

NPSAG ANNUAL REPORT 2014

NPSAG Annual report Year 2014

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NPSAG:s verksamhet

NPSAG grundades i december 2000 av kärnkraftbolagen i Finland och Sverige. Strålsäkerhetsmyndigheten (SSM) deltar i NPSAG som observatör och medverkar också som finansiär i flera för SSM säkerhetsviktiga FoU-projekt. Avsikten med NPSAG är att utgöra ett gemensamt forum för diskussion av frågeställningar med bäring på probabilistiska säkerhetsanalyser (PSA) för nordiska kärnkraftverk och med fokus på behovet av forskning och utveckling bland de medverkande parterna.

NPSAG följer och diskuterar aktuella probabilistiska utmaningar nationellt och internationellt, liksom PSA-aktiviteter vid de medverkande kärnkraftbolagen. Gruppen initierar och koordinerar FoU-projekt och -aktiviteter och diskuterar hur resultaten kan utnyttjas på bästa sätt. NPSAG värnar om en effektiv erfarenhetsåterföring i de projekt som bedrivs och om en bred omvärldsanalys till nytta för hela branschen.

Under årens lopp har NPSAG:s internationella nätverk vuxit kraftigt, t.ex. inom BWROG, EU:s forskningsprogram och OECD/NEA i Paris. Detta är i linje med gruppens mål att bidra till internationell utveckling och samsyn på frågor rörande PSA och riskinformerade tillämpningar.

NPSAG activities

The Nordic PSA Group NPSAG was founded in December 2000 by the nuclear utilities in Finland and Sweden. In addition, the Swedish Radiation Safety Authority (SSM) participates as an observer, and also takes part in the funding of many of the projects. NPSAG is intended to be 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, e.g., within BWROG, EU research projects, and OECD/NEA. 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 Godkännande

Dokumenttyp: Rapport
Statusdatum: 2015-02-09
Status: Godkänd

Deltagande organisationer: RAB, FKA, OKG, TVO, Fortum, SSM, Fennovoima

Granskningsprocess: Dokumentet har granskats inom deltagande organisationer.
Omdöme: Rapporten bedöms innehålla värdefull information och de rekommendationer som ges kommer beaktas inom deltagande organisationer.

Signatur:

A handwritten signature in blue ink, appearing to read 'P. RINGHALLS AR', written over a horizontal line.

Namn, Organisation

NPSAG ANNUAL REPORT 2014

NPSAG Annual report 2014

Summary of 2014

The year of 2014 was an interesting and exciting year in terms of research project progress as well as positive changes in the NPSAG meeting structure.

During 2014 the ongoing projects showed good progress and a few projects reached completion or near completion.

NPSAG meetings were held in January, June and October. The meetings focused on the progress of ongoing projects as well as on the NPSAG meeting structure. In October NPSAG organised the annual Autumn Seminar. This time in Helsinki, Finland. Interesting presentations from both Finnish and Swedish participants were held including a wide range of topics within PSA.

At the October meeting Fennovoima was accepted as a new member of the group.

The new secretary from 2013, Lars Dahlström, was supported by Agnes Maripuu. In 2015 Agnes Maripuu will take over the position as NPSAG secretary.

The Annual report from the Nordic PSA Group (NPSAG) presents NPSAG activities and activities in NPSAG financed projects during the recent year. If you have any questions on the activities or NPSAG in general please contact the NPSAG secretary (address on last page).

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NPSAG Charter and Basis for Roadmap

During the year 2014 the NPSAG Charter was completed and signed by all NPSAG members. The NPSAG Charter describes the strategic plan and covers the goals and strategies for the Nordic PSA Group. The charter includes the overall objectives for the NPSAG organisation, obligations for the members, organisation etc.

In addition, completion of the Basis for the NPSAG roadmap was reached during 2014. The Basis for the roadmap will be used as fundament for discussion and creation of an NPSAG roadmap. The document provides a complete overview of the NPSAG activities including those

performed during the years 2000-2013 as well as currently ongoing activities. Possible future activities have also been suggested for each area of interest to NPSAG. The motives for future research programs arise from uncertainties in existing methods and data as well as from a need for new methods and data to handle extended scopes of analyses. Other sources for the roadmap are recommendations from recent research projects.

The roadmap will provide steering of NPSAG activities and assurance of development in a predetermined direction both in the short and long term perspective.

