ASAMPSA_E SEVENTH FRAMEWORK PROGRAMME	Advanced Safety Assessment Methodologies: extended PSA	EURATOM

"NUCLEAR FISSION"

Safety of Existing Nuclear Installations

Contract 605001

Synthesis report of the End-Users survey and review of ASAMPSA_E guidance and final workshop conclusions. Identification of follow-up useful activities after ASAMPSA_E

Reference ASAMPSA_E

Technical report ASAMPSA_E/WP10/D10.5/2017-40

Reference IRSN PSN-RES/SAG/2017-00003

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WP No: 10	Lead topical coordinator : Yves GUIGUENO	His organization name : IRSN

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Title	Synthesis report of the End-Users survey and review of ASAMPSA_E guidance and final workshop conclusions. Identification of follow-up useful activities after ASAMPSA_E
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Reviewer(s)	Yves GUIGUENO (IRSN), Ivan IVANOV (TUS)
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Summary:

The ASAMPSA_E project aims at helping to develop efficiently PSAs methodologies able to identify low probability events or combinations of events which can lead to extreme consequences and at discussing their application in the NPP safety enhancement decision making process.

Seventeen draft reports, related to general issues for extended PSA, selection of hazards and development of PSAs have been written during the main phase of the project. They reflect the expertise and experience available within the project.

Preliminary versions of the reports have been sent for external review together with a final questionnaire.

The objective of the review was to collect proposal for improvements of the preliminary ASAMPSA_E reports while the objectives of the questionnaire was to gather PSA End-Users opinions on the fulfilment of their initial needs, on conclusions and recommendations presented in the reports and on additional needs.

This document presents the responses to the questionnaire and a synthesis of improvements proposed by reviewers.

A draft version has been used to present the responses and feedbacks during an international workshop hosted by Vienna University on 12, 13 and 14 September 2016.

The final version of this document incorporates a synthesis of the discussions during the Vienna workshop.

Visa grid

	Main author(s):	**Verification**	**Approval (Coordinator)**
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SUMMARY

The ASAMPSA_E project aims at helping to develop efficiently PSAs methodologies able to identify low probability events or combinations of events which can lead to extreme consequences and at discussing their application in the NPP safety enhancement decision making process.

Seventeen draft reports, related to general issues for extended PSA, selection of hazards and development of PSAs have been written during the main phase of the project. They reflect the expertise and experience available within the project.

Preliminary versions of the reports have been sent for external review together with a final questionnaire.

The objective of the review was to collect proposal for improvements of the preliminary ASAMPSA_E reports while the objectives of the questionnaire was to gather PSA End-Users opinions on the fulfilment of their initial needs, on conclusions and recommendations presented in the reports and on additional needs.

This report presents the responses to the questionnaire and a synthesis of improvements proposed by reviewers for each deliverable of the project as agreed during an international workshop hosted by Vienna University on 12, 13 and 14 September 2016. It also presents a general evaluation of the project deliverables from the point of view of PSA End-users, and identifies areas for follow-up activities.

"Lessons of the Fukushima Dai-ichi accident for PSA - Technical report ASAMPSA_E / WP30 / D30.2 / 2015-08"

Almost all respondents consider that lessons identified in the report are relevant. However, one respondent does not support the positions given in the report on several issues and other respondents/reviewers also identify additional lessons.

Workshop outcomes and recommendations were the following:

TEPCO engineers have reminded that before the Fukushima Dai-ichi accident, the probability that a tsunami exceeds 10 m was 10^{-6}/y and decision to reinforce the existing protective walls was not taken.

(1) Consider all reviewers' comments (questionnaire answers, comments in the report)

(2) ASAMPSA_E should clearly state that high amplitude natural hazards (possibility correlated) are associated with low frequency with high uncertainties. In that context, solution to address the risk is not necessarily PSA development (quantitative results may be highly uncertain and difficult to use). The ASAMPSA_E project should indicate some other paths for the utilities (with no complex PSA development): for example, direct NPP reinforcements to protect the plant against postulated events, which frequency is not the crucial issue (it shall be recognized that it can happen in adverse circumstances)

(3) For natural hazards, ASAMPSA_E should emphasise the importance of periodic update of the initiating events to be considered

(4) Modify the wording of the D30.2 report which gives too much importance on the PSA capacity to identify problems (in general, PSA cannot exceed experts' knowledge which is for rare events (natural hazards) not sufficient)

(5) Check the report on passive system: during Fukushima Dai-ichi accident, it was a chance that the steam driven pumps operates "passively" - with DC current - during 2-3 days

(6) Emphasize limitations of the PSAs methodology in this report. Remind that PSA is a part of more global system that contributes to the safety.

"Risk Metrics and Measures for an Extended PSA - Technical report ASAMPSA_E / WP30 / D30.5 / 2016-17"

Concerning the list of risk metrics presented in the report, respondents and reviewers considered that it is globally relevant. It should be completed by adding a metric related to Early Loss of Containment Function and investigations on the current actual use of risk measures.

For multi-unit PSAs, the report should explicitly explain the impacts of Inter-units CCF and Risk integration process.

Concerning limitations and applicability, guidance should be given on how to restrict the use of risk metrics when all data and parameters are not best estimate with similar and low uncertainty band.

Recommendations related to risk metrics for an extended Level 1 PSA are globally agreed while feedbacks on risk metrics for extended Level 2 PSAs are less consensual (7/12 respondents agreed with the recommendations on risk metrics for L2 PSAs; 5/12 disagreed).

Workshop recommendations

(1) Consider all reviewers' comments

(2) Clarify in the report if extended PSA needs new risk metrics

(3) Comment more the link between risk metrics and multi-units PSA, with the perspective of RIDM applications.

(4) Keep the notion "early" and "late" in the risk metrics

(5) Check the vocabulary "severity metrics"

(6) Comment the link between risk metrics and uncertainties (see discussion on huge uncertainties for rare natural hazards)

(7) Complete the rapports with the notions of "integrated PSA" and "separated PSA" (separated PSA if IE uncertainties are very high ???)

(8) Add a chapter that explains that the use of risk metrics is developed in the RIDM report (for example risk metrics for relative comparisons of design options)

(9) Explain better the interest for non-core melt accident + containment failure

(10) Add risk metric for seasonal effects

(11) Clarify the wording CDF with core damage or with no core damage (contradiction to be solved)

(12) For RIDM report: quality of PSA can be verified, mainly thanks to benchmarks / comparison / per review

(13) Check if the numerical value proposed for RMF (1 TBq) is relevant: if too low, all accidents shall be considered

(14) Give a clear ASAMPSA_E position on CRT metric. Take into account the uncertainties of rare events frequency which makes doubtful the integral metrics approach

(15) Comment the interest to have one metric for L2 PSA that could be the equivalent to CDF for L1 PSA.

Follow-up activities identified during the workshop:

(1) Comparison of risk metrics applications at international level.

"The PSA assessment of Defense in Depth – Memorandum and proposals - Technical report ASAMPSA_E / WP30 / D30.4 (support material) / 2016-15" (report 1)

Although three quarters of respondents consider that the document constitutes a relevant support material, two-thirds consider that PSA studies should not be restructured accordingly. Interest and feasibility of the approach have to be investigated.

Workshop conclusions:

(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation in Excel by WP10, comments in the report)

(2) Keep this report separately from the D30.4 deliverables

(3) Add reference to the EU council directive 2014 (the concept of DiD is fundamental, …., art 8b)

(4) Modify the title of the report: add "investigation" and precise in the text that the objective of the report is related to "investigation"

(5) Add example of OJT applications (JANSI for Japan reactors)

(6) Take into account reviewers comments and IRSN comments (at the end of the report).

"The PSA and Defense in Depth concept" -Technical report ASAMPSA_E / WP30 / D30.4 / 2016-26" (report 2)

Three quarters of respondents consider it give adequate information on the use of PSA to support assessment of defense in depth. However, only half agree with the approach proposed in the report.

Workshop conclusions:

(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation in excel by WP10, comments in the report)

(2) Agglomerate the different positions and propose activities for the future

(3) Consider the following question: how to prove as far as possible DiD application?

(4) Discuss deterministic approach / application of existing/classical PSA and benefit of restructured PSA (for DID implementation application).

Follow-up activities identified during the workshop:

(1) Available methodologies to demonstrate that DiD is appropriately implemented.

"Recommendations on Extended PSA and its Use in Decision Making - Technical report ASAMPSA_E / WP30/D30.6/2016-28"

This document was a preliminary report. Few answers and reviewers' feedbacks have been received for this document. Answers and comments point out that improvements are required to obtain adequate and commonly accepted guidance. In particular, main risk-informed applications need to be described as well as numeric values of acceptability criteria or targets used in RIDM.

