

Paper 315

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

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Presentation outline

- Overview of funding structure
- Some important organisations for R&D project definition and prioritisation
- Some examples of recent and ongoing R&D activities



Overview of funding structure

Shows the funding flow from various R&D budgets to the different R&D projects.

Many projects are co-funded by two or more sources

Many co-operation projects

Most projects rather small





SSM

- Total R&D budget ~8 M€
- About 6 M€ in nuclear safety and radiation protection projects, reactor safety ~4 M€
- Mainly universities and businesses
- About the same percentage per area over the past several years

	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



NPSAG – Nordic PSA Group

- A common forum for discussion of issues related to probabilistic safety assessment (PSA) of nuclear power plants, with focus on research and development needs
- Full members: Forsmark, Ringhals, Oskarshamn, Olkiluoto and Fennovoima. SSM, STUK (regulators in Sweden and Finland), and the Swedish Nuclear Fuel and Waste Management Co (SKB) are associate members
- Meetings about three times a year
- Organizes a yearly seminar and Castle meetings about every second year
- Project portfolio varies from year to year, nowadays approximately 0,15 – 0,5 M€ - + in kind contributions



NKS

- A forum for Nordic cooperation and competence in nuclear safety, including emergency preparedness, serving as an umbrella for Nordic initiatives and interests
- Financed and supported by Nordic authorities, companies and other organizations.
- Two programs:
 - 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 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
- Budget:
 - SSM contribution to NKS ~ 450 k€ per year, which is about 50 % of the total NKS budget.
 - In 2017 the contributions of the owners and additional financiers were more than 1.1 million euros.
 - Plus contributions in kind by participating organizations, worth approximately the same amount (NKS max funding is 50% of the total).



ERC – Energy Research Centre

- Initiates and co-ordinates (including international co-ordination) R&D programs and offer specialist services in the energy area.
- A non-profit organisation owned by Energy companies in Sweden, The Swedish grid operator “Svenska Kraftnät”, Energigas Sverige and Swedegas.
- Represents four earlier independent R&D organisations
 - a total of 2846 reports were published before joining.
- 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



NBSG – National Fire Safety Group

- Co-operation group for fire protection development at the Swedish NPPs since 2002.
- Co-operation continues in a number of successive three-year agreements.
- Members - 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.
- Yearly budget ~0,2 M€



Funded Activities – SSM 2018 (Examples)

Project	Budget
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 - Accident Phenomena of Risk Importance

- Co-operation project started already in the nineties. APRI-10 is the current phase.
- 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.
- Total budget is ~ 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

- 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



NPSAG Projects (examples)

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



Tud office – T-book

- TUD office funded by utilities (no SSM funding but SSM follows the work) directly
- Continuous work with providing updated reliability data to the probabilistic analyses performed by the utilities.
- Main delivery – T-book (version 8 2015)



SITRON - Site Risk of Nuclear Installations

- Objective to search for practical approaches for Nordic utilities to assess the site level risk.
 - Safety goals, risk criteria and PSA applications for a multi-unit site.
 - Develop methods to assess risk for multi-unit scenarios - identify, analyze and model dependencies between the units.

- Based on the assumption that unit-specific PSAs are used as far as possible.

- Discusses result presentation and risk criteria for site level PSA.



NKS Projects (examples)

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



FIREBAN

- Scope to investigate and assess the reliability of fire barriers in NPP during realistic fire scenarios to support the plant-scale risk assessment.
- Objective to establish data and methods to determine the conditional probabilities for failure of fire barrier.
- Establishment of a link between existing data on fire barriers and probabilistic fire modelling in NPP.
- 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.



SPARC - Scenarios and Phenomena Affecting Risk of Containment Failure and Release Characteristics

- 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 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.



SC-AIM

- Identify and specify methods to improve and facilitate safety culture in complex projects and
- Identify and specify methods to assure safety culture in complex projects.
- A basic premise 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.



Energy Research Centre

➔ Four projects co-financed with SSM

- CONCRETE
- ENSRIC
- COMRADE
- GINO



CONCRETE

- 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.

ENSRIC - Energiforsk Nuclear Safety Related I&C

- 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 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.



COMRADE - Condition Monitoring, thermal and Radiation Degradation of polymers inside NPP containments

- An initiative from the Nordic NPPs.
- 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.



GINO - Grid Interference on Nuclear power plant Operations

- 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.
- 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.



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.



Main Conclusions

- 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.

- Many stakeholders involved in R&D prioritization
 - Some overlapping in the different processes.
 - Some risk for dependencies in the decision process
 - Need for active involvement by many parties - results in the solid base to start the projects
 - Funding organisations not only receivers of reports, but also active in participation, e.g. pilot studies, benchmarks, such arrangements lead (hopefully) to more interest and confidence in the eventual applications.