS max funding is 50% of the total).

Website: www.nks.org.

2.6. The Swedish Energy Research Centre

The Swedish Energy Research Centre initiates and co-ordinates (including international co-ordination) R&D programs and offer specialist services in the energy area. The centre is a non-profit organisation owned by Energy companies in Sweden, The Swedish grid operator "Svenska Kraftnät", Energigas Sverige and Swedegas. The current centre represents four earlier independent R&D organisations: Värmeforsk (Thermal Engineering R&D 1968), Svenskt Gastekniskt Center AB (Swedish gas technical center 1990), Elforsk (Electricity R&D 1993) and the research program Fjärrsyn (district heating 2006). Until the joining in 2015, a total of 2846 reports were published.

Annual Nuclear R&D budget is around 1,2 M€ and projects are targeting:

- Mainly feasibility studies and small projects
- Lifetime Extension / long term operation
- Focus on supporting structures and systems

Web site: www.energiforsk.se (in Swedish).

2.7. The Halden Reactor Project

The Halden Project is a joint undertaking of national organizations from 19 countries sponsoring a jointly financed programme under the auspices of the OECD - Nuclear Energy Agency. Discussions are under way for enlarging the member circle. Collaborations with East-European countries in support of plant safety and reliability are also expanding. The programmes are to generate key information for safety and licensing assessments and aim at providing:

- Extended fuel utilization: Basic data on how the fuel performs in commercial reactors, both at normal operation and transient conditions, with emphasis on extended fuel utilization.
- Degradation of core materials: Knowledge of plant materials behaviour under the combined deteriorating effects of water chemistry and nuclear environment.
- Man-Machine Systems: Advances in computerized surveillance systems, human factors and man-machine interaction in support of upgraded control rooms.

These are collectively known as The Joint Programme. Key features of the Joint Programme are: Practical applicability of results; Continuously upgraded facilities; Qualified technical personnel and Innovative technologies.

The Joint programme is financed by the participating countries and is renewed every three years. As a host country, Norway covers about 30% of the Joint programme cost. The Project's employees include, amongst others, ~120 university graduates and ~25 foreign experts on temporary assignment. The number of employees has been gradually increasing during the last 5 years as the work programme expanded.

The programme results are systematically reported in Halden Work Reports and in Enlarged meetings organized by the Project. Participants' activities are also presented at these meetings. Special workshops with participation of experts are frequently arranged for in-depth assessments of specific issues.

A number of organizations in the participating countries execute their own development work in collaboration with the Project. These bilateral arrangements constitute an important complement to the Joint programme.

The organizations participating in the Halden Project represent a complete cross section of the nuclear community, including licensing and regulatory bodies, vendors, utility industry and research organizations.

The programme is executed by the Norwegian Institute for Energy Technology (IFE) at its Halden establishment. All technologies and products developed in the programme are available to participants, who also have access to Halden facilities and expertise for their own development work. Several programme items have applications in a range of non-nuclear industries as demonstrated by a number of projects carried out in cooperation with participant organizations.

Web site: https://www.ife.no/en/ife/halden/hrp/the-halden-reactor-project.

2.8. National Fire Safety Group (NBSG)

NBSG is a co-operation group for fire protection development at the Swedish NPPs founded in 2002. The co-operation continues in a number of successive three-year agreements. Members are the Swedish Radiation Safety Authority (SSM), the Swedish Nuclear Fuel and Waste Management Co (SKB) and the Swedish NPP utilities. A research program is maintained and updated on a yearly basis. The main tasks are:

- Prioritisation of R&D for fire safety in Swedish nuclear industry (own funding)
- Monitoring of R&D developments
- Interpretation of rules and requirements
- Support / follow ongoing R&D activities
- Dissemination of results via interfaces and communication with other fire safety related groups, e.g. BRANDFORSK (FIRE RESEARCH) and NPSAG.

Priority projects are those where the results are directly applicable in practical fire protection and carried out in co-operation with universities.