Workshop recommendations:

(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation in excel by WP10, comments in the report)

(2) The future report D30.7 shall be a very different version from D30.6 to reflect all reviewers' comments and discussions during the workshop:

- Remind the PSA applications RIDM
- Comment the impact of extended PSA
- Comment the uncertainties issues of rare IE frequency and the link with PSA development
- Comment the PSA criteria to be used for multi-unit site

(3) Contact IAEA to be informed on draft standards/TECDOC that could be referenced in the ASAMPSA_E report (coordinator)

(4) It is recommended to consider a TECDOC report on DEC approach: Assessment of Vulnerabilities of Operating Nuclear Power Plants to Extreme External Events. The draft report has been provided to the workshop participants.

Follow-up activities identified during the workshop:

(1) RIDM and extended PSA will need further exchanges of information at international level.

"List of external hazards to be considered in ASAMPSA_E - Technical report ASAMPSA_E / WP21 / D21.2 / 2015-10"

Almost all respondents consider that the lists of natural and man-made external hazards are exhaustive and that hazards combinations have been correctly identified. The report covers all types of hazards cited in documents by IAEA and WENRA-RHWG and the recommended 10 most important external hazards for the End-users. It could be mentioned that the list of hazards is quite detailed and it is difficult to be reflected in the screening analysis. The Cross-correlation chart for combinations of hazards is not fully filled.

As open issues should be indicated the lack of methods for assessment of hazard combinations, with the exception of methods proposed in some topical reports.

Workshop recommendations:

(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation in excel by WP10, comments in the report).

(2) Separate extreme temperature in extremely cold temperature and extremely warm temperature (due the very different type of impacts).

(3) Comment the link between the hazards to be considered in PSA with the design IE (and their amplitude)

In real case, a limited number of external hazards have to be considered. This should be explained in the report and also the global process: complete list ⇒ a selection for one site ⇒ an aggregation of hazards which have similar impact ⇒ screening ⇒ final list for PSA.

(4) Add comments for the assessment of correlated hazards. It seems that the highest importance and difficulty is for extreme weather conditions (see the real events report - D10.3). Insist more on the importance of the correlations with internal hazards which are risk significant.

Workshop recommendation for follow-up activities:

(1) A project of method for hazards combination modelling could be built for some specific examples (extreme weather correlated events seem to be a good candidate).

"Methodology for Selecting Initiating Events and Hazards for Consideration in an Extended PSA – Technical report ASAMPSA_E / WP30 / D30.3 – 2016-13"

Based on the questionnaire and review, it was concluded that:

- The report presents some good examples and discussions of practices for selection;
- Guidance for screening criteria application based on examples is needed;
- Screening phase should be associated with a cliff-edge effect analysis for the quantitative criteria;
- Application of the qualitative and quantitative screening criteria to correlated hazards is needed;
- Application of qualitative and quantitative screening criteria to multi-source scenarios (with distinct reference to spent fuel pool) is needed;
- Discussions on the uncertainties treatment needed;
- The compliance of document with end-user recommendations should be checked.

The recommendations to achieve the report as agreed during the Vienna workshop are the following:

(1) Consider all reviewer's comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation in excel by WP10, comments in the report).

(2) Introduce a discussion on the structure of PSA: separated models for each external hazard or a fully integrated PSA model

(3) Try to explain better how to do a bounding analysis (such analysis is supposed to be simple in the context of screening)

(4) Give 2 definitions of the screening objective: to identify the most important hazards that contribute to the risks or to identify the hazards for which it is useful to develop a PSA (EDF approach shall be summarized)

(5) Explain what is the difference between the screening criteria proposed in the report and other criteria commonly applied in countries

(6) Add screening criteria based on IE frequency and comment its appropriateness (see EDF comments)

(7) Recommend to add some warning in PSA summary report on what has been screened out

(8) Comment the link between screening criteria and uncertainties on the frequency of external events

(9) Check the consistency with all topical reports for screening criteria

(10) Consider, in the screening methodology, the impact of external hazards on non-safety system and secondary effects.

Workshop proposal for follow-up activities:

(1) Benchmark on the importance of non-safety system and secondary impacts in external hazards assessment.

"Review of existing practices to model and implement SEISMIC hazards in extended PSA - Technical report ASAMPSA_E / WP21 / D21.3-1 / 2016-27"

Workshop recommendations to achieve the report:

(1) Consider all technical remarks in the questionnaire answers. Consider comments provided directly by IRSN expert (O. Scotti)

(2) Modify the report title to limit confusion with WP22 report

(3) Modify the organisation of the references (to be done by topic, with a number)

(4] Explain what is hazard desagregation (identify which source has the most impact ...)

(5) Explain how temporal signals that are representative for seism class can be elaborated (see with IRSN for practical example from UHS)

(6) Add a chapter on site effect modelling

(7) Explain in the report that a new tendency is now coming: industry starts to apply physical modelling of fault rupture; the softwares can be validated on real events and open as an alternative to the statistical/historical data: check that the report gives enough information on the technics available to identify active faults in the vicinity of a NPP.

Workshop proposal for follow-up activities:

(1) Aftershocks modelling (probabilities of occurrence, amplitude …)

(2) Application of fault rupture modelling for PSA.

"Report 1: Guidance document - Implementation of SEISMIC hazards in Extended Level 1 PSA - Technical report ASAMPSA_E / WP22 / D22.2-3 report1/ 2016-19"

Workshop recommendations to achieve the report:

(1) Consider all technical remarks in the questionnaire answers

(2) There are so many technical comments that VUJE propose to organize a brief workshop in Slovakia to improve the report with the 5 or 6 main reviewers, based on an updated version of the report. Such an approach has been considered as very good by the workshop participants

(3) Add examples for fragility analysis ("classical approach" or more advanced using temporal signal - IRSN will provide an example of research in this area). In general help of experts involved in structural analysis will be welcome here

(4) Introduce the concept of graded/simplified approach (with the help of EDF) and discuss its validity

(5) Propose a set of recommendations in the next version of the report for approval by the project partners

(6) Comment statement: in general, the ASAMPSA_E project reports shall indicate what shall be examined in the context of extended PSA and promote pragmatic solutions that make the work easy (a minima feasible) for the industry.

Workshop proposal for follow-up activities:

(1) Specific method to calculate the probability of fire induced by earthquakes.

"Report 2: Review of existing practices to model and implement FLOODING hazards in extended PSA - Technical report ASAMPSA_E / WP21&22 / D21.3-3 &-D22.2-3 report2/ 2016-20"

The report gives a good and detailed state of the art of practices giving a sound basis for modelling of flooding events and their consequences. However, it focuses on very detailed PSA developments and some parts will need to be improved / completed as the methodologies are still under development.

The recommendations to achieve the report as agreed during the Vienna workshop are given below:

1) Consider all technical remarks in the questionnaire answers (see INR synthesis, Excel WP10 answers compilation and in the report review)

(2) The report will be completed to introduce in appendix the concept of "graded approach". EDF will provide a summary of its own definition

(3) A hierarchy of the most important issues to be analyzed in a flooding PSA will be proposed: IE frequency assessment, protection failure, etc.
(4) The consistency between screening criteria presented in this report with those given in D30.3 will be checked
(5) The importance of non-safety system (ventilation ducts as water path,), how the operator close the doors, the doors tightness, etc. will be discussed in the report.

Ideas of follow-up activities as agreed during the Vienna workshop are given below:
(1) Multi unit issues
(2) Combination of hazards assessment and modelling
(3) Uncertainties in the assessment of flooding event frequency for the different causes
(4) Assessment of SSCs fragilities for flooding (e.g.: water propagation modelling).

"Report 3: Guidance document - Implementation of EXTREME WEATHER hazards in extended PSA - Technical report ASAMPSA_E / WP22 / D22.2-3 report3/ 2016-21"

Most of active End-users consider that the report provides adequate guidance on extreme weather hazards assessment methodologies and implementation in PSA and agree with its conclusions / recommendations. However, some improvement needs have been identified.