NPSAG meetings during 2014; no 40, 41 and 42

During the year 2014 three NPSAG-meetings were held.

Meeting no 40 was held at Arlanda, Stockholm, on the 22nd of January 2014. Main topics at the meeting were project progress as well as the possibility to renew the NPSAG web page.

Meeting no 41 was held at Arlanda, Stockholm, on the 3rd of June 2014. To the meeting a new meeting structure was implemented. The new structure aimed to enhance focus on key issues as well as extend information exchange between the member utilities. In the new structure less active issues can be discussed only if specific new information is available or if discussion is needed for some other reason.

Meeting no 42 was held at TVO headquarters in Helsinki, Finland, on the 8th of October 2014. The meeting was held in connection to the NPSAG autumn seminar. During the meeting a discussion was held on which focus area each regular meeting (three per year) should have. This macro meeting structure is needed in order to initiate and evaluate project suggestions so that they can be included in NPSAG members' R&D budgets. If tender and tender response deadlines are not met, the projects may be delayed. The structure is shown in figure 1.



Figure 1. The schematic figure above describe how NPSAG plan new research projects, including when tender requests are sent out and responses are discussed and evaluated.

The pace of tender request, evaluation and acceptance is based on the time frame for budget planning in NPSAG members' organization. Planning of the R&D budget takes place in September for the coming year.

NPSAG autumn seminar

The NPSAG autumn seminar was held at TVO headquarters in Helsinki on the 7th of October. The seminar had participants from both Sweden and Finland, which enjoyed a number of interesting presentations.

The presentations can be obtained by contacting the NPSAG secretary. Contact information can be found at the end of this document.



The NPSAG autumn seminar is an annual event. In 2015 the event will take place at Forsmark nuclear power plant in Sweden on the 6th of October 2015.

Presentations and speakers

- NPSAG project: PSA Level 3 by Andy Wallin Caldwell (Lloyd's Register Consulting) and Ilkka Karanta (VTT).
- SAFIR-2018 program by Jari Hämäläinen (VTT) and Ilkka Niemelä (STUK)
- STUK presentation of YVL Guidelines by Jorma Sandberg (STUK)
- Hanhikivi 1 project and status of PRA by Juho Helander (Fennovoima)
- PSA Level 2 by Stefan Eriksson (RAB) and Cilla Andersson (RAB)

Common methodology for analysis of initiating events (34-003)

The project is supported by NPSAG. Within NPSAG the project is financed by RAB, FKA, OKG and SSM. The project is performed by ÅF, with Gunnar Johanson as project leader. The project started in 2013 and was completed during 2014.

The overall aim of project was to perform a survey of methods used for identification, categorization and frequency estimation of initiating events in current Swedish PSAs. During the course of this project, several harmonization issues related to initiating event analysis have been identified and examined.

The project results can be found in the two main project reports:

- *Methods for identification and categorization of initiating events.*
The identified issues concerns choice of method, criteria for screening, strategies for systematic mapping, and verification of completeness (e.g. comparison with deterministic methods).
- *Methods for classification and parameterization.*
The identified issues concerns choice of method, criteria for quantitative screening and selection of data source, and which data to include to achieve reasonable estimations of the initiating event frequencies.

Project activities and reached milestones

The project has been finalized and project reports have been completed during 2014.

Planned project activities for 2015

No activities will be performed during 2015 since the project was completed in June 2014.

Completed reports and published papers

Following project reports have been completed:

- NPSAG report 34-003-01 Methods for Identification and Categorization of IE
- NPSAG report 34-003-02 Methods for Classification and Parameterization of IE

All project reports (above) were completed during 2014.

The reports make up the final reporting of the project and describe the overall conclusions.



EXAM HRA – Evaluation of current HRA methods (11-004)

The project is supported by SAFIR, NPSAG and NKS (only phase 3a). Within NPSAG the project is financed by RAB, FKA and SSM. The project is performed by ÅF, Lloyd's Register Consulting, VTT and RISA with Gunnar Johanson (ÅF) as project leader. The project started in 2010 and will be completed in 2015.

The overall aim of the project is to provide guidance on a state of the art HRA for the purpose of PSA as well as to provide means to improve the experience feedback on plant features based on HRA and PSA results. This includes identifying discrepancies and actual aspects explaining why differences in results can be observed in HRA applications.