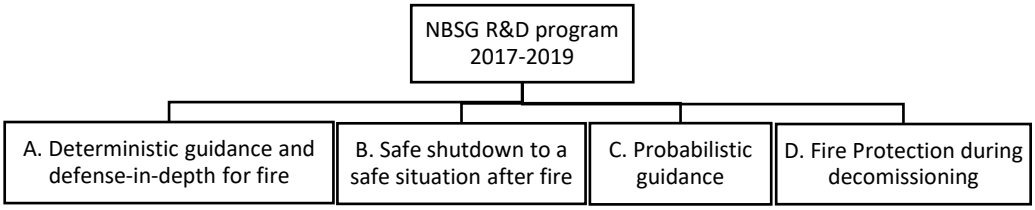
The projects are divided into the categories listed below:

- Support/development of practical fire protection by improving fire brigade intervention planning.
- Clarification of requirements by efforts towards harmonisation and consensus regarding new requirements, in support of ongoing modernisation at existing NPPs and SKB facilities. Also support for decommissioning issues for existing fleet and design of new SKB facilities.
- Feedback of experience, e.g. based on analysis of historical data or by improving experience feedback systems.

- Monitor and participate in international fire R&D development, e.g. OECD FIRE.
- Lobbying research useful for the nuclear industry
- Development of analysis tools and it support.

NBSG is further responsible for a yearly seminar where the stakeholders can meet – fire safety services, emergency services in the authorities local to the nuclear sites, Swedish Civil Contingencies Agency (MSB), insurance companies and consultants.

The R&D program for 2017-2019 is shown below:



Some details of project areas that are primary for NBSG:

- National and international fire protection requirements
- Risk informed fire protection
- Methods for fire analysis
- Data for deterministic and probabilistic fire analyses
- Development of realistic probabilistic fire analyses
- Deterministic view on design requirements
- Effects from fire gases, smoke and soot
- Development of knowledge about fires in electrical equipment and cables
- Ignition sources and fire cell barriers
- Fire protection during decommissioning

NBSG budget last five years has been approximately 200 k€ per year.

Web site: https://projectportal.afconsult.com/ProjectPortal/nbsg (in Swedish, login required).

3. FUNDED ACTIVITIES

3.1. Overview

As mentioned in the introduction, projects are usually funded by a number of organisations, both direct funding and indirect funding via co-operation organisations like NPSAG and NBSG. Some projects also include in-kind contributions. The funding organisations usually also contribute with some review resources for final reports and participation in project status meetings and workshops. An overview of the funding flow is given in figure 1 above.

3.2. SSM Funding

Examples of SSM funded activities are given in Table 3.

Basic support to universities include financing of Doctors thesis in support of both investigating R&D issues and supporting competence and resource creation and maintenance. Halden choose their projects rather individually but such projects may also ask for extra direct funding from SSM.

Table 3: Examples of SSM R&D funding for 2018

Project	Status
Basic support universities	400 k€
Halden Reactor Project	350 k€
APRI-10	220 k€
RASTEP Source term tool	60 k€
GINO	50 k€
NPSAG projects	~50 k€
NBSG	25 k€
ICDE	3 k€
FIRE	1,3 k€

APRI stands for Accident Phenomena of Risk Importance. This co-operation project started already in the nineties. The idea is that the project shall be a common platform for power utilities and authorities and a knowledge data base concerning phenomena and important accident scenarios in case of severe accidents at nuclear power plants. The new and evolving knowledge shall contribute to the assessment of existing technical and administrative measures (emergency procedures, instructions, emergency planning, and quality of severe accidents and risk studies, e.g. PSA level 2) for dealing with severe accidents. APRI-10 is the current phase. The total budget is around 600 k€ per year (SSM one third and the industry the remaining part). Results are compiled in SSM report series and also discussed at a yearly seminar with 60-70 participants.

RASTEP (Rapid Source Term Prediction) is a computerized source term prediction tool aimed at providing a basis for improving off-site emergency management. RASTEP uses Bayesian belief networks (BBN) to model severe accident progression in a nuclear power plant in combination with pre-calculated source terms (i.e., amount, timing, and pathway of released radio-nuclides). The output is a set of possible source terms with associated probabilities. This project started in 2012 (also included NKS funding). Current activities include implementation at SSM and discussions on improvement of the level 2 PSA which results are essential for the prediction quality.