The recommendations to achieve the report as agreed during the Vienna workshop are given below:
(1) Consider all technical remarks in the questionnaire answers (see SSTC synthesis, Excel WP10 answers compilation and in the report review)
(2) It appears from the review that the report does not provide any recommendations for the assessment of combinations of hazards. It is highly recommended that the partners involved in WP21 complete the report and make the links with the geoscience community activities. This was one objective of the project and explains why ASAMPSA_E has done effort towards EGU conference. During the WS, it was explained that single hazards were appropriately assessed but not the combined ones, which is absolutely NOT APPROPRIATE in a risk assessment study. The report has to be completed to explain the gap that exist between what scientific are doing and the need
(3) Credibility of data: ENSI explains that extreme weather studies were done in Switzerland but credibility of values is questionable. Forsmark requests to explain in ASAMPSA_E what shall be done when high uncertainties exist on numerical value of PSA data. JANSI explains that in that case sensitivity analysis can be done and that PSA numerical results are not so important. It is highly recommended to modify this ASAMPSA_E report (and other) in that sense: when reliable numerically cannot be obtained, then the PSA development may not be an appropriate solution for risk assessment/management. More straightforward approach (including sensitivity analysis and plant reinforcement feasibility) can be preferred
(4) Strategic views: the PSR approach /periodic update of meteorological data/climate change impact management shall be introduced in the report. It is suggested to distinguish between new NPP (reinforcement shall in theory not be needed if the design is appropriate) and old NPP (we know many NPPs have to be reinforced). Nevertheless, it is argued that on a new site, all events cannot be predicted in advance (?)
(5) Fragility analysis: it is recommended to improve the information on fragility analysis in the report (for example SSC behaviour at very hot temperature)

(6) It is recommended to consider a TECDOC report on DEC approach: Assessment of Vulnerabilities of Operating Nuclear Power Plants to Extreme External Events. The draft report has been provided to the workshop participants.

Open issues for follow-up activities as agreed during the Vienna workshop:

(1) Applicable methodologies to predict extreme weather conditions obviously need further research activities, especially on combined extreme weather events

(2) Considering the slow progress in this area and the limited reliability of data for PSA, PSA cannot be a recommended approach and alternative approach shall be preferred for risk identification and management. This may need some further clarification.

"Report 4: Guidance document - Implementation of BIOLOGICAL INFESTATION hazards in extended PSA - Technical report ASAMPSA_E / WP21 & WP22 / D21.1 & D22.1 / D22.2-3 report4/ 2016-22"

Most of active End-users consider that the report provides adequate guidance on biological infestation hazards assessment methodologies and implementation in PSA. Almost all respondents agree with its conclusions / recommendations. However, some improvement needs have been identified:

- what is described in the report needs to be made more specific to biological infestation hazards;
- combined/correlated hazard scenarios should be more developed;
- multi-source scenarios should be more developed (with distinct reference to spent fuel pools);
- more considerations on uncertainties specific to biological hazard is necessary;
- providing examples of assessments may be useful, if feasible.

The recommendations to achieve the report as agreed during the Vienna workshop are the following:

(1) Consider all technical remarks in the questionnaire answers (see WP10 synthesis, Excel WP10 answers compilation) and in the report review

(2) Provide examples in the report, in particular for LUHS and make the link with D10.3 (real external events)

(3) For a new site, it may be difficult to predict in advance which biological infestation event can occur

(4) Remind that PSA is not the only things to do to reinforce plant safety.

Proposal for follow-up activities as agreed during the Vienna workshop:

(1) Organize a benchmark on existing PSA with regard to LUHS: risk quantification and UHS design comparison (with backfiring examples).

"Report 5: Guidance document - Implementation of LIGHTNING hazards in extended PSA - Technical report ASAMPSA_E / WP21 & WP22 / D21.1 & D22.1 / D22.2-3 report5/ 2016-23"

Most of active End-users consider that the report provides adequate guidance on lightning hazards assessment methodology and a majority of respondents consider it provides adequate guidance for implementation in PSA.

The recommendations to achieve the report as agreed during the Vienna workshop are the following:

(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation by WP10, comments in the report)

(2) Find additional contributors able to complete/improve the report (TUS and VUJE are the main contributors, this is not sufficient on this topic)
(3) Complete the report with Forsmark experience as presented during the Uppsala workshop (many NPP modifications, link with the low power system, ...)
(4) Recognize in the report the difficulty to identify failures scenarios for a NPP, induced by lightning impact, position the topic and discuss how to handle it.

Proposal for follow-up activities as agreed during the Vienna workshop:
(1) In relation with PSA activities (or RIDM) discuss calibration of lightning protections and compare protections solution in different area (data server -e.g. google, military applications, communication devices, airplane traffic, ...).

"Report 6: Guidance document - MAN-MADE hazards and ACCIDENTAL AIRCRAFT CRASH hazards modelling and implementation in extended PSA - Technical report ASAMPSA_E / WP21 & WP22 / D21.3 & D22.2-3 report6/ 2016-24"
Most of active End-users consider that the report provides adequate guidance on man-made hazards and accidental aircraft crash assessment methodologies and implementation in PSA, agree with its conclusions / recommendations and find it useful for their activities. However, one respondent (Forsmark) does not support recommendations to add assessment of air-craft crashes into the common PSA. Open issues seem to be mainly related to aircraft crash, it is necessary to have something specific to man-made hazards in general.

The recommendations to achieve the report as agreed during the Vienna workshop are the following:
(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop , questionnaire answers and their compilation in excel by WP10, comments in the report)
(2) Consider NEI 07-13 Methodology aircraft Impact assessment for new plant design
(3) Include Koeberg NPP experience in the report (proposed by EDF that can contact them)
(4) In the recommendations: discuss in an open way the need to develop an aircraft crash PSA (depend from one site to the other - see airplane traffic) and identify open issues for man-made hazards.

"External Events in L2 PSA - Technical report ASAMPSA_E/WP40/D40.4/2016-14"
Most of active End-users consider that the report provides adequate guidance regarding implementation of external hazards into Level 2 PSA and agree with its conclusions / recommendations. Proposal for a L2 PSA for multi-unit site seems interesting but needs further developments

The recommendations to achieve the report as agreed during the Vienna workshop are the following:
(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation in excel by WP10, comments in the report)
(2) Promote "graded" approach for the development of L2 PSA for external events
(3) Introduce the discussion on low quality data for rare IE events (natural hazards) and how it should be considered for L2 PSA development (shall we exclude such IE from L2 PSA?, how to be consistent in risk metrics applications? Shall ASAMPSA_E promote full-scope integrated PSA (all IE in one PSA) or promote separated PSA (one PSA for each type of IE, to avoid mixing situations with different quality in IE data))
(4) Comment more precisely the choice to be done between L1-L2 integrated or separated methodologies in the context of external hazards.

Workshop thinking for follow-up activities:
(1) It appears that a limited experience in external IE L2 PSA exists. This topic shall be considered later for international cooperative actions.

"Guidance on the verification and improvement of SAM strategies with L2 PSA - Technical report ASAMPSA_E / WP40 / D40.5 / 2016-16"
Most of active End-users consider that the report successfully covers the topic and agree with its conclusions / recommendations.

The recommendations to achieve the report as agreed during the Vienna workshop are the following:
(1) Take into account the reviewers' comments
(2) ENSI proposes to provide information for H2 management on Switzerland NPPs (the Authors shall contact ENSI)
(3) Add risk of excessive pressure peak in the containment in case of RCS content blow-down
(4) Complete the reports for BWRs SAM (the author shall contact FKA)
(5) Complete the report with details on the FLEX approach (example of application Slovenia, Spain, in addition to US - the authors shall contact JSI and IBERDROLA)
(6) Remind that research shall be promoted where uncertainties are too high
(7) Complete the report on equipment qualification issues.

The following issues have been identified and agreed during the Vienna workshop for follow -up actions:
(1) Practices exchanges on SA qualification: which environmental conditions shall be defined,
(2) Implementation of FLEX strategy and link with L2 PSA
(3) Dry spent fuel storage risk assessment.

"Complement of existing ASAMPSA2 guidance for shutdown states of reactors, Spent Fuel Pool and recent R&D results - Technical report ASAMPSA_E / WP40 / D40.6 / 2016-25"
Most of active End-users consider that the report successfully covers the topic and agree with its conclusions / recommendations. Improvement needs have been pointed out. In particular, It would be preferred to get some suggestions / propositions on the fission product release (from SFP) assessment, given the fact that the calculation codes are not always of satisfying performance regarding this. Section 4 is not enough complete and not quite up-to-date: additional R&D related information should be provided.

The recommendations to achieve the report as agreed during the Vienna workshop are the following:
(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation in excel by WP10, comments in the report)
(2) Provide some order of magnitude of Source term assessment in case of SFP accident and explanation on the technical basis to be used, describe better the accident progression in case of SFP accident
(3) Complete the application of PSA with Forsmark experience: yearly application of PSA for each outage: risk management for the operations to be done depending on which system is (un)available during outage
(4) For integral codes to be used for source term assessment, complete the information available on ASTEC by information equivalent for MAAP and MELCOR
(5) Provide information from the AIR-SFP project (this should end in September 2016)
(6) Indicate in which condition the spent fuel can be cooled with air circulation (contact NRG which has performed recently an assessment)
(7) Contact SARNET management board for the complements to be added on recent R&D results
(8) Indicate additional specific SFP configurations example (e.g. 2 SFP in a same reactor hall - VVER440).