The project is at the third and final phase since start-up of the project, which is divided in four phases (0 to 3). Phase 3 involves the development of a guidance document on HRA application methods.

The second seminar of phase 3 will be held in January 2015. The second seminar will focus on the guidance and the choice of methods for HRA applications.

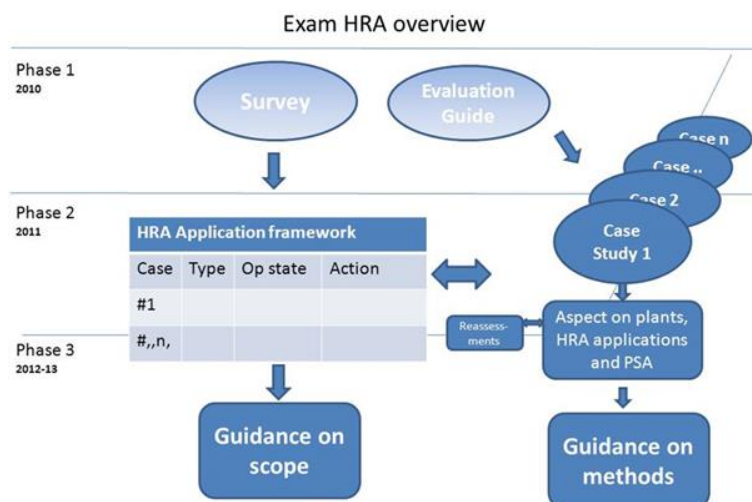
Project activities and reached milestones in 2014

During 2014 two project workshops were organised:

- 27-28th of August – Workshop at VTT
- 11-12th of November – Workshop at ÅF

The workshops aimed to follow up the development of the case reports by contributions from the stakeholders to represent the studied PSA/HRAs. In addition, guidance documents were developed during 2014.

Two project milestones were successfully reached: (1) completion of Phase 3 of the project and (2) completion of Draft Project reporting



Completed reports and published papers

Following project reports and papers have been completed and published during 2014:

- EXAM HRA Phase 3a Summary report. NKS-305 March 2014 (ES konsult 2012020-028 2014-03-24).

A complete list of the project reports and published papers can be found in appendix A.

Reference to overall conclusions

The following references contain conclusions concerning the EXAM HRA project:

- EXAM HRA Case study C.16 – Heavy load drop, FKA report FTT-2013-0046, to be submitted Jan 2015
- EXAM HRA Case study C.14 – HRA methods or treatment of actions without procedures. VTT research report VTT-R-04996-14 Dec 2014
- EXAM HRA Case study C.15 – HRA method for Hazards, Lloyds Report 211017-TN-001, 2013-02-03
- EXAM HRA Case study C.13 – LOCA during shutdown, Vattenfall report, to be submitted Jan 2015
- Survey and process for selection of scenarios to be included in HRA Assessment. ES konsult report 2010006-013, Rev. 3 2013-10-13
- EXAM HRA Application guide. ES konsult report 2012020-013. Dec 2014
- Draft Exam HRA Practical Guide. ÅF report 6034743-012, to be submitted Jan 2015

Planned project activities for 2015

For coming year, 2015, the following project activities are planned:

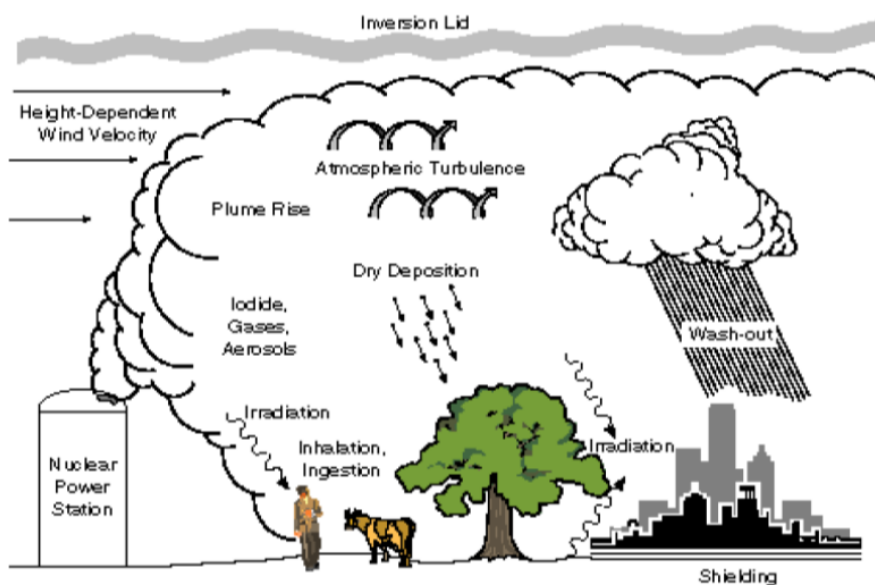
- Closing Seminar 22nd of January 2015
- NPSAG Review and issuing of final reporting February-March 2015
 - o Draft Exam HRA Practical Guide, Final draft January 2015
 - o Planned, Final (Phase 3) summary report, draft January 2015