NBSG projects are described separately. The NBSG funding is used mainly for R&D projects whereas ICDE and FIRE participation is more as a member fee for administrative costs. NPSAG projects are funded on a case by case depending on NPSAG members interests, but the budget set aside by SSM is about 50 k€ per year. GINO details, see NKS.

3.3. NPSAG

Recent activities projects co-ordinated via NPSAG are presented in table 4.

Table 4: NPSAG Co-ordinated Projects

Project	Status
Level 3 PSA	Started 2014, completed 2016
TuD – T-book	Ongoing activity
ICDE	Ongoing activity
SITRON – Site risk methods	Started 2016, ongoing
HRA dependencies	Started and completed 2016
HRA errors of commission	Phase 1 completed phase 2 in 2018
Simplified seismic methods	Completed 2017

The level 3 project final NPSAG report [1] was issued in March 2017. The main results were also presented at PSAM 13.

The TUD office is funded by utilities (no SSM funding but SSM follows the work) directly and this funding concern the continuous work with providing updated reliability data to the probabilistic analyses performed by the utilities.

The International Common Cause Data Exchange project (ICDE) is a long-term project for collection and analysis of CCF events. The project is coordinated via OECD-NEA and has been running for two decades, and both SSM and utilities provide funding.

The SITRON project (Site Risk of Nuclear Installations) [2,3] is coordinated with SAFIR PRAMEA efforts. The first objective with the SITRON project was to search for practical approaches for Nordic utilities to assess the site level risk. This objective concerns with safety goals, risk criteria and PSA applications for a multi-unit site. The second objective with the project is to develop methods to assess risk for multi-unit scenarios. This objective concerns with methods to identify, analyze and model dependencies between the units.

Development of a practical method for site PSA is based on the assumption that unit-specific PSAs are used as far as possible. This may require further analyses of multi-unit scenarios and dependencies. The project also discusses result presentation and risk criteria for site level PSA.

The site PSA implies both needs (a) to complement and restructure unit-specific PSAs to cover multi-unit considerations and (b) to post-process and integrate results from unit-specific PSA models to assess the risk on site level and to identify the most important multi-unit dependencies and events. The objective is to demonstrate the approach by pilot studies using existing PSA models provided by utilities. International activities in this topic will be followed (WGRISK, IAEA).

The purpose with the HRA dependency project [4] was to:
1. suggest efficient ways to identify important human actions for dependency evaluation;
2. implement the HRA dependencies in the selected plant models;
3. evaluate how the implementation would influence the PSA results.

The project was performed together with PSA/HRA engineers from all three Swedish nuclear power plants, i.e. Ringhals, Forsmark, and OKG. As the HRA dependencies have been implemented to some extent in all three plant models, the focus was thus to check what has been done and how it can be improved. The project has increased the understanding about efficient ways to identify important human actions for dependency evaluation, and the practical issues related to the evaluation of dependency levels and the incorporation into the PSA model. The most important conclusions/findings are repeated here:

- The HRA dependencies should be evaluated for the Category A Human Failure Events (HFEs) modelled for similar components (e.g. valves, measures, indicators, etc.) in redundant trains within the same function/system. The relevant HFEs for similar components in the redundant trains can easily be identified.
- Inter-system HRA dependencies in Category A HFEs are typically not modeled in the plant model and it is believed not to be a significant contributor to the plant risk, though some caution is needed, especially in case of site risk evaluations.
- From the plant risk estimation point of view, it is reasonable to argue that human dependencies are already considered in the CCF events for the affected components and thus HRA dependencies are not further added in the model. It is important, when such a claim is made, to ensure that this is indeed the case. In any case, the qualitative part of the assessment suggested here provides potentially valuable insights.
- MCS searching can find important Category C HFE combinations for dependency treatment. Shutdown PSA model contains more human actions and thus more HFE combinations are expected.
- Justification of independence between operator actions is important both for the identification of the HFE combinations as well as for the dependency level assessment.