Proposal of issue for follow-up actions agreed during the Vienna workshop:
(1) Which conditions allow SFP stabilization in case of accident?

General evaluation and follow-up activities

Most of active End-users consider that overall documentary structure is suitable and intend to use the project deliverables. However, some End-users comments underline that reports could be considered as state-of-the-art review rather than guidance for industrial applications. Answers also highlight that some End-users expectations have not been treated or with an unsufficient level of details; the most often mentioned issues are the following: methodology for simultaneous accident progression in core and SFP, the level of conservatism (same level in all PSA parts …?), how to include mobile equipment in PSA, how and when "seasonal PSA (winter/summer)" must be developed? It might be interesting to address these issues in future activities.

In addition to issues identified in previous paragraphs, respondents have also mentioned the following areas for follow-up activities: treatment of uncertainties for combination of external hazards, rare events; methodologies for multi-unit sites L1-L2 PSA; modelling long-lasting accident progression; PSA for internal hazard, mainly fire; HRA issues; assessment of releases into waters and ground and related source term characteristics; risk aggregation; risk-informed decision process and PSA model capability; best practice to use PSA, interpret and present the results; PSA modelling for DiD assessments. In the event of a new proposal, respondents would be interested to participate again.

CONTENT

GLOSSARY

CERP	Conditional Early Release Probability
CLRP	Conditional Large Release Probability
COG	CANDU owner's group
DID or DiD	Defense in Depth
EPZ	Emergency planning zone
ET	Event tree
EVA	Extreme Values Analysis
FMEA	Failure mode and effects analysis
FMECA	Failure mode, effects, and criticality analysis
SGTR	Steam Generator Tube Rupture
HCLPF	High Confidence, Low Probability of Failure
HEP	Human error probability
HRA	Human reliability analysis
HVAC	Heating, Ventilation and Air-Conditioning
IE	Initiating event
INPO	Institute of nuclear power operation
LOD	Line Of Defense
LOP	Line of Protection/Layers of Provisions
LPSD	Low power and shut down
LUHS	Loss of ultimate heat sink
OPT	Objective Provision Tree
OSY	Outdoor switchyard
PDS	Plant damaged state
PSR	Periodic safety review
SBO	Station black out
SD	Shut down
SFP	Spent fuel pool
TSO	Technical support organization
UHRS	Uniform Hazard Response Spectrum
WANO	World Association of Nuclear Operators

1 INTRODUCTION

1.1 PRESENTATION OF THE REVIEW AND QUESTIONNAIRE

Initiated after the Fukushima Dai-ichi nuclear accident, the ASAMPSA_E project aims at helping to develop efficiently PSAs methodologies able to identify low probability events or combinations of events which can lead to extreme consequences and at discussing their application in the NPP safety enhancement decision making process in the European context. The nuclear accident in Japan resulted from the combination of two correlated extreme external events (earthquake and tsunami), and its consequences (flooding in particular) went beyond what was considered in the initial NPP design. If the performance of a Level 1-Level 2 PSA concludes that such a low probability event can lead to extreme consequences, the industry (system suppliers and utilities) or the Safety Authorities may take appropriate decisions to reinforce the defense in depth of the plant.

For this purpose, the ASAMPSA_E project has developed some guidance reports for the development and application of PSA in that context. The project has also provided a framework where specialists of geosciences (earthquake, flooding ...) and specialists of PSAs can work together.

The definition of an extended PSA, which constitutes the object of the project, has been proposed as follows:
An extended probabilistic safety assessment (PSA) applies to a site of one or several Nuclear Power Plant(s) (NPP(s)) and its environment. It intends to calculate the risk induced by the main sources of radioactivity (reactor core and spent fuel storages, other sources) on the site, taking into account all operating states for each main source and all possible relevant accident initiating events (both internal and external) affecting one NPP or the whole site.

During the first phase of the project, some End-Users' needs have been collected and have resulted in 62 recommendations for the project (Appendix 1).

Seventeen draft reports, related to general issues for extended PSA, selection of hazards and development of PSAs have then been written during the main phase of the project. They reflect the expertise and experience available within the project.

Preliminary versions of the reports have been sent for external review together with a final questionnaire. The list of preliminary reports submitted to the review and concerned by the questionnaire is the following.

General issues for PSA

- *Lessons of the Fukushima Dai-ichi accident for PSA*
- *Risk metric for extended PSA*
- *Link between extended PSA and defense-in-depth concept*
- *Guidance for decision making based on extended PSA*

Selecting hazards for PSA

- *List of external hazards to be considered in ASAMPSA_E*
- *Criteria to select initiating events to be considered in an extended PSA*

Developing PSA

- *Guidance documents on practices to model and implement*
  - *EARTHQUAKE hazards in extended PSA*
  - *FLOODING hazards in extended PSA*
  - *EXTREME WEATHER hazards in extended PSA*
  - *BIOLOGICAL hazards in extended PSA*
  - *LIGHTNING hazards in extended PSA*
  - *MAN-MADE HAZARDS AND AIRCRAFT CRASH in extended PSA*
- *Implementation of external events modeling in extended L2 PSA*
- *Optimization of SAMG strategy by L2 PSA*
- *Complement of existing ASAMPSA2 guidance for shutdown states of reactors, spent fuel pool and recent R&D results.*

The objective of the review was to collect proposal for improvements of the preliminary ASAMPSA_E reports while the objectives of the questionnaire was to gather PSA End-Users opinions on the fulfilment of their initial needs, on conclusions and recommendations presented in the reports and on additional needs.

This document presents the responses to the questionnaire and a synthesis of improvements proposed by reviewers.

A draft version has been used to present the responses and feedbacks during an international workshop hosted by Vienna University on 12, 13 and 14 September 2016.

The final version of this document incorporates a synthesis of the discussions during the Vienna workshop.

1.2 INFORMATION ABOUT RESPONDENTS

1.2.1 LIST OF RESPONDENTS

The list of the 20 organizations, who have answered the questionnaire, is presented in the following table.

Table 1 - List of respondents

	Organization	**Country**
1	AREVA(*)	Germany
2	BEL V(*)	Belgium
3	EDF(*)	France
4	ENSI	Switzerland
5	FORSMARK(*)	Sweden
6	INRNE(*)	Bulgaria
7	IRSN(*)	France
8	JANSI(*)	Japan
9	JSI(*)	Slovenia
10	KAERI	Korea
11	LEI(*)	Lithuania
12	NIER(*)	Italy
13	Risk Pilot AB	Finland
14	RATEN ICN(*)	Romania
15	STUK	Finland
16	SSTC NRS(*)	Ukraine
17	TRACTEBEL Engineering(*)	Belgium
18	TUS(*)	Bulgaria
19	VUJE(*)	Slovakia
20	ZAPORIZHZHYA NPP	Ukraine

Organizations marked with (*) are partners of the ASAMPSA_E project.

1.2.2 ACTIVITIES OF RESPONDENTS

The activities of the respondents are the following:

- 12 PSA developers/practitioners (7 are also PSA reviewers),
- 13 PSA reviewers,
- 6 hazards specialists,
- 6 other end-users.

1.3 METHODOLOGICAL ASPECTS

Given the number and state of the preliminary reports, and as it has been suggested in the questionnaire, respondents have given priority to reports they considered important for their activities or for which they have expertise.

As a result, the number of answers to the questionnaire and contributions to the review vary from one report to another one and is relatively low. Answers are nevertheless sufficient to outline End-Users' opinion related to the preliminary reports and identify their expectations for the final version.

The number of reviews received for each report is presented in the table below.

Table 2 – Reviews of preliminary reports

General issues for PSAs	
Lessons of the Fukushima Dai-ichi accident for PSA	5 reviews
Risk metric for extended PSA	6 reviews
Link between extended PSA and defense-in-depth concept	6 reviews
Guidance for decision making based on extended PSA	1 review
Selecting hazards for PSA	
List of external hazards to be considered in ASAMPSA_E	4 reviews
Criteria to select initiating events to be considered in an extended PSA reviews	5 reviews
Developing PSA	
EARTHQUAKE hazards / implementation in extended PSA	3/7 reviews
FLOODING hazards in extended PSA	2 reviews
EXTREME WEATHER hazards in extended PSA	7 reviews
BIOLOGICAL hazards in extended PSA	2 reviews
LIGHTNING hazards in extended PSA	3 reviews
MAN-MADE HAZARDS AND AIRCRAFT CRASH in extended PSA	2 reviews
Extended L2 PSA	4 reviews
Optimization of SAMG strategy by L2 PSA	3 reviews
Complement of existing ASAMPSA2 guidance for shutdown state, spent fuel pool and recent R&D results	2 reviews

The different topics addressed in the questionnaire are considered in the same order in the following sections. For each report, the following aspects have been assessed:

- answers to the questionnaire,
- feedbacks from reviewers,
- synthesis.