PSA Level 3 (29-001)

The project is supported by SAFIR, NKS and NPSAG. Within NPSAG the project is financed by RAB, FKA and OKG. The project is performed by Lloyd's Register Consulting, RiskPilot, VTT, ÅF and Vattenfall AB, with Andy Wallin Caldwell (Lloyd's Register Consulting) as project leader. The project started in 2013 and will be completed in the end of 2015. End reporting will be finalized at the beginning of 2016.

Level 3 PSA provides a tool to assess the risks to society posed by a nuclear plant, and could be integral in making objective decisions related to the off-site risks of nuclear facilities. This study intends on furthering Nordic understanding of the potential of Level 3 PSA to determine the influences and impacts of off-site consequences, the effectiveness of off-site emergency response, and the potential contributions of improved upstream Level 1 and Level 2 PSAs.

During 2014 the working group and interested stakeholders have been working to detail the inputs for the Level 3 PSA pilot study. The larger share of the 2014 resources have been allocated toward the pilot study, while a larger share of the 2015 funds are planned to be applied to the guidance document development.



Planned project activities for 2015

For coming year, 2015, following project activities are planned:

- Planned seminar/workshop on 20th of January 2015
- Present progress on pilot and workshop final guidance
- Complete pilot projects
- Develop guidance document

Project activities and reached milestones in 2014

On the 21st of January 2014 the 1st annual seminar was organised. The objective of the seminar was to present and discuss the progress of the NPSAG/NKS Level 3 Probabilistic Safety Assessment Project and to receive feedback.

In addition first-year reports was published during 2014. The reports describe Industrial survey, Risk Metrics, Regulations guides and Standards, and the Finnish pilot project.

The pilot projects were developed focusing on planning and input specification.

During 2014 four project milestones were successfully reached:

- Completion of Phase 1 of project – Industrial survey, Risk metrics
- Continuation of Regulations, guides and standards
- Development of pilot project plans
- Development of guidance document outline

Completed reports and published papers

Following project reports and papers have been completed and published during 2014:

- Phase 1 report:
NPSAG / NKS report-303
- PSAM 12 paper

The primary deliverance of guidance document, completed next year, will contain the initial project conclusion. Project outcome so far can be found in the project reports and papers.

NAFCS-2 Analysis of CCF data (20-004)

The project is supported by NPSAG. Within NPSAG the project is financed by RAB, FKA, OKG and SSM. The project is performed by ÅF, with Gunnar Johanson as project leader. The project started in 2009 and will be completed in 2016.

The over-all aim of this project is to develop and present qualitative and quantitative results concerning common cause failure events from the Nordic and German plants.

Common cause failure (CCF) events can significantly impact the availability of safety systems of nuclear power plants. In recognition of this, CCF data are systematically being collected and analysed in several countries under the framework of the ICDE project, which is coordinated by OECD/NEA.

The project has been on hold since January 2014.

Project activities and reached milestones during 2014

Seven reports were approved by NPSAG in December 2013 and delivered to NPSAG in January 2014.