The purpose of phase 1 of the HRA Errors of Commission project (HRA-EOC) [5] in 2017 was to:

1. Perform a thorough literature review on the requirements, methods and existing research and application studies related to EOCs
2. Perform an international survey on how EOC is considered in the world wide nuclear power plants PSA's and the research works that have been performed in international organizations.
3. Provide recommendations (at least preliminary) on how to consider EOCs in a PSA including identification, modelling, quantification and preventions.
4. Suggest a reasonable R&D plan for NPSAG stakeholders in relation with EOC issues A separate paper is given on this project.

Phase I provides some recommendations for minimal guidance on EOC Definition and the Focused Scope, EOC Identification, EOC Modelling, EOC Quantification and EOC Preventions/mitigations.

Phase II with pilot studies at the participating utilities continues during 2018 with implementation of recommendations in the selected plant models and evaluate how the implementation would influence the PSA results.

A project for development of a simplified seismic approach was completed in 2017 [6]. The assumed moderate risk level allows for conservative assumptions. Review Level Earthquake, RLE used as the basis for the SMA, is 0.11g in Sweden which is an estimate of an earthquake of 1E-5 annual return frequency at site.

3.4. NKS

NKS has a wide project portfolio covering severe accidents and risk analysis. Current activities of interest in risk analysis are listed in Table 5:

Table 5: NKS Co-ordinated Projects

FIREBAN	Determination of fire barriers' reliability for fire risk assessment in nuclear power plants
SPARC	Scenarios and Phenomena Affecting Risk of Containment Failure and Release Characteristics
SC_AIM	Safety culture assurance and improvement methods in complex projects
SITRON	Site Risk Of Nuclear Installations
AVESOME	Added Value of uncertainty Estimates of SOurce term and MEteorology
EPHSOGAM	Early Phase Source Term Estimation From Gamma Spectra

The Fireban project scope is to investigate and assess the reliability of fire barriers in NPP during realistic fire scenarios to support the plant-scale risk assessment. The objective is to establish data and methods to determine the conditional probabilities for failure of fire barrier. The scientific merit is the establishment of a link between existing data on fire barriers and probabilistic fire modelling in NPP. The technical merit of the project is the possibility to allow users to better determine the overall probability of loss of compartmentation between redundant systems in case of different fire scenarios. This is an important risk analysis for nuclear power plants, as it has been shown that the loss of compartmentation has severe consequences for a safe reactor shut down process. This project is ongoing.

The SPARC project concerns a robust severe accident management strategy, which is paramount for minimizing the environmental impact in the case of a severe accident involving melting of a reactor core. Both physical phenomena (deterministic) and accident scenarios (stochastic) are sources of uncertainties in the assessment of effectiveness of the accident mitigation. Adequate approaches are necessary in order to address both deterministic (epistemic) and stochastic (aleatory) sources of uncertainty in a consistent manner. The goal of the project is to develop approaches and data for addressing the effects of scenarios and phenomena on the risk of containment failure and characteristics of release in case of a severe accident.

The SC_AIM project The project has two aims: 1) To identify and specify methods to improve and facilitate safety culture in complex projects and 2) To identify and specify methods to assure safety

culture in complex projects. A basic premise of the project is that so far there has been a lot of attention on how to diagnose and evaluate safety culture, but actually not so much on how to improve the safety culture. A second premise is that improvement of safety culture in projects sets some unique requirements due to e.g. multiple organizations interacting, diverse background of personnel, schedules and contract issues etc.

SITRON is described in section 3.3.

3.5. Swedish Energy Research Centre

The energy research centre has 6 programs in 2017, where four have co-financing from SSM. These four are:

- CONCRETE
- ENSRIC
- COMRADE
- GINO

The objective with CONRETE is to secure the life time of concrete structures at Swedish and Finnish NPPs while providing for a safe, reliable and cost effective operation. The focus for 2016-2018 is to:

- Study the local climate in the reactor containment in order to identify environment conditions with potential for degradation and containment tightness,
- Develop methods to study pre-stressed cables and steel lining,
- Verification of calculation tools used for containment studies,
- Investigate safety related issues concerning water paths.

A Power company Concrete day has been organised yearly since 2016 with different themes, as Digitalisation, Rock and Concrete, Future materials and analysis methods. One recent report is "Acceptance Criteria for Maintenance of Nuclear Concrete Structures", Energiforsk report 2017-358.