2 QUESTIONNAIRE ON TECHNICAL REPORTS

2.1 GENERAL ISSUES FOR PSA

2.1.1 LESSONS OF THE FUKUSHIMA DAI-CHI ACCIDENT FOR PSA

Report on "Lessons of the Fukushima Dai-ichi accident for PSA - Technical report ASAMPSA_E / WP30 / D30.2 / 2015-08" identifies some lessons learned from the Fukushima Dai-ichi accident for PSA. Based on the public information on the causes that have led to major radioactive release during the Fukushima Dai-ichi accident (initiating events, material and human response), the authors, ASAMPSA_E WP30 members, have performed a review to examine the gaps/insufficiencies/incompleteness in the existing L1 and L2 PSAs. The consideration of external initiating events for the different levels of defense-in-depth is one of the focal points in this review. Recommendations on the way of developing the different components of PSAs are proposed by the authors in order to be taken into account by the ASAMPSA_E project. Moreover, first recommendations on the use of PSA information in decision making have been included as well.

The report concludes that:

- More importantly, although the tsunami hazard was considered both in the site evaluation and design of the Fukushima Dai-ichi NPPs, the related risk was underestimated;
- In view of Fukushima Dai-ichi accident, the existing (Level 1 and Level 2) PSAs for NPPs manifest specific insufficiencies about the identification of rare events and their combinations;
- Where the results of engineering judgement, deterministic and probabilistic safety assessments indicate that combinations of events could lead to anticipated operational occurrences or to accident conditions, such combinations shall be considered in the PSA in principle;
- The screening process shall be established in a way that ensures that no relevant risk contributor is omitted;
- Similarly, PSA Level 1 end states at the interface to the PSA Level 2 should be transferred to and treated within Level 2. Specifically, PSA Level 1 states with containment failure prior to core damage, e.g. due to impacts of hazards, should routinely be transferred;
- During the development of accident sequence models for a PSA and for reliability assessments of systems, components, and operator actions, best estimate boundary conditions should be used to the extent practicable;

- The probabilistic assessment of emergency operating procedure (EOP) and any accident management procedures/measures should systematically consider accessibility and operability of equipment as well as feasibility of measures in case of hazard impacts;
- Another important field is the assessment of human reliability (HRA) for the purposes of PSA; HRA needs to include a more comprehensive and realistic assessment of the effect of hazards on human performance;
- PSA models for multi-unit sites should systematically include relevant dependencies on the systems levels, e.g. via shared support systems or buildings, as well as dependencies on the accident sequence level, e.g. via the impact of a severe accident in one unit on measures or systems in another unit, into their PSA models. In addition, shared staff resources, mobile equipment, etc. have to be considered;
- Another important challenge in light of the Fukushima Dai-ichi accident pertains to the assessment of the adequacy of DiD;
- The insights in this report confirm that safety related decision making should be made within in risk-informed context, encompassing deterministic, probabilistic and other information;
- Risk-informed decision making should consider the risk profile of the plants based on sets of PSA risk measure/metrics for Level 1 and Level 2, which are understood and presented as uncertainty distributions;
- In summary, the Fukushima Dai-ichi accident justifies the basic assumption of the ASAMPSA_E project of extending the scope of PSA to include all operating modes, all events and hazards, and all relevant potential sources like e.g. the spent fuel pool.

2.1.1.1 Answers to the questionnaire

Q1 - Do you consider that the lessons of the Fukushima Dai-chi identified in the report are relevant?

Yes / Total non-blank answers	**No** / Total non-blank answers
13 / 14	**1** / 14

If not, please specify which ones and why. Synthesis of answers:

"Forsmark has in a separate report attached to this questionnaire specified his view of the relevance of the D30.2-report. On several issues we do not support the positions given in the report. On other topics we ask for complementary basis for being able to develop conclusions/recommendations" (Forsmark). See Appendix 2.

If you have identified additional lessons, please develop them.

"The report is globally excellent.

Some statements seem questionable and some formulations are ambiguous; this can lead to misinterpretations by an external reader (see the proposed corrections in the text).

Important information could be added. For example it is important to emphasize that the implementation of passive systems should not be accompanied by procedures that set out the regulation of these systems. In

Fukushima Dai-ichi this was the case of the Isolation Condenser of the reactor No. 1 whose failure, caused by the loss of control of its operation, would not have happened if the above principle, namely the non-regulation of a passive system, had been respected. The document mentions several times the requirement for an assessment of the implemented defense in depth but does not stress enough the fact that the essential condition for making this assessment is to have available and, as far as feasible, exhaustive representation of the safety architecture with a structure compatible with the principles of defense in depth. In addition, it should be noted that this representation is in fact an essential input data for the PSA. Similarly, the requirement of integration of support systems and the role of operators, highlighted in the text, requires that these provisions are adequately integrated into the safety architecture. Some specific issues are raised in the text with proposals for the reformulation of the corresponding paragraphs" (NIER)

"It should be clearly emphasized that nuclear plants should be capable to survive in case of station black-out (passive systems or diesel driven pumps or reliable steam driven pumps or some other electrically independent equipment)." (STUK)

"According to the conclusions in paragraph 4.2.2 of the technical report "ASAMPSA_E/WP30/D30.2/2015-08" the risk of hydrogen detonations or deflagrations should be investigated systematically. However, other combustible gases, such as carbon monoxide, which can be produced during molten core-concrete interactions, may also impose potential threat to hermetic containment integrity. Therefore it is recommended to indicate in 4.2.2 of "ASAMPSA_E/WP30/D30.2/2015-08" technical report that the potential risk from all combustible gases detonation or deflagration should be investigated systematically. See for example paragraph 3.64 of NS-G-2.15 "Severe Accident Management Programmes for Nuclear Power Plants" that indicates the necessity to control concentration of combustible gases (without limiting the analysis to hydrogen only)." (SSTC NRS)

"see comments in the report" (EDF)

"See in the attached report from Forsmark". See Appendix 2.

"1. Multi-units and Site Level Risk Metrics
2. Multi-units and Site-level Accident Analysis and Management
3. Risk characterization in the Level 3 PSA Framework" (KAERI)

2.1.1.2 Feedbacks from reviewers

The report has been reviewed by EDF, JANSI, JSI, NIER and Forsmark (see Appendix 2).

The overall comment by Forsmark is that "the recommendations put too much burden on the PSA and PSA developer. […] It is important that the ASAMPSA_E recognizes and stresses the limitations of PSA and recommends a feasible scoop of the PSA and how the limitations of the PSA can be handled without spend a large amount of resources".

Other main comments not already mentioned in 2.1.1.1 are the following:

- stipulate that PSA and other risk assessment that include external event assessment are not valid for more than 5 to 10 years and there is therefore no need to include climate changes (Forsmark),

- the report make in several places distinction between safety classes and non-safety classed systems: this has to be corrected (Forsmark),
- evaluate if it is better to develop separate level 1 and level 2-PSA for different events (Forsmark),

2.1.1.3 Synthesis

A large majority of respondents consider that lessons of the Fukushima Dai-chi identified in the report are relevant. However, one respondent does not support the positions given in the report on several issues and other respondents/reviewers also identify additional lessons.

Workshop outcomes and recommendations:

TEPCO engineers have reminded that before the Fukushima Dai-ichi accident, the probability that a tsunami exceeds 10 m was 10^{-6}/y and decision to reinforce the existing protective walls was not taken.

(1) Consider all reviewers' comments (questionnaire answers, comments in the report).

(2) ASAMPSA_E should clearly state that high amplitude natural hazards (possibility correlated) are associated with low frequency with high uncertainties. In that context, solution to address the risk is not necessarily PSA development (quantitative results may be highly uncertain and difficult to use). The ASAMPSA_E project should indicate some other paths for the utilities (with no complex PSA development): for example, direct NPP reinforcements to protect the plant against postulated events, which frequency is not the crucial issue (it shall be recognized that it can happen in adverse circumstances).

(3) For natural hazards, ASAMPSA_E should emphasise the importance of periodic update of the initiating events to be considered.

(4) Modify the wording of the D30.2 report which gives too much importance on the PSA capacity to identify problems (in general, PSA cannot exceed experts' knowledge which is for rare events (natural hazards) not sufficient).

(5) Check the report on passive system: during Fukushima Dai-ichi accident, it was a chance that the steam driven pumps operates "passively" - with DC current - during 2-3 days.