Planned project activities for 2015

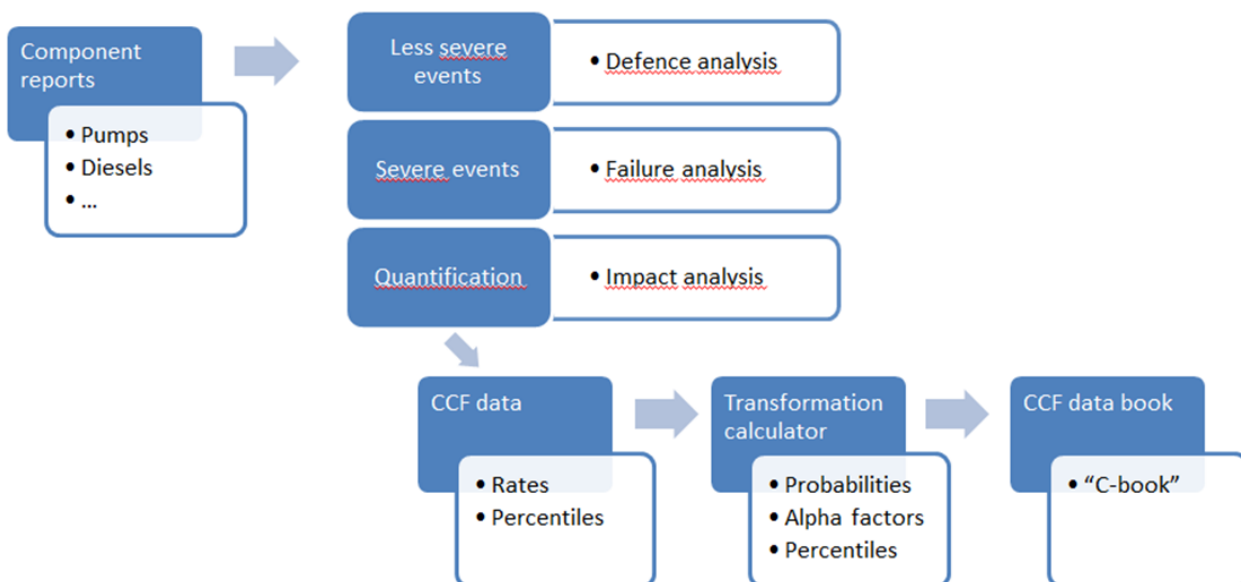
In 2015 the project will start up "year 4". During 2015 there are plans to create a "C-book", which presents CCF data of previous analysed components. The format of the C-book will be based on the approved NPSAG report 20-004-08 "Quantitative summary report".

Completed reports and published papers

Following project reports was delivered to NPSAG in 2014:

- 20-004-07 Diesel report
- 20-004-08 Quantitative application of NAFCS component reports
- 20-004-09 Qualitative application of NAFCS component reports
- 20-004-10 Summary of quantitative and qualitative application reports
- 20-004-11 Breaker report
- 20-004-12 Battery report
- 20-004-13 Level measurement report

A complete list of completed reports can be found in appendix A.



Reference to overall conclusions

In following references the conclusion of NAFCS-2 project can be found:

- 20-004-08 Quantitative application of NAFCS component reports
- 20-004-09 Qualitative application of NAFCS component reports
- 20-004-10 Summary of quantitative and qualitative application reports
- Conference paper "Summary of Nordic PSA group CCF applications" (NPSAG Castle meeting 2013)

DIGREL – Reliability analysis of digital systems in PSA context (22–002)

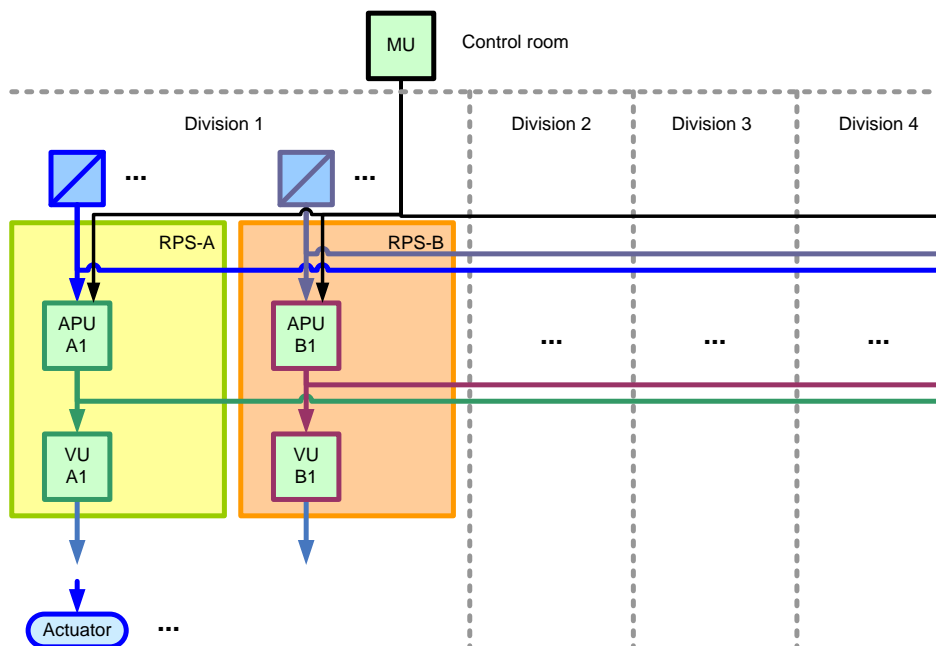
The project is supported by NKS, SAFIR and NPSAG. Within NPSAG the project is financed by RAB, FKA, OKG and SSM. The project is performed by VTT, Risk Pilot AB and Lloyd's Register Consulting, with Jan-Erik Holmberg (Risk Pilot) as project leader. The project started in 2010 and will be completed in 2015.