In the coming years a considerable amount of I&C systems and equipment must be replaced or upgraded because of different aspects of aging. This is a challenge and the experience from recent years is that the life cycle costs when introducing new digital platforms has turned out to be much higher than originally anticipated. The main focus of ENSRIC (Energiforsk Nuclear Safety Related I&C) 2016-2018 will be to find cost- and time effective methods to extend the life time of the present analogue systems. A moderate estimation is that the investment cost for the renewal is in the order of ~100 M€ per reactor for F1-F3, R3-R4, O3 and OL1-OL2. Another focus area for the program is the asset management of the already installed digital platforms, finding time- and cost effective strategies for changes and updates. ENSRIC vision is that the activities should contribute to safe and robust I&C systems that promotes low Life Cycle Cost. ENSRIC will enable using international experience applied to a Nordic context, to assist the NPPs and authorities to take necessary decisions early in the process. It also constitutes an arena to discuss future I&C strategies for NPPs, authorities, researchers and vendors.

A joint Nordic project on Condition Monitoring, thermal and Radiation Degradation of polymers inside NPP containments (COMRADE) has been developed following an initiative from the Nordic NPPs through Energiforsk. A pre-study identified that there are gaps in knowledge for setting functional based acceptance criteria for polymeric materials at the nuclear power plants. Furthermore a need in gaining a better understanding on how a polymeric component reacts to different levels of low dose radiation and synergistic effects between thermo-oxidative and irradiation degradation was identified. The aim is to provide the power plant operators as well as regulators and polymer manufactures with a deeper knowledge of the degradation of polymers and to develop methods for setting acceptance criteria of polymeric materials.

Grid Interference on Nuclear power plant Operations (GINO) is an R&D program aiming at gaining better understanding and possibility to pro-actively minimize interference on nuclear power plant (NPP)

operation due to issues in the external grid. The benefits include revised safety and assessed safety margins, avoidance of extended outages and maintenance periods, fewer unplanned shut-downs, and lower cost of component replacement.

The proposed activities include survey of operational events from the off-site power system with focus on retrofit of mitigating actions, methodologies to verify that the outer grounding line network in the nuclear power plants is intact, a generic lightning model of the Nordic nuclear power plants to study how lightning strikes at overhead power lines are transmitted on-site, survey on new electrical devices with different technology compared to existing electrical devices, and sub-synchronous resonance (SSR) phenomenon and modelling combined with hybrid simulations. The program started in 2016 and is planned until 2018.

3.6. NBSG

NBSG has a rather extensive number of projects, usually rather limited in size. The projects covers fire defence-in-depth, in general terms as well as in fire prevention, fire detection, fire confinement and fire extinguishing. Other areas are safe shutdown with general analysis methods, fire scenarios, and secondary impacts, probabilistic guidance and fire protection during decommissioning.

Details cover: hydrogen risk from batteries, fire testing of cables, use of reduced oxygen level, safe distances, pilot study on link between fire testing and fire PRA, cable data bases, transformer fire protection, control room personnel fire training, fire barrier reliability, cable fire simulation, pool fires, PRISME related work, use of OECD FIRE database in support of fire event tree construction etc.

4. CONCLUSION

SSM financed R&D covers a rather broad spectrum of projects that are financed either by SSM alone or together with other stakeholders including industry. Though SSM has its own process for deciding on funding, also co-operation groups are many times involved. There is some overlapping in the different processes. There is also some risk that different organizations decisions are impacted by decisions in other organizations, since the same person e.g. from SSM may be member in several of the co-operation organizations and thus being involved in deciding on funding of the same project at several places.

A positive thing with a broad debate of some projects is that many stakeholders need to be active in the preparation of projects, which results in the solid base to start the projects. Stakeholders are involved in many projects not only as receivers of reports, but also through active participation, e.g. pilot studies, benchmarks etc. This has been the case, e.g. with the NPSAG HRA projects involving both the utility PSA group and operators. Such arrangements lead (hopefully) to more interest and confidence in the eventual applications.

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