(6) Emphasize limitations of the PSAs methodology in this report. Remind that PSA is a part of more global system that contributes to the safety.

2.1.2 RISKS METRICS

The report "Risk Metrics and Measures for an Extended PSA - Technical report ASAMPSA_E / WP30 / D30.5 / 2016-17" provides a review of the main risk measures for Level 1 and Level 2 PSA (Level 3 is not included, but Level 2+), their advantages, limitations and disadvantages and their relevance for extended PSAs and for decision-making.

It concludes that:

- the choice of one appropriate risk measure or a set of risk measures depends on the decision making approach as well as on the issue to be decided;

- the general approach for decision making aims at a multi-attribute decision making approach. This can include the use of several risk measures as appropriate;
- for extended L1 PSAs: Fuel Damage Frequency and Radionuclide Mobilization Frequency are recommended;
- for extended L2 PSAs: characterization of loss of containment function and total risk measure based on aggregated activity releases of all sequences rated by their frequencies are proposed;
- no specific need identified for multi-units PSAs.

2.1.2.1 Answers to the questionnaire

Q2 - Do you believe that the list of risk metrics presented in the report is exhaustive?

Yes / Total non-blank answers	**No** / Total non-blank answers
9 / 13	**4** / 13

If not, please specify what should be added.

"Early Loss of Containment Function" (AREVA)
"L3 PSA risk metrics could be discussed, too. Comparison with deterministic safety assessment and its acceptance criteria could be made" (RiskPilot Ab)
"does not really deal with the "extended" aspect of the topic …. Content would be quite the same for internal events." (IRSN)
"Relating to Multi-units Risk Metrics, it seems be necessary to explain explicitly the impacts of Inter-units CCF and Risk integration process should be explicitly explained in the report." (KAERI)

Q3 - On the other hand, do you believe that something should be removed from the list?

Yes / Total non-blank answers	**No** / Total non-blank answers
2 / 13	**11** / 13

If yes, please provide argumentations.

"Some investigations on the current use of some risk measures on an international scale should be performed. This could permit nuancing the relative importance of each risk measure." (BEL V)
"Presentation of time-dependent risk measures is confusing and unnecessarily complicating.[…] Many of the L2 risk measures are overlapping, e.g., multiple variants of release category based risk measures (3.4-3.10)." (RiskPilot Ab)
"Both proposals for (PSA L2 risk metric) RC based on INES scale (CCA and EDF) should be discussed, and a proposal from the project should be developed - or at least they should be presented as variables of the same proposal for INES based RC. Relation between frequency of kinetics based RC and frequency of release based categories should

be detailed – maybe don't need both. The Severity Metric seems to be related to L3 PSA […] may be deleted." (RATEN ICN)

Q4 - Do you consider that the definitions, limitations and area of applicability for risk metrics are clearly and concisely presented in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers
10 / 13	**3** / 13

If not, please provide justifications.

"Some of the definitions are not presented very carefully. Particularly those, that involves probability distributions and use of them to obtain specific measures." (LEI)

"The definition is Ok but the limitations and the applicability are not well described related to the influence of boundary conditions, used conservatism and different degree of uncertainty for used parameters. […] risk metrics shall be used when all data and parameters are best estimate with similar and low uncertainty band. PSA including external event will not fulfil these basic demands for using risk metrics. ASAMPSA_E must therefore give guidance on how to restrict the use of risk metrics or specify demands to exclude certain events that do not fulfil the demands for using risk metrics." (FORSMARK)

"Please see the answer to the question N 6." (NIER)

Q5 - Do you agree with project recommendations related to risk metrics for an extended Level 1 PSA presented in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers
9 / 12	**3** / 12

If "No", please indicate which ones and why.

"Not sure what is actually recommended (in ch. 5). For practical (and regulatory) reasons, we should have some CDF-based metric which is applicable for light water reactors. For other facilities, some other metric is usually needed, but then we are usually already in level 2 considerations." (RiskPilot Ab)

"Non core melt sequences are of interest only if containment has failed (bypass or open penetration)" (EDF)

"No evaluation of the RMF (Radionuclide Mobilization Frequency) is given by Bel V (document examined by Level 1 PSA expert)."(BEL V)

"[…] recommendations have to be based on the increased influence on the output from boundary conditions, used conservatisms, and different degree of uncertainty for used parameters." (FORSMARK)

"Please see the answer to the question N 6." (NIER)

Q6 - Do you agree with project recommendations related to risk metrics for an extended Level 2 PSA presented in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers
7 / 12	**5** / 12

If "No", please indicate which ones and why.

"Source term risk should not be dismissed as only complementary risk measure as it is much more powerful than e.g. LRF." (AREVA)
"Not sure what is actually recommended (in ch. 5). For regulatory purposes, we should agree on some metrics which can be coupled with licensing process. For other applications, the issue is more open, but of course it would be beneficial that industry has some consensus on main metrics." (RiskPilot Ab)
"The document focuses excessively on the "absolute quantitative aspects" while in my opinion view, the main interest of PSA in general and the PSA Level 2 in particular, focuses on the relative comparison between the obtained results. In other words, what is really important is the comparison of PSA results for different configurations of the safety architecture to help the process of selection and decision. I feel this is an aspect that should be further highlighted. […] the concept of "practically eliminated", which is punctually mentioned in the document (§3.2.2 & § 3.3.2) but that is not enough put into perspective with the potential of a PSA to help demonstrate the practical elimination; on the other side there is within the document a search for a level of detail - in terms of quantitative results - that may not be necessary for the situations that are categorized in this area (i.e. practically eliminated). […]" (NIER)
"If a "Containment Failure Frequency" aggregates core melt and non core melt sequences frequencies, the insights of the sum will be limited (for example this sum will be more or less the SGTR frequency for a PWR). This frequency will also aggregate risk with different order of magnitude so it will be hard to get useful insights from it. Additionally this measure should be named "Containment Failure Frequency leading to abnormal releases" (otherwise this frequency is a least 1 as the equipment hatch is open once a year !). […] for "total risk" metric : as the sum will add a lot of assumptions with different level of conservatism it will be hard to get useful insights from this metric. Considering that this metric requires a lot of work it should be presented as an optional metric to be discussed with the country's safety regulator and not as a recommendation." (EDF)
"Discuss and specify if risk metrics are used taking into account also non-safety systems / SAMG / mobile systems." (FORSMARK)

2.1.2.2 Feedbacks from reviewers

Many proposals and comments have been received from BEL V, EDF, NIER, TRACTEBEL and FORSMARK. Only most important ones are presented here.

a) General comments:

Concerning practical elimination, the text should be consistent with WENRA ("the practical elimination of accidents with consequences that would not be limited in space and / or in time"). (NIER)

"As many external events and hazards are time dependent, the report should focus on ways to handle time dependent events." (FKA)

"Text is based on an idea that all data are best estimate with similar uncertainties. […] Using risk metric based on PSA where internal events and external events are combined have to be done very restrictive as it is a large risk that conservative data effects the risk metric in a way that the result cannot be interpreted just by looking at the quantitative results. The report has to be developed to include this reality related to data." (FKA)

b) Risk metrics for L1 PSAs

"Some of the definitions of CDF are restricted to core damages leading to releases other definitions do not lead to any releases at all: it is confusing and not understandable outside the PSA-specialists." This comment (by FKA) suggests that clarifications should be provided in the report.

"Calculated CDF results are not consistent with operational experience." (CCA)

It is difficult to "compare CDF results assessed by two different teams". (BEL V)

More details should be provided on the "specificities of the time dependent CDF (« picture » of the NPP at a certain time taking into account actual unavailabilities, etc.)". (BEL V)

Reliability and consistency of Change in CDF "can only be guaranteed if the PSA have been benchmarked against similar reactors PSAs". (FKA)

"The issue of Importance Risk Measures is not well known. Some guidance on this point should be interesting." (BEL V)

Concerning L1 PSA Radionuclide Mobilization Frequency, RMF, "if the threshold is too low, it will lead to a very high frequency with no safety meaning…" (EDF)

c) Risk metrics for L2 PSAs

About Large Release Frequency, one reviewer (EDF) disagreed with the recommendation that the LRF should be complemented by a release metric which addresses very large releases.

Concerning Large Early Release Frequency: "Analysis of currently used LERF is necessary. LERF is not adequate:

- quantitative diversity throughout the countries
- quantitative value is just preset, not mathematically derived (and has no technical justification, hence the different definitions in terms of released quantities, the radionuclides released …),
- ambiguity – large and early – explainable in many ways (see ASAMPSA2)
- comes from US requirements for radiation protection and not for safety purposes,
- related to immediate consequences only,
- represent frequency only, not risk.