To assess the risk of NPP operation and to determine the risk impact of digital system upgrades on NPPs quantifiable reliability models are needed along with data for digital systems that are compatible with existing PSAs. Due to the many unique attributes of these systems, several challenges exist in systems analysis, modelling and in data collection. Currently there is no consensus on the reliability analysis approaches. The objective of the project is to provide guidelines to analyse and model digital systems in a PSA context, using traditional reliability analysis methods (FMEA, Fault tree analysis).

Project activities and reached milestones during 2014

During 2014 the following project activities were performed:

- WGRISK activity (task group) focusing on the development of best practice guidelines on failure modes taxonomy for reliability assessment of digital I&C systems for PSA
- Development of the generic digital I&C system example and associated demonstration PSA-model
- Finnish-Swedish-German collaboration specifically on software modelling and quantification
- Final reports (public NKS report): overall DIGREL report, software reliability report



In addition three project milestones were successfully reached during 2014. (1) The WGRISK taxonomy report was completed and accepted by WGRISK. (2) The example PSA model was updated with respect to SW reliability analysis approach and sensitivity studies (model made both with Risk Spectrum and FinPSA). (3) SW reliability estimation was revised both with respect to the utilization of operation experience and the assessment of complexity. In addition two papers were presented in PSAM12 conference and two NKS report are under preparation (to be published in the beginning of 2015).

Planned project activities for 2015

For the upcoming year, 2015, a Nordic end user workshop is planned to the 15th of January. Follow-up project MODIG (Modelling of digital I&C), proposal submitted to NKS and SAFIR (not financed by NPSAG).

Completed reports, publications and references to overall conclusions can be found on the next page.

(Continuing DIGREL – Reliability analysis of digital systems in PSA context (22-002))

Completed reports and published papers.

The following papers were presented at PSAM12 conference during 2014:

- Amri, A., Authén, S., Bruneliere, H., Deleuze, G., Georgescu, G., Holmberg, J.-E., Kim, M.C., Kondo, K., Li, M., Piljugin, E., Postma, W., Sedlak, J., Smidts, C. Stiller, J., Thuy, N., OECD/NEA WGRISK task on failure modes taxonomy for digital I&C – DIGREL. Proc. of 12th International Probabilistic Safety Assessment and Management Conference, 22-27.6.2014, Honolulu, paper 123.
- Bäckström, O., Holmberg, J.-E., Jockenhoevel-Barttfeld, M., Porthin, M., Taurines, A., Quantification of Reactor Protection System Software Reliability Based on Indirect and Direct Evidence. Proc. of 12th International Probabilistic Safety Assessment and Management Conference, 22-27.6.2014, Honolulu, paper 458.

Reference to overall conclusions

In following references the interim conclusions of the project can be found:

- Authén, S, Björkman, K., Holmberg, J.-E., Larsson, J. Guidelines for reliability analysis of digital systems in PSA context — Phase 1 Status Report, NKS-230 Nordic nuclear safety research (NKS), Roskilde, 2010.
- Authén, S., Gustafsson, J., Holmberg, J.-E., Guidelines for reliability analysis of digital systems in PSA context — Phase 2 Status Report, NKS-261 Nordic nuclear safety research (NKS), Roskilde, 2012.
- Authén, S., Holmberg, J.-E., Guidelines for reliability analysis of digital systems in PSA context — Phase 3 Status Report, NKS-277, Nordic nuclear safety research (NKS), Roskilde, 2013.
- Authén, S., Holmberg, J.-E., Lanner, L. & Tyrväinen, T. Guidelines for reliability analysis of digital systems in PSA context — Phase 4 Status Report. NKS-302, Nordic nuclear safety research (NKS), Roskilde, 2014.
- Bäckström, O., Holmberg, J.-E., Jockenhövel-Barttfeld, M., Porthin, M. & Taurines, A. Software reliability analysis for PSA. NKS-304, Nordic nuclear safety research (NKS), Roskilde, 2014.

