RESEARCH REPORT

VTT-R-07266-11

Proceedings of the Deterministic/probabilistic safety analysis workshop October 2011

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Summary

This report describes the outcome of the workshop on deterministic/probabilistic safety analysis organised October 3-5, 2011 in Espoo. Totally 55 nuclear safety analysis experts from Europe and USA participated in the workshop. The objective with the workshop was to prepare a joint research agenda on deterministic/probabilistic safety analysis for the coming 3-4 years. As a result an action plan was prepared with the following content:

- Network. All participants and other potential important members will be invited to join a network with the aim to develop deterministic/probabilistic safety analysis. Exchange of experience and training will be important activities within the network.
- Develop an EC proposal for research project. The proposal will be put together by the technical committee of the workshop (VTT, KTH, FKA/Vattenfall and Scandpower) with support from the networks NPSAG, SAFIR and NULIFE (NUGENIA). The proposal will be based on on-going research activities on a national basis and the contributions and discussions at the workshop.

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Contents

Abbreviations

ASAMPSA2	EU FP7 project on Advanced Safety Assessment Methodologies: Level 2 PSA
CSN	Consejo de Seguridad Nuclear
CSNI	Committee on the Safety of Nuclear Installations (OECD/NEA)
DID	Defence-in-depth
DPSA	Dynamic PSA
DSA	Deterministic safety analysis
ETSON	European TSO Network
FKA	Forsmarks Kraftgrupp AB
IDPSA	Integrated Deterministic-Probabilistic Safety Analysis
ISA	Integrated safety analysis
KTH	Kungliga tekniska högskolan, Royal Institute of Technology, Stockholm
NPSAG	Nordic PSA Group
NULIFE	Nuclear plant life prediction, Network of Excellence in EC's 6th Framework Programme (A network transferring into an association NUGENIA with is part of the EU- based SNE-TP-platform)
PRA	Probabilistic risk analysis
PSA	Probabilistic safety assessment, Probabilistic safety analysis
PWR	Pressurised water reactor
RI-ISI	Risk-informed in-service-inspection
SDTDP	Stimulus driven theory of probabilistic dynamics
SMAP	Safety margins action plan (task group of OECD/NEA)
SNE-TP	The Sustainable Nuclear Energy Technology Platform
SSC	Systems, structures and components
SSM	Swedish Radiation Safety Authority
TSD	Theory of stimulated dynamics
TSO	Technical Support Organisation
WGAMA	OECD/NEA Working Group on the Analysis and Management of Accidents
WGRISK	OECD/NEA Working Group on Risk Assessment

1 Introduction

1.1 Background

Integrated use of deterministic and probabilistic safety analysis is a means to enable risk-informed decision making. This is based on the fact that safety justification must be based on both deterministic and probabilistic considerations to address the mutual interactions between (i) stochastic disturbances (e.g. failures of the equipment) and (ii) deterministic response of the plant (i.e. transients).

Development has been made on development and application of risk-informed tools. For instance the concept “dynamic PSA” (DPSA) has been proposed in order to identify unknown important scenarios (weaknesses) or unnecessary conservatism.

Nordic organisations Forsmarks Kraftgrupp (FKA), Royal Institute of Technology (KTH), Scandpower and VTT have taken initiative to start planning of a common research agenda which could be a framework to

- Development of new approaches to integrated deterministic probabilistic safety analysis
- Development and application of the tools for risk informed decision making.

To organise an international workshop was identified as a practical means to achieve a tentative research agenda. This report describes the outcome of the workshop organised October 3-5, 2011 in Espoo.

2 Objectives and scope of the workshop

The objective with the workshop was to prepare a joint research agenda on deterministic/probabilistic safety analysis for the coming 3-4 years.

Questions discussed in the workshop included:

- How to integrate deterministic and probabilistic methods in a consistent manner?
- How to handle the problem of uncertainties in safety analyses?
- How to handle the decision making where compromises are needed (for example between safety requirements, cost—safety respectively safety—complexity)?
- How to secure full coverage of events in PSA and DSA-assessment?
- How to handle scenarios including effects of non-safety system, manual action and time dependency within assessed scenarios.

2.1 Organisation of the workshop

The workshop was organised by a committee:

- Yvonne Adolfsson, Scandpower, Sweden
- Jan Erik Holmberg, VTT, Finland

- Göran Hultqvist, Forsmark Nuclear Power Plant, Sweden
- Pavel Kudinov, Royal Institute of Technology (KTH), Sweden
- Ilkka Männistö, VTT, Finland

Financial support was received, besides from the above organisations from Swedish Radiation Safety Authority (SSM), Sweden, SAFIR2014 (The Finnish Research Programme on Nuclear Power Plant Safety) and from the workshop participants in form of participation fees. Nordic PSA Group (NPSAG) and NULIFE have provided in-kind support and provided financial guarantees to workshop organizers.