See also the reference [3] where details are available." (CCA)

"It seems not possible to consider LERF as a quantitative risk metric." (EDF)

Within the reviewers, and with regards to ASAMPSA_E recommendations on LERF, there is no consensus on whether an agreement on a precise definition of LERF (Bq;time) should be searched or it should be considered not possible to use this metric as a quantitative one. One reviewer strongly supports that an international group would specify which metrics should be used for LERF for future PSA- up-dates.

About risk metrics based on Release Categories Frequencies, one reviewer (EDF) disagreed with the statement that "release categories as an end state of a L2 PSA cannot be considered satisfactory, since they cannot provide information on accident consequences in themselves, and all quantitative risk targets are based on some type of radioactive release quantification."

Position of the ASAMPSA_E project about Release Categories based on INES scale (CCA) and Proposal for INES Scale for a Harmonized Level 2 Risk Metric (EDF) should be provided: does the project recommend or not the use of such as risk metrics? (FKA)

About Functional and Phenomena Based Risk Metric, one reviewer (EDF) considers that it "should be moved to an appendix". Another one (FKA) claims that: "ASAMPSA_E should give more support to this risk metric …useful for the plant owners and the regulators to understand which plants up-dates shall be prioritized."

About Integral Risk or Total Risk Measures, one reviewer (FKA) "does not believe that any PSA are developed with good enough best estimate data to make this valid. It will be more important to find other ways to transfer the total knowledge from PSA into plant designers and plant owners", and another one (EDF) considers that it "should be seen as an optional complement to the many other risk measures under consideration". On the other hand, CCA has supplemented the section with a 15 pages description of the Common Risk Target (CRT) methodology, which has been developed together with risk targets to try to find a parameter complying with existing safety requirements and criteria published by IAEA.

One respondent (RATEN ICN) considers that: "APPENDIX B: NUCLEAR POWER PLANT RISKS may be deleted, it is not in the declared scope of the report".

d) Multi-source PSA and site level risk metrics

One reviewer (BEL V) expressed the following expectation:"Is there any practical advice to be mentioned for adaptation of initiating event frequency basis to multi-unit PRA ("events per site calendar year")?"

2.1.2.3 Synthesis

Concerning the list of risk metrics presented in the report, respondents and reviewers considered that it is globally relevant. It should be completed by adding a metric related to Early Loss of Containment Function and investigations on the current actual use of risk measures.

For multi-unit PSAs, the report should explicitly explain the impacts of Inter-units CCF and Risk integration process.

Concerning limitations and applicability, guidance should be given on how to restrict the use of risk metrics when all data and parameters are not best estimate with similar and low uncertainty band.

Recommendations related to risk metrics for an extended Level 1 PSA are globally agreed while feedbacks on risk metrics for extended Level 2 PSAs are less consensual (7/12 respondents agreed with the recommendations on risk metrics for L2 PSAs; 5/12 disagreed).

Workshop recommendations

(1) Consider all reviewers' comments

(2) Clarify in the report if extended PSA needs new risk metrics

(3) Comment more the link between risk metrics and multi-units PSA, with the perspective of RIDM applications.

(4) Keep the notion "early" and "late" in the risk metrics

(5) Check the vocabulary "severity metrics"

(6) Comment the link between risk metrics and uncertainties (see discussion on huge uncertainties for rare natural hazrds)

(7) Complete the rapports with the notions of "integrated PSA" and "separated PSA" (separated PSA if IE uncertainties are very high ???)

(8) Add a chapter that explains that the use of risk metrics is developed in the RIDM report (for example risk metrics for relative comparisons of design options)

(9) Explain better the interest for non-core melt accident + containment failure

(10) Add risk metric for seasonal effects

(11) Clarify the wording CDF with core damage or with no core damage (contradiction to be solved)

(12) For RIDM report: quality of PSA can be verified, mainly thanks to benchmarks / comparison / per review

(13) Check if the numerical value proposed for RMF (1 TBq) is relevant: if too low all accidents shall be considered

(14) Give a clear ASAMPSA_E position on CRT metric. Take into account the uncertainties of rare events frequency which makes doubtful the integral metrics approach

(15) Comment the interest to have one metric for L2 PSA that could be the equivalent to CDF for L1 PSA.

During the workshop, the following follow-up activity has been proposed: International comparison of risk metrics applications.

2.1.3 ASSESSMENT OF THE DEFENSE-IN-DEPTH WITH PSAS

Report 1

Report "The PSA assessment of Defense in Depth – Memorandum and proposals - Technical report ASAMPSA_E / WP30 / D30.4 (support material) / 2016-15" concerns the peculiar roles of the Defense in Depth (DiD) concept and the Probabilistic Safety Assessment (PSA) approach for the optimization of the safety performances of the nuclear installation.

It proposes a process for the assessment of the safety architecture implementing DiD, which is articulated in four main steps devoted to:
(1) the formulation of the safety objectives,
(2) identification of loads and environmental conditions,
(3) representation of the safety architecture and
(4) the evaluation of the physical performance and reliability of the levels of DiD.

A final additional step achieves the practical assessment of the safety architecture and the corresponding DiD with the support of the PSA.

The risk space (frequency/probability of occurrence, versus consequences) is the framework for the integration between the DiD concept and the PSA approach.

Additional qualitative key-notions are introduced in order to address the compliance of the safety architecture with a number of (IAEA) safety requirements. In this context, the role of the PSA is no longer limited to the verification of the fulfilment of probabilistic targets but includes different contributions to the assessment of the DiD identified in this report.

The report has not been reviewed by the ASAMPSA_E partners.

It recommends/concludes:

- The definition and implementation of the safety architecture of a nuclear installation must be coherent with the principles of the Defense in Depth (DiD);
- Unquestionably, the assessment of the DiD, i.e. the verification of the compliance of the implemented safety architecture with the DiD principles can be supported by PSA. For this objective, a certain number of practices should evolve. This document presents and motivates the ways to be followed in order to achieve these evolutions;
- The reference to the risk space is essential to integrate the insights coming from the deterministic and probabilistic studies and to evaluate the effectiveness of the levels of DiD;
- The classification of the Postulated Initiating Event according to their frequency of occurrence, with reference to the plant operational states and their relationships with the DiD levels and with the allowable risk space, are essential for the identification of loads and environmental conditions to be considered in the design and sizing of provisions;
- The Objective Provision Tree (OPT) and the Line Of Protection (LOP) are tools proposed to support the identification of possible deficiencies in terms of DiD level and to provide the essential information for the subsequent development of the PSA;

- Further activities are requested to finalize the proposed approach; they concern the detailed definition of the above criteria and metrics, coherently with the indications provided within the document.

Report 2

Report "The PSA and Defense in Depth concept - Technical report ASAMPSA_E / WP30 / D30.4 / 2016-26" stresses that after the Fukushima Dai-ichi accident the question of further improvements of DiD returned to the focus of discussions. The report is therefore dedicated to the investigation of the link of Probabilistic Safety Assessment (PSA) and assessment with respect to the Defense-in-Depth (DiD) concept for NPP.

The main focus in this report is on the discussion of how an "extended PSA" can be used to verify the adequacy of the application of the defense-in-depth concept. In line with other activities of the ASAMPSA_E project, the report treats mainly PSA Level 1 and Level 2 issues.

In section 2, the report reminds the most important aspects of the current understanding of the DiD concept and discusses important links to PSA in general and extended PSA in particular. Based thereon, several specific issues are identified for further investigation.

Section 3 treats the link between the initiating event determination for an extended PSA, intermediate PSA results and the classification of potential initiating events (PIE) for DiD assessments.

Section 4 is dedicated to classification schemes for systems, structures, and components (SSC), the reliability of engineered safety functions and the links to PSA.

Complementary, in section 5, the report looks at requirements on PSA models to facilitate DiD-related assessments and other important DiD-related issues not previously discussed.

Finally, the conclusions and recommendations address several issues regarding the relationship between PSA and DiD, which could not be investigated in depth in this report and need to be subject of future discussions.

The report main conclusions are:

- Keeping in mind complementary objectives of DiD and PSA, it is recommended that DiD and PSA be developed independently of each other;
- PSA should be structured in such a way that the individual levels of DiD can be identified;
- DiD as well as PSA have their own concepts for including or dismissing events or phenomena from their respective analyses; it is not recommended to harmonize these features;
- The discussion on the evolution of the DiD concept – partly to be found in the present document – is not related to the progress in PSA methods; whatever the DiD concept, PSA will be able to reflect it in principle;
- If PSA shows that a particular level of DiD does not contribute significantly to reducing risk, or if PSA indicates that even without a particular level of DiD risk targets can be met, there are arguments to relieve DiD requirements for this particular plant;
- On the other hand, if PSA indicates a high risk, it is advisable to improve the design, possibly by strengthening the DiD approach; the consideration of "extended PSA" results as an important safety

indicator in that context can be promoted but this, however, requires that the PSA accomplishes the highest quality standards.