Members of the Nordic PSA Group

The members of NPSAG during 2014 can be found below. Please do not hesitate to contact the NPSAG secretary with question about the NPSAG activities.

Organisation	Contact person	e-mail
Forsmarks Kraftgrupp AB	Anders Karlsson	ask@forsmark.vattenfall.se
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Ringhals AB	Stefan Eriksson	stefan.x.eriksson@vattenfall.com
Strålsäkerhetsmyndigheten	Ralph Nyman	ralph.nyman@ssm.se
Teollisuuden Voima Oy	Lasse Tunturivuori	lasse.tunturivuori@tvo.fi
Secretary / Responsible for Annual report	Lars Dahlström and Agnes Maripuu, ÅF Industry AB	lars.dahlstrom@afconsult.com agnes.maripuu@afconsult.com

Appendix A – Project reports

Collection of completed reports and published papers

Project NAFCS-2 Analysis of CCF data (20-004)

The following project reports and papers have been completed and published since the start of the project.

20-004-01 Pump report
20-004-02 MOV report
20-004-03 CV report
20-004-04 Generic process for Data Collection
20-004-05 Pumps – Swedish gross data and comments on data collection
20-004-06 CV – Swedish gross data and comments on data collection
20-004-07 Diesel report
20-004-08 Quantitative application of NAFCS component reports
20-004-09 Qualitative application of NAFCS component reports
20-004-10 Summary of quantitative and qualitative application reports
20-004-11 Breaker report
20-004-12 Battery report
20-004-13 Level measurement report

Project EXAM HRA – Evaluation of current HRA methods (11-004)

The following project reports and papers have been completed and published since the start of the project, including phase 0 to 3.

Phase 0	
	EXAM-HRA – Evaluation of existing applications and guidance on methods for HRA. ES konsult report 2008029-010, 2009-12-07
	Aho Mathiesen, H. Master thesis: Requirements on HRA – A review of requirements on HRA from international standards, Swedish NPPs and interviews with performers in the field. Relcon Scandpower and Linköping University
Phase 1	
	Survey and process for selection of scenarios to be included in HRA Assessment. ES konsult report 2010006-013, 2011-01-13
	Guide for evaluation of operator actions in PSA with regard to plant specific features. ES konsult report 2010006-010, 2011-01-13 Revised 2014.
	EXAM-HRA Case study C.0 - Closing of containment AirlockVTT-R-00764-11, 2011
	EXAM-HRA Phase 1 Summary report, ES konsult report 2010006-023, 2011-01-28 NPSAG Report 11-004-01
	EXAM-HRA Phase 2 program, ES konsult PM 2011001-004, 2011-02-09.
Phase 1 reports revised in phase 2	
	EXAM HRA Case study C.1p – Manual Restoration of Residual Heat Removal System during full power operation, Scandpower Report 34800030-R-001, version U2.
	EXAM HRA Case study C.1s – Manual Restoration of Residual Heat Removal System during shutdown conditions, Scandpower Report 34800030-R-002, version U1.
	EXAM HRA Case study C.2 – External water supply, Scandpower Report 34800030-R-003, version U1.
Phase 2 reports	
	EXAM HRA Case study C.7/C.13 - Containment water filling, C.7 - PSA level 1 / C.13 - PSA level 2. VTT-R-02061-12
	EXAM HRA Case study C.10 - Assessment of manual depressurization of the containment (venting). RISA Report nr. 12-186. Berlin 14.03.2012
	EXAM HRA Case study A.1/A.2 - Pre-initiators. FKA Report, FTT-2011-0603.
	Draft EXAM HRA Case study C.5 – Failed manual isolation of leak. Ringhals AB, Darwin id 2172765.