Totally 55 experts from Europe and USA participated in the workshop (see Figure 1 and Att. 1). Agenda of the workshop is in Attachment 2. Four keynote speakers were invited to the workshop on topics:

- Dynamic Probabilistic Safety Assessment (DPSA) - Methods and Issues;
- A Next-Generation Safety Analysis Code;
- Can we measure Changes of Safety Margins in Nuclear Power Plants?
- A view of a regulator on application of Dynamic PSA.

10 technical presentations were given by other workshop participants.

In addition, four discussion sessions were organised on topics:

- Needs for investment and R&D for DPSA;
- DPSA tools — state-of-the-art and visions;
- Obstacles in putting DPSA into practice;
- Tasks for the research agenda.

Presentations and discussion sessions are summarised in Ch. 3.

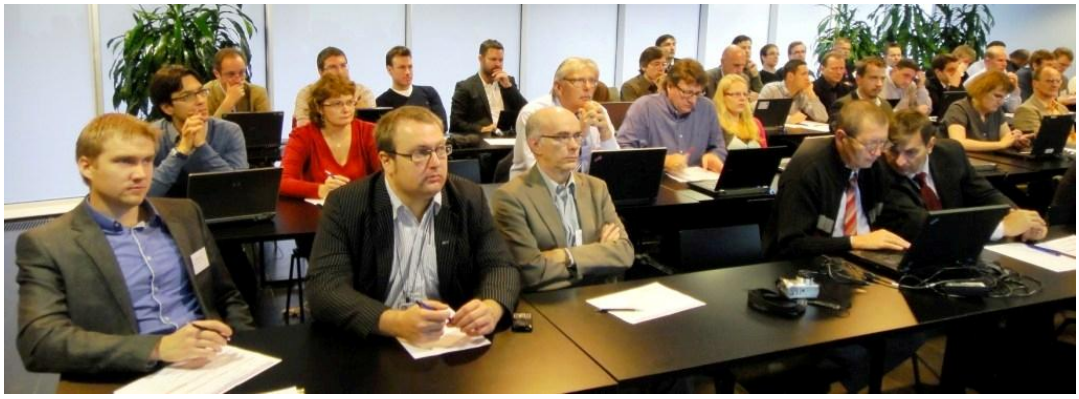

Figure 1.DPSA workshop participants.

3 Presentations by the participants

Presentation slides have been distributed among participants electronically.

3.1 Meaning of DSA/PSA – Yvonne Adolfsson, Scandpower

The presentation outlined the principles and examines the differences of deterministic safety assessment (DSA) and probabilistic safety assessment (PSA).

Historical evolution of both analysis methodologies was presented, and further directions for development were identified.

3.2 Introduction to the DPSA Workshop – Göran Hultqvist, Forsmark NPP

The presentation examined the strengths and weaknesses of DSA and PSA methodologies, outlines the need for improved methodologies. Consideration was given to safety limits and safety margins. The presentation also stated the DPSA workshops goals and the networks behind the workshop.

3.3 Dynamic Probabilistic Safety Assessment – Tunc Aldemir, Ohio State University, *Keynote Presentation*

The need for dynamic PSA methodologies is based on importance of dynamic interactions between plant processes and triggered stochastic events, possibility of overly conservative results from classic PSA, omission of failure scenarios due to dynamic interactions and analysis of systems with significant hardware / software / firmware / process / human interactions. Overview into several different dynamic PSA methodologies was given.

Specific applications to analysis of I&C systems and severe accidents (ADAPT / MELCOR) were presented, with results.

3.4 The Link between Defence-in-Depth and DPSA – Per Hellström, Scandpower

The principles of defence-in-depth were presented, with emphasis on expected frequency of initiating events and design principles. Roles of deterministic and probabilistic safety assessments have been examined in the context of defence-in-depth (DID). Conclusions were presented on the results gained from PSA and DID levels, for example the evaluation of strength of DID levels.

3.5 Time Uncertainty Analysis in the Context of Deterministic/Probabilistic Studies – Javier Hortal, Consejo de Seguridad Nuclear

A methodology was presented for taking into account time uncertainties and time-variable modelling uncertainties in deterministic/probabilistic methods. Theory of stimulated dynamics (TSD) is presented as an analysis tool for the problem. TSD is a particular approach to solve the stimulus driven theory of probabilistic dynamics (SDTPD). Analysis case of a simple physical system was presented.

3.6 Use of Computerized Tools for Combined Deterministic / Probabilistic Analysis – Javier Hortal, Consejo de Seguridad Nuclear

CSN-MOSI approach to ISA (integrated safety approach) was presented. A combination of deterministic and probabilistic analyses is required for ISA methodology. A computer tool for performing ISA, the SCAIS package was detailed in the presentation. SCAIS allows simulations of accident sequences from normal operation to severe accidents, including the simulation of procedures.

Results provided by SCAIS include probabilistic quantification of fault trees and risk metrics.

3.7 Handling Multiple Criteria to Assess Safety Benefits of Modifications – Francois Beaudouin, EDF

An EDF methodology for decision making between different plant modifications to balance cost and safety benefits was presented. A multiple criteria theory-based approach is utilized to produce a non-monetary index for evaluating plant modifications. The six criteria reflect various benefits of the modifications, including PSA information. Expert panel is used for assessing coefficient weights between the criteria. Results of the methods application to a real life modification portfolio of 58 plant modifications were presented.

3.8 Framework and Analysis Tools to Support Deterministic / Probabilistic Safety Analysis – Robert W. Youngblood, INL, *Keynote Presentation*

Introduction to the presentation considered integration of deterministic and probabilistic methods consistently, handling of uncertainties in safety analyses and decision making between different criteria.

The R7 tool was presented, which is “clean sheet” development of a systems code to perform modern safety analysis. The need for a new tool for application of the developed DPSA methodologies was emphasized. Differences of the R7 approach and existing approaches are examined.

3.9 A Genetic Algorithm DPSA Approach to Identification of Safety Vulnerabilities – Pavel Kudinov, KTH

A DPSA approach for identifying unknown safety vulnerabilities was presented. While classic PSA is useful for assessing risks for known vulnerabilities, unknown vulnerabilities are left unidentified. The presented DPSA approach allows finding risk significant scenarios while accounting for time dependent interactions between deterministic and stochastic parameters. The developed tool utilizes deterministic simulation code and genetic algorithm to handle exploration of event space avoiding combinatorial explosion. Example application to VVER-1000 scenarios with high pressure injection into pressurizer was presented.

3.10 Can We Measure Changes of Safety Margins in Nuclear Power Plants? – Martin Zimmermann, PSI, *Keynote Presentation*

A description of the SMAP (CSNI action plan in the area of safety margins) framework was given. Implementation of the SMAP by SM2A task group was presented. The application case examined the safety margin change in a hypothetical 10% power uprate using the Zion PWR plant model. Analysis of changes in safety margin using SMAP framework was presented.

3.11 PRA as a Tool for Safety Related Decision Making in Fortum – Kalle Jänkälä, Fortum Power and Heat

Loviisa NPPs PRA and its application in decision making were presented. The different risk informed applications included identifying need for plant

modifications, support for new design, prioritization of design options, operator training, risk-informed test intervals & allowed outage times, risk-informed technical specification evaluation, risk-informed safety classification of SSCs, RI-ISI and risk-informed maintenance. Methodologies for and experiences from aforementioned uses was presented.

3.12 Applications and Issues of DPSA and Time-dependant Reliability Analysis – Robertas Alzbutas, Lithuanian Energy Institute

An analysis methodology based on theory of stimulated dynamics was presented. While classic PSA focuses on scenarios, probabilities and consequences, TSD focuses on system dynamics, transitions and states. A test case on DPSA analysis of hydrogen recombinators was presented. Application tool REPEAT (Reliability Parameters Estimation and Analysis Toolkit) was introduced. Several ideas for future research and development were also presented.

3.13 Probabilistic Approach to the Design of a Safety System – Luciano Burgazzi, ENEA

A reliability-based approach to the design of a thermal-hydraulic passive system is being considered. The probability of failure of the system is assessed in terms of safety margin, corresponding to the limit state function. Results help designer determining the allowable limits or set the safety margin for the system operation parameters, to meet the safety and reliability requirements.

3.14 Overview of EDF Research in the Field of Risk Informed Safety Margins — Valentin Rychkov, EDF

CSNI/SMAP (CSNI safety margins action plan) was presented. The use of classic PRA for safety margin evaluation was examined with identified problems. SM2A Zion PWR uprate study was presented from EDF point of view. Potential directions of improvement were identified, including incorporation of safety margin vectors into sequences, the use of operational experience through further scenarios and dynamic uncertainty quantification.

3.15 Developing a Tool for Rapid Source Term Prediction Based on Bayesian Belief Network – Vidar H. Swaling, Scandpower

The development of RASTEP, a tool for Rapid Source Terms Prediction, was presented. RASTEP is intended for fast, online diagnosis of an event or accident. The need for the tool is based on the crucial importance of early source term prediction for accident management purposes at SSM (Swedish regulatory body). RASTEP combines variety of plant information, including PRA level 1 and 2, utilizing a Bayesian belief network, with potential application in accident cases, what-if-analyses of severe accident scenarios and training.

3.16 A View of a Regulator on Application of Dynamic PSA – Wiktor Frid, SSM, *Keynote Presentation,* presented by Pavel Kudinov, KTH

The Swedish Radiation Safety Authority's (SSM) regulations and advice relevant to deterministic and probabilistic safety analyses were presented. SSM recognizes

the advantages of integrated DPSA approach in several areas, e.g. improved possibility of analysing operator actions, time dependent events, interactions between events, improved transparency, more realistic analysis of severe accident phenomena and improved treatment of uncertainties. Significance of the 2011 Fukushima nuclear accident to the use of DPSA was explained.

4 Proposed research agenda

4.1 Background and motivation

Presentations and discussions at the workshop showed that there is a need to introduce a new collective name ***Integrated Deterministic-Probabilistic Safety Analysis (IDPSA)*** for the variety of different approaches and tools developed for combined probabilistic and deterministic analysis during the last decades.

IDPSA is a family of methods which use tightly coupled probabilistic and deterministic approaches to address aleatory (stochastic aspects of scenario) and epistemic (modelling) uncertainties in a consistent manner. For example, what has been referred to in the past as dynamic PSA (DPSA) belongs to the family of IDPSA methods.

The main motivation for development of the IDPSA methods was early realization that static logic models applied in PSA has inherent limitations in resolving of time dependent interactions between

- Physical phenomena;
- Control logic;
- Operator actions;
- Equipment failures.

These interactions can make the result contingent upon the order and timing of the events sequences. PSA can quantify probability of known threats, but it cannot reveal unknown vulnerable sequences. PSA event trees and “master level” fault trees are based on those threats, which are defined based on expert judgement and analysed in detail with deterministic plant simulations, e.g. thermo-hydraulic and reactor-physical transient accident analyses. If the accident scenario simulations are not covering vulnerable sequences, the threats remain unknown. As a consequence PSA “success” paths can end up with core damage and “failure” scenarios might lead to no damage. Even if the threat is known, scenarios with significant timing factors and process-system feedback loops are challenging for static event tree-fault tree approach. Dynamic process failures in Digital I&C and passive plants are also difficulty to resolve with static fault/event trees approach because a “process” failure is achievable even if none of the system components fails.

Increasingly stringent safety and licensing requirements and new design solutions necessary to match the expectations present new challenges for classical PSA / DSA. For instance:

- Increasing complexity of the existing plant systems for prevention and mitigations of events and respective PSA models, which lead to:

  - Growth of resources necessary for development and maintenance of PSA models;
  - Increased complexity of the input models and associated uncertainties in the different accident analysis codes;
  - Non-transparency of very complex PSA models aiming at realistic presentation of complex system design;
  - Increasing reliance on expert judgement in providing conservative assumptions about uncertainties in time dependent scenarios;
  - Increased complexity in assessment of the impact of human operator actions on time dependent scenarios.
- New designs which on one hand achieve very low core damage frequencies by reducing the number of equipment that can break, on the other hand rely more on physics of passive safety systems and complicated digital control systems than on human operator:
  - Passive safety systems in new plants and retrofits in existing plants;
  - Severe accident management in design;
  - Digital I&C.
- Risk informed decision making for:
  - Development of design and operational procedures;
  - Safety and licensing.

Importance of operator actions in accident conditions can be hardly over-estimated, as well as timing and history of the events and operator actions which are difficult to model in PSA.

IDPSA is considered as a complementary to PSA and DSA approaches intended to help in:

- Resolving time dependent interactions between physical phenomena, equipment failures, safety and non-safety systems interactions, control logic, operator actions;
- Identification and characterization of a-priori unknown vulnerable scenarios, or “sleeping threats”;
- Consistent treatment of different sources of uncertainties;
- Reduction of reliance on expert judgment and simplifying assumptions about interdependencies;
- Potential reduction of the cost of safety analysis due to larger involvement of computers in what they can do better: multi-parameter, combinatorial exploration of the plant scenarios space.

However, it would be a mistake to consider IDPSA as a tool that is called to replace PSA and DSA approaches and experts in the decision making process. IDPSA is a complimentary tool that can provide additional help to PSA and DSA practitioners and experts by reducing and quantifying uncertainties in a consistent and resource- and time-efficient manner.

IDPSA tools have been under development for decades. Considerable experience of IDPSA applications in research community has been accumulated. However, until now, wide application in industrial practice was hindered mostly by:

- Prohibitive computation costs for running of hundreds and thousands of transients with deterministic codes;
- Immaturity of deterministic codes;

- Absence of pressing demands for risk informed decisions and ability to "solve" old problems with "classical" approaches.

None of the reasons listed above is true anymore:

- Computational clusters with dozens of CPUs and hundreds of cores are affordable and readily available resources in academia and industry. With such computation power the timescale for exploration or realistic plant event space is about few weeks.
- Extensive development and validation of deterministic codes have been performed nationally and internationally during the last decades. There is still a large room for improvement, especially considering specific demands of IDPSA, but industry and regulators already use deterministic best estimate codes in decision making process on a regular basis.
- Most important, however, is inability in the framework of classical approaches to provide a robust, transparent and cost efficient solution to "new" problems such as passive safety systems, DI&C, growing complexity of the plant safety systems, and the role of the operator.

It shall be noted that the workshop also gave good examples where DSA and PSA are combined and used today by the industry in the area of Safety Related Decision Making, see section 3.7 and 3.11.

Making summary of the overview of the state-of-the-art approaches to safety analysis we see that the industry has a need and research teams have developed a capability. To bring them together we need a strategy for deployment of new approaches into practice of safety analysis.

4.2 Objectives of the Research agenda

Research agenda is called to define a strategy for deployment of IDPSA in support of existing methods of PSA and DSA. Main objectives of the deployment are:

i. To provide new tools for improvement and completeness of understanding of plant safety and operational vulnerabilities by complementing existing DSA and PSA approaches.
ii. To enable increased consistency in risk informed decision making process for:
    a. Design and operational procedures;
    b. Licensing.

4.3 Deployment strategy

One of the main obstacles for the deployment of IDPSA tools, is a lack of mutual awareness between research and industrial communities about:

i. New possibilities which can be open for the industry with frontier IDPSA methods.
ii. Specific industrial needs where IDPSA tools can be utilized to demonstrate their advantages.

Therefore **first step** for the deployment is to create a network of:

- IDPSA research and developers, and

- Potential users:
  - PSA and DSA practitioners in Utilities, Vendors and Regulators.

The goal of IDPSA network is to provide a platform for:

- regular exchange of information and experience
- organizing dedicated workshops, training, exercises;
- development of joint research proposals.

Second step towards deployment of IDPSA methods is to define and address a set .of pilot realistic applications and benchmarks to demonstrate advantages and present limitations of joint application of IDPSA with PSA and with DSA for:

- Realistic quantification of safety margins with uncertainty estimation for:
  - Assessment of the plant changes impact on safety and operation;
  - Integral risk assessment and risk informed regulation.
- Identification and characterization of undiscovered plant vulnerabilities (safety and/or operational) to:
  - Identify possible incompleteness, over- or false- conservatism in existing PSA and DSA models;
  - Reduce reliance on assumptions in engineering judgment about complex time dependencies and scenarios;
  - Improve PSA models with IDPSA generated data (e.g. sequences, probabilities, etc.) and to use PSA generated data as initial and boundary conditions in IDPSA;
- Increasing transparency and robustness of risk-informed decision making;
- Improvement of plant safety and operation.

The experience accumulated in pilot realistic applications and benchmarks will help to:

- Show cost/benefit of joint application of IDPSA, PSA and DSA in risk informed decision making;
- Summarize recommendations on guidelines for joint application of IDPSA, PSA and DSA in risk informed decision making;
- Identify the needs for further developments of the IDPSA methods, tools and data.

4.4 Priorities for development of IDPSA methodology

Few tasks have been identified in the research agenda as high priority for deployment of IDPSA methodology:

i. Methods for transparent post-processing and representation of IDPSA generated information for risk informed decision making:
   - While striving for completeness in the process of plans scenario space exploration, IDPSA produces tremendous amount of information. Automatic post-processing tools are necessary to make use of such information in a transparent and robust manner.

ii. Methods for defining the event space:
   - IDPSA is using minimal assumptions about possible scenarios (sequences of events). However completeness of the IDPSA analysis is contingent on how detailed is specification of the plant event space:
     a) what has happened;

b) what can happen and when.

At least part of such information (about what has happened) can be provided by PSA/DSA. A consistent and robust approach is necessary for defining:

- aleatory uncertainties: possible events (e.g. failure of the equipment, operator actions, etc.) and their timing ("time windows" for each event), and
- epistemic uncertainties: e.g. heat transfer coefficients, friction factors, etc.

As a step towards development of best practice guidelines, a clear classification of IDPSA methods has to be elaborated to clarify for each method belonging to the IDPSA family:

- Typical intended applications;
- Limitations;
- Requirements for the data quality.

This step is important to avoid misuse of IDPSA tools beyond the limits of their applicability.

We expect that the needs for further development of IDPSA methodology and methodology of joint application of IDPSA with PSA and with DSA will be identified in the process of addressing pilot applications and benchmarks.

4.5 Requirements for IDPSA tools and data

General increase of "usability" by a non-developer is important for wide implementation of IDPSA tools in practice. User friendly interfaces for development of input and post processing of output results are necessary for the deployment of the tool.

Workshops dedicated to training with specific IDPSA tools are considered as important element in the deployment strategy.

As a by-product of IDPSA application to realistic tasks we expect to identify the needs for improvements, verification and validation of the basic elements of the IDPSA tools such as:

- Deterministic analysis tools (thermal hydraulics, neutronics and severe accident codes);
- Numerical integration tools and probabilistic assessments in multi-dimensional space.

Identification of the needs and ways to provide new data specific for application of IDPSA is another important task for the IDPSA network.

Minimum requirement for the realistic pilot applications is availability of consistent:

- PSA model and
- DSA model.

Development of such models from a scratch is possible but extremely labour intensive task which is beyond affordable for the most of the network partners in the nearest future.

5 Action plan

An action plan was presented during the workshop with the following content:

- Network. All participants and other potential important members will be invited to join a network with the aim to develop DPSA. Exchange of experience and training will be important activities within the network.
- Develop an EC proposal for research project. The proposal will be put together by the technical committee of the workshop (VTT, KTH FKA/Vattenfall and Scandpower) with support from the network NPSAG, SAFIR and NULIFE(NUGENIA). The proposal will be based on on-going research activities on a national basis and the contributions and discussions at the workshop.

More detailed information about the network and EC proposal is given in section 5.1 and 5.2 below.

A suggested action plan and time-schedule is given in section 5.2.3.

5.1 Network

Preliminary interest was shown by all participants to join the network. A questionnaire will shortly be sent out to all participants and also to potential members not present at the workshop. Also those present from US and Russia at the workshop will have the possibility to join the network.

The network is supposed to promote IDPSA as a complementary method to existing DSA and PSA. The aim is to make IDPSA transparent and easy to understand for both users and regulators. Supposed activities within the network are:

- Email communication with exchange of experience and information about on-going projects and other activities related to IDPSA.
- Workshops.
- Education and training in IDPSA applications, methods and tools.
- Identification and definition of potential cooperation projects (such as the proposal to EC).

5.1.1 Cooperation with other networks and organisations

There are a number of organisations which could have special interest in IDPSA for example:

- NULIFE (NUGENIA/SNE-TP)
- ETSON – European TSO Network
- WGRISK - Working Group on Risk Assessment
- WGAMA - Working Group on the Analysis and Management of Accidents

- National research programs (SAFIR) and groups (NPSAG)

TSO stands for Technical Support Organisation.

Contacts and announcement through these organisations will be made by members in the technical committee.

5.1.1.1 NULIFE (NUGENIA/SNE-TP)

NULIFE is a network with more than 50 organisations for research in the fields important for nuclear reactors. NULIFE was started in 2006. The network identifies common needs for research and support the development of common programs. NULIFE develop projects that are funded by the members but also projects that target EU-research funds. NULIFE is in a transition phase to integrate with the EU-commission supported program SNE-TP (Sustainable Nuclear Energy – Technology Platform) program. A combined program for Generation II and III reactor are under development. This new organisation will be called NUGENIA.

5.1.1.2 ETSON

The aim of ETSON is to promote and develop European scientific and technical co-operation between the TSOs in the field of nuclear safety. This will be achieved by exchanging in particular systematically R&D results and experience in connection with the operation of nuclear facilities and safety assessments. The partners promote a harmonisation of nuclear safety assessment practices in Europe and encourage initiatives to define and implement European research programmes. This will support the further development of the international state of the art in science and technology by using common resources and synergies in all working areas.

5.1.1.3 WGRISK

The main mission of the OECD/NEA working group on risk assessment (WGRISK) is to advance the understanding and utilisation of probabilistic safety assessment (PSA) in ensuring the continued safety of nuclear installations in member countries. While PSA methodology has matured greatly over the years, further work is required. WGRISK has been active in several of these areas, including:

- human reliability;
- software reliability;
- low power and shutdown risk.

In order to maintain a current perspective, the working group collaborates and assists other working groups within the CSNI, such as operating experience and organisational factors as well as keeping close co-ordination with other international organisations.

Over the past twenty years, the NEA PWG5 and now WGRISK have looked at the technology and methods used for identifying contributors to risk and assessing their importance. Work during much of this period was concentrated on Level-1 PSA methodology. In recent years the focus has shifted into more specific PSA methodologies and risk-informed applications.

5.1.1.4 WGAMA

The OECD/NEA Working Group on Analysis and Management of Accidents (WGAMA) objective is to assess and where necessary strengthen the technical basis needed for the prevention, mitigation and management of potential accidents in nuclear power plants, and to facilitate international convergence on safety issues and accident management analyses and strategies. In order to fulfil this objective, the working group shall:

- Exchange technical experience and information relevant for resolving current or emerging safety issues;
- Promote the development of phenomena-based models and codes used for the safety analysis, including the performance of benchmarking exercises;
- Assess the state of knowledge in areas relevant for the accident analysis and where needed;
- Promote research activities aimed to improve such understanding, while supporting the maintenance of expertise and infrastructure in nuclear safety research.

5.1.1.5 Nordic PSA group (NPSAG)

Nordic PSA-group (NPSAG) consists of the Nordic utilities and the Swedish regulator as associate member. NPSAG co-ordinates research and development program within the Nordic sphere in the area of risk assessment. NPSAG has been active since year 2000.

5.1.1.6 SAFIR

SAFIR is the national program for research on nuclear reactors in Finland. All utilities, the regulator and VTT are part of this program that covers all issues related to nuclear reactor safety.

5.2 Proposal

5.2.1 European Commission

Based on the suggested development strategy a proposal will be sent to the European Commission (EC). The project will be suggested to continue during 2013-2016. The proposal will build on interest and contributions from all participants in the network.

A supposed outcome of the proposal is that about 50% of the total funding will come from the commission and the other half from national organisations (utilities, research organisations, regulators etc.).

Each participant will be given the opportunity, via a questionnaire, to give suggestions based on national research projects within this field. Suggestions could be on pilot applications and benchmarks for application of IDPSA. A condition for the applications and benchmarks are that both PSA and DSA models should exist for the suggested studies. It is not within the scope of the EC project to produce PSA or DSA models.

The technical committee will formulate a preliminary proposal based on received suggestions from participants.

All results carried out within the common research project should be a property of all participants within the project. Those of interest for the majority will be chosen.

The EU FP7 project on Advanced Safety Assessment Methodologies: Level 2 PSA (ASAMPSA2) is developing a best practice guideline for PSA Level 2. The final report (in development) includes descriptions on methods and tools that are in the area of combining deterministic and probabilistic approaches and also in Dynamic PSA. ASAMPSA2 project results will be used to support the IDPSA project proposal.

5.2.2 Without EC funding

Without funding from EC the development of IDPSA will continue but with smaller steps. As suggested only half of the suggested projects should be financed via EC. The participants at the workshop though, expressed an interest to create a project even without EC funding, however with a scope related to available funding and in-kind deliveries.

5.2.3 Next actions and time schedule

Actions	Time schedule
A questionnaire will be sent out to all participants and other potential participants. The questionnaire will contain need for information such as: - Expression of interest and contact information; - Description of on-going and planned activities; - Suggestions for pilot application or benchmarks; - Indication of availability of PSA/DSA-models; - Interest for providing or development of IDPSA tools.	2011-10-28
Responses from all interested participants	2011-11-15
Analysis of responses technical committee work meeting	2011-11-23
First draft of proposal	2012-01-13
Proposal finalised	2012-04-01
Project start	Late-2012 – beginning 2013

6 Conclusions

The DPSA workshop gathered a broad group of experts in the fields of PSA and DSA. Many are involved in development of IDPSA methods that can complement these existing methods to cover weaknesses in these methods. Several events in nuclear reactors worldwide indicate that existing methods for safety assessment do not give a correct view of the safety of nuclear power plants.

The workshop described the existing developments in field of safety assessment (methods and tools) in USA and Europe and the potential benefits for reactor safety assessment and the understanding of the safety of nuclear power plants.

There was a clear message from the workshop that there is a need for increased co-operation in Europe (in conjunction with US and Russia) to get a broader understanding of the benefits of using these methods in securing safety margins for existing plants. On-going national program shall be connected to each other by different co-ordination actions.

Based on this understanding the workshop resulted in a common support for developing of a European based program on Integrated Deterministic and Probabilistic Safety Assessment (IDPSA). This will include establishment of

- a network for communication;
- training program;
- benchmarking exercises;
- development of methodologies;
- development of tools;

This will be performed through common projects funded by a large group of European utilities or national program. A first step will be to develop a project proposal to the next EU-call for research projects for fission (in April 2012). The organizer of the workshop is willing to take the lead for this development. A plan schedule for that work was presented at the meeting.

Att. 1. Workshop participants

Technical Committee		
Yvonne	Adolfsson	Scandpower
Göran	Hultqvist	Forsmark/Vattenfall AB
Jan-Erik	Holmberg	VTT
Pavel	Kudinov	KTH
Ilkka	Männistö	VTT
Keynote Speakers		
Tunc	Aldemir	The Ohio State University
Robert	Youngblood	INL
Martin	Zimmermann	PSI
Participants		
Robertas	Alzbutas	Lithuanian Energy Institute
Cilla	Andersson	Ringhals AB
Stefan	Authen	Risk Pilot AB
Klaus-Dieter	Bandholz	ESN Sicherheit und Zertifizierung GmbH
Francois	Beaudouin	EDF
Pascal	Brack	EDF
Valentina	Bredova	SSM
Luciano	Burgazzi	ENEA
Ola	Bäckström	Scandpower
Inessa	Chirman	SSM
Per	Claesson	Vattenfall AB
Etienne	Claus	Tractebel Engineering SA
Vincent	Clochard	AREVA NP SAS
Otso	Cronvall	VTT
Eric	de Geus	NRG
Claude	Faidy	EDF-SEPTEN
Vidar	Hedtjärn Swaling	Scandpower
Juho	Helander	Fortum Power and Heat
Per	Hellström	Scandpower
Javier	Hortal	Consejo de Seguridad Nuclear
Kalle	Jänkälä	Fortum Power and Heat
Ismo	Karppinen	VTT
Christian	Karlsson	Vattenfall AB
Toivo	Kivirinta	Fortum Power and Heat
Tomas	Kliment	VUJE, a.s.

Joakim	Klug	Vattenfall AB
Sergei	Knizhniak	SSM
Heiko	Kollasko	Areva GmbH
Nadezda	Kozlova	SSM
Tomasz	Kozlowski	KTH
Torbjörn	Lindén	Vattenfall AB
Ilkka	Niemelä	STUK
Mirela	Nitoi	JRC
Lovisa	Nordlöf	OKG
Anders	Olsson	Scandpower
Yves	Pellegrinelli	BKW FMB Energie AG
Jari	Pesonen	TVO
Paolo	Picca	ENEA
Jan	Prochaska	VUJE, a.s.
Tommi	Purho	Fortum Power and Heat
Rauno	Rintamaa	VTT
Sean	Roshan	Royal Institute of Technology
Valentin	Rychkov	EDF R&D
Sami	Sirén	Fortum Power and Heat
Thomas	Steinrötter	GRS
Tobias	Szabo	Karlsruhe Institute of Technology
Oleg	Zakharov	SSM

Att. 2. Workshop agenda

Monday October 3, 2011

Time	Title	Presenter
00	Registration	
	Session chair: Jan-Erik Holmberg	
01	Opening of the workshop VTT welcome Meeting logistics	Jan-Erik Holmberg Rauno Rintamaa Ilkka Männistö
02 03	Introduction to the workshop: Meaning of DPSA Meaning of the research agenda	Yvonne Adolfsson Pavel Kudinov Göran Hultqvist
10:00	Coffee break	
04	Keynote speaker: Dynamic Probabilistic Safety Assessment (DPSA) - Methods and Issues?	Tunc Aldemir
05	The link between Defence-in-Depth and PSA	Per Hellström
06	Time uncertainty analysis in the context of deterministic/probabilistic studies	Javier Hortal
12:30	Lunch	
	Session chair: Ola Backstrom	
07	CSN approach to the use of computerized tools for integration of deterministic and probabilñistic safety assessments	Javier Hortal
08	Handling multiple criteria to assess safety benefits of modifications	Beadouin Francois, Pascal Brac
09	Discussion session: Needs for investment and R&D for DPSA	Moderator Göran Hultqvist
15:20	Coffee break	
10	Keynote speaker: A Next-Generation Safety Analysis Code	Robert Youngblood
11	A GA-DPSA Approach to Identification of Safety Vulnerabilities	Pavel Kudinov
12	Discussion session: DPSA tools - state-of-the-art and visions	Moderator Pavel Kudinov
17:45	Adjourn day 1	
19:30	Dinner	

Tuesday October 4, 2011

Time	Title	Presenter
	Session chair: Yvonne Adolfsson	
13	Summary of day 1	
14	Keynote speaker: Can we measure Changes of Safety Margins in Nuclear Power Plants?	Martin Zimmermann
15	PRA as a tool for safety related decision making in Fortum	Kalle Jänkälä
10:20	Coffee break	
16	Applications and Issues of DPSA and Time-dependant Reliability Analysis	Robertas Alzbutas
17	Probabilistic Approach to the Design of a Safety System	Luciano Burgazzi
18	Overview of EDF research in Risk Informed Safety Margins.	Valentin Rychkov
12:30	Lunch	
	Session chair: Pavel Kudinov	
19	Developing a tool for rapid source term prediction (RASTEP)	Vidar Hedtjärn Swaling
20	Keynote speaker: A view of a regulator on application of Dynamic PSA	Wiktor Frid (Pavel Kudinov)
21	Discussion session: Obstacles in putting DPSA into practice	Moderator Jan-Erik Holmberg
14:30	Coffee break	
22	ESREL2011 DPSA session	Tunc Aldemir
23	Discussion session: Tasks for the research agenda	Moderator Yvonne Adolfsson
17:10	Adjourn day 2	
	Preparation of the proposal for the research agenda	Organisation committee

Wednesday October 5, 2011

Time	Title	Presenter
	Session chair: Jan-Erik Holmberg	
24	Summary of day 2	
25	From NULIFE to new legal entity in GEN-II and GEN-III R&D in Europe	Rauno Rintamaa
26	Presentation of a proposal for a research agenda	Organisation committee
10:00	Coffee break	
	Discussion session: Revision of the research agenda Conclusions	Moderator Göran Hultqvist
12:00	Lunch	
13:00	Adjourn day 3	
	Preparation of the proceedings of the workshop	Organisation committee