2.1.3.1 Answers to the questionnaire

Questions Q7 to Q 9 are related to the report: "The PSA assessment of Defense in Depth – Memorandum and proposals - Technical report ASAMPSA_E / WP30 / D30.4 (support material) / 2016-15".

Q7 - Do you consider that the report provides adequate guidance for using PSA in assessment of DiD?

Yes / Total non-blank answers	**No** / Total non-blank answers
9 / 13	**4** / 13

If not, please provide your position.

"This report proposes some alternative ideas. Report 2 answers better to this question." (Risk Pilot Ab)

"May be that it is necessary to read the report more time. However content of section 5 and 6 are in principle the same as any nowadays PSA. E.g. when extended ETs are used in PSAL2 headers DID1 and DID2 are replaced by particular headers representing safety system functions.
May be that more stress should be put on evaluation of particular provisions of OPT … . However there is practical problem how to set metrics." (VUJE)

"This report gives a general overview of the process for DiD assessment with support of the PSA but we do not see how it could be practically used. It is not clear when this process should be applied during the design or during the operation of the plant. See comments in the report" (EDF)

"It would be expected to receive guidance on both the need and benefits of using PSA in the assessment of DiD and, secondly, on how to do this in practice.
Concerning the first aspect, it is noticed that report 2 mentioned below (D30.4/2016-26 about the link between the DiD concept and extended PSA) is more reticent. For a possible evaluation which would need a change of the structure of the PSA model, it is admitted that there is no consensus if the added value justifies the work. This nuancing is less clear in the support material. Hence, it is recommended to emphasise the link and the status of the two documents (for instance, by indicating clearly that the support material is considered helpful to elaborate but doesn't represent the recommendations and guidance of the working group/project). The second point (implementation) and, more specifically, the part about the evaluation which would require a change of the structure of the PSA model is only briefly discussed as §6 and 7 remain quite general. Specific issues which might appear when implementing the method are not mentioned." (Bel V)

"The DiD principles - Independence of functions for different level of DiD - are a vision. No existing NPPs fulfils the DiD-vision. No plant has been evaluated against the DiD-vision.
The first step in assessing fulfilment of DiD will be to dedicate each structure, system and component to one specific DiD-level in which it shall perform its function. This has to be performed for all systems involved in the safety cases. Both safety classified systems and non-safety classified systems. We have not seen any example of such classification of a plant. Any PSA assessment of fulfilment of DiD-vision has to use system within a certain

DiD-level to understand the strength of each of the DiD level and to understand the existing dependency between the different DiD-levels.
Besides this, Forsmark has difficulties to support the description and the conclusion in the report D30.4. Forsmark and all Swedish utilities and our regulators uses the INSAG 10 report to specify the DiD-levels which is the original defintion of DiD-levels. The report is based on a different definition of DiD-levels (IAEA-report SF-XXX). This definition is similar but gives for DiD-level 2 another definition.
Forsmark is doubtful of the need of the two reports related to DiD-levels. The report develop more confusions than it gives support for any safety improvements.
See more in the Forsmark review report." (Forsmark)

"The modalities to assess the effectiveness of DiD levels using PSA needs to be clearly presented." (RATEN ICN)

"This report provides very general and high level considerations about safety assessment mainly applicable to new designs (GEN IV). So the practical application to existing plants (or new plants) for which PSA is already performed is not obvious." (IRSN)

"Generally yes by offering a new concept/proposal. However, the example of event tree (Fig. 6-2) is very general. The real application of PSA for DiD is needed first to convince the end-users to use the methodology rather offering concept which may work with further development." (JSI)

Q8 - Do you consider that PSA studies should be structured to facilitate the assessment for each level of DiD?

Yes / Total non-blank answers	**No** / Total non-blank answers
5 / 14	**9** / 14

If not, please develop your position.

"The first two levels of DiD as presented in the document are not normally part of the PSA. The PSA is made with a specific goal." (AREVA)

"See below (Report 2)" (Risk Pilot Ab)

"Actually PSAL1 provide overall overview of effectiveness of DID2 and DID3. PSAL1 as such form nowadays well standardized activities and suggestion to change going process could be questionable. Eventual splitting between DID2 and DID3 is reasonable only in cases when we would like to evaluate overall effectiveness of DID2. However there is practical problem because many old plants have tiny border between DID2 and DID3 or DID2 is almost missing (subjective opinion)." (VUJE)

"DiD assessment could be considered as a particular application of PSA (mainly by assessing the independence between DiD levels). We do not think particular PSA requirements or structure for assessing DiD levels are needed." (EDF)

"As we consider that the position of the project/working group is clarified in the document D30.4/2016-26 and the present document is intended as a support document which clarifies some aspects of the subject, reference is made to the answer to Q12 hereafter." (Bel V)

"If it was a clear demand to fulfill the DiD-vision, the first step will be to perform a deterministic assessment based on INSAG-10 definition of the DiD (or another definition). Such assessment needs to start with a classification of each SSC into DiD levels it shall be active.
We do not believe that the PSA-specialists shall perform this kind of classification.
When such classification is performed for a plant the PSA -specialists can be activated to assess dependencies between the DiD-levels. This will then complement the deterministic assessment with deeper insights on dependencies between system and component used in different DiD-levels." (Forsmark)

"This will depend on the estimated application of PSA results. If it is desired for PSA to be able to assess the DiD levels, a specific structure for PSA needs to be implemented (one in which the individual levels of DiD can be identified) -the question of necessary resources to do this should be taken into account. The new structure may use the classic PSA, but modifications and a guidance to perform them will be required." (RATEN ICN)

"In the present form, the PSA studies are used to assess the risk of the NPP operation. In order to facilitate the assessment for each level of DiD, the traditional PSA should be revised taking into account the new approaches (e.g., as proposed from the authors of this report, but fully developed and approved)." (INRNE)

"The interest and feasibility have to be investigated: PSA can provide interesting insights about DiD without being restructured." (IRSN)

"Specific PSA could be used by the designer to assess level of DiD, but the classical approach of PSA should be maintained to separate clearly the two methodology deterministic and probabilistic." (IRSN)

"Currently in my opinion the method is not mature enough. This opinion is supported by the following statement in the report: "Further activities are requested to finalize the proposed approach; they concern the detailed definition of the above criteria and metrics, coherently with the indications provided within the document"." (JSI)

Q9 - Do you agree with the approach proposed in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers
10 / 13	**5** / 13

If not, please indicate the points you disagree and why.

For the first two levels of DiD, the PAA (probabilistic availability analysis) can be performed." (AREVA)

"This is not a strong "no". There are several question marks in the proposed ideas, such as:
- use of PSA to assess qualitative safety objectives
- ambiguity between definitions for LOP, LOD, DID level
- how different provisions would be actually assessed, especially immaterial and indirectly impacting ones
- applicability of the "strong"/"medium" line approach
See also comments in the report." (Risk Pilot Ab)

"We agree on the general framework but guidance on the different methodological steps should be improved by focusing on specific aspects of the ASAMPSA_E projects (external hazards, multi-unit site, SFP, Design Extension Conditions, off-site impact...)." (EDF)

"As we consider that the position of the project/working group is clarified in the document D30.4/2016-26 and the present document is intended as a support document which clarifies some aspects of the subject, reference is made to the answer to Q12 hereafter.
General comment: it is observed that some paragraphs (for instance in the executive summary or in §7) might give the impression that the role of current PSAs is limited to the verification of the fulfilment of probabilistic criteria. Although a modification of the PSA model would be needed to achieve all objectives proposed by the authors, it is noticed that several aspects listed in the executive summary (effectiveness of redundancies, human factor, uncertainties, balanced character etc.) can (and are) already be (partially) evaluated using current PSAs." (Bel V)

"See our responses above to question 7 and 8." (Forsmark)

"The approach needs to be more detailed, given information on practical use of the existing PSA studies for this assessment. The specific cases of proving "independence", "compliance", "sufficient margins", deserve detailed treatment in the report." (RATEN ICN)

"The approach is interesting for a new design." (IRSN)

"Yes if the approach is a supplement of the classical PSA. No if not." (IRSN)

"In general yes, the approach seems promising. However as it is written in GIF RSWG report for ISAM, there is lack of experience in application: "Unfortunately, due to a relative lack of experience with some of the elements of the ISAM, and a complete lack of experience in application of the fully integrated methodology, no definitive estimates of resource requirements for ISAM application exists at the present time.
In my view the method should first be demonstrated by application to existing reactor