(Continuing) Phase 2 reports	
	EXAM HRA Reassessment: Comparison of models and analysis methods. RISA Report nr. 12-187. Berlin 14.03.2012.
	PSAM 11 paper, EXAM-HRA – Evaluation of Existing Applications and Guidance on Methods for HRA, June 2012
	EXAM HRA Summary report, ES konsult report 2011001-015, 2012-03-20, NPSAG Report 11-004-02
	EXAM HRA Phase 3 program. ES konsult PM 2011001-016, 2012-02-23.
Phase 3a reports	
	Draft EXAM HRA Case study C. 16 – Heavy load drop
	Draft EXAM HRA Case study C.14 – HRA methods or treatment of actions without procedures.
	EXAM HRA Case study C.15 – HRA method for Hazards, NPSAG Report 211017-R-001
	Draft EXAM HRA Case study C.13 – Loca during shutdown
	Draft: Establishing Desirable Attributes of Current Human Reliability Assessment (HRA) Techniques in Nuclear Risk Assessment, OECD/NEA draft report 2013-11-29
	EXAM HRA Phase 3a Status report 2012020-026 1.0. 2013-11-21
	EXAM HRA Seminar summary. ES konsult report 2012020-025.
	EXAM HRA Phase 3b program. ES konsult PM 2013050-001, 2013-12-10.
	EXAM HRA Phase 3a Summary report. NKS-305 March 2014 (ES konsult 2012020-028 2014-03-24).
Phase 3b reports	
	Draft EXAM HRA Application guide. ES konsult report 2012020-013.
	Draft Exam HRA Practical Guide, Final draft January 2015
	Planned, Final (Phase 3) summary report, draft January 2015

Project DIGREL – Reliability analysis of digital systems in PSA context (22-002)

The following project reports and papers have been completed and published since the start of the project.

Scientific publications	
	Authén, S., Holmberg, J.-E., Reliability analysis of digital systems in a probabilistic risk analysis for nuclear power plants, Nuclear Engineering and Technology, Vol. 44, No. 5, June 2012. 471–482.
	Authén, S., Holmberg, J.-E., Reliability analysis of digital systems in a probabilistic risk analysis for nuclear power plants, Nuclear Engineering and Technology, Vol. 44, No. 5, June 2012. 471–482.
	Holmberg J.-E., Software reliability analysis in probabilistic risk analysis, Nuclear Safety and Simulation, Vol. 3, Number 4, December 2012, 281–291.
	Holmberg J.-E., Software reliability analysis in probabilistic risk analysis, Nuclear Safety and Simulation, In: Yoshikawa, H., Zhang, Z. (Eds.), Progress of Nuclear Safety for Symbiosis and Sustainability, Springer, 2014, Ch. 32.
Technical reports	
	Authén, S, Björkman, K., Holmberg, J.-E., Larsson, J. Guidelines for reliability analysis of digital systems in PSA context — Phase 1 Status Report, NKS-230 Nordic nuclear safety research (NKS), Roskilde, 2010.
	Proceedings of the DIGREL seminar, Development of best practice guidelines on failure modes taxonomy for reliability assessment of digital I&C systems for PSA, October 25, 2011, VTT-M-07989-11, Espoo, 2011.
	Authén, S., Gustafsson, J., Holmberg, J.-E. Guidelines for reliability analysis of digital systems in PSA context — Phase 2 Status Report, NKS-261, Nordic nuclear safety research (NKS), Roskilde, 2012.
	Björkman, K., Bäckström, O., Holmberg, J.-E., Use of IEC 61508 in Nuclear Applications Regarding Software Reliability — Pre-study, VTT-R-09293-11, VTT, Espoo, 2012.
	Proceedings of the DIGREL seminar, Development of best practice guidelines on failure modes taxonomy for reliability assessment of digital I&C systems for PSA, November 6, 2012, VTT-M-07735-12, Espoo, 2012.
	Authén, S., Holmberg, J.-E., Guidelines for reliability analysis of digital systems in PSA context - Phase 3 Status Report, NKS-277, Nordic nuclear safety research (NKS), Roskilde, 2013.
	Porthin, M. and Holmberg, J.-E. Modelling software failures using Bayesian nets, HARMONICS working report W2.06, VTT Research report VTT-R-08279-12, VTT, Espoo, 2013.

(Continuing) Technical reports	
	Holmberg, J.-E. Method for the assessment of software common cause failures in the reactor protection system, HARMONICS working report W2.07, VTT Research report VTT-R-08280-12, VTT, Espoo, 2013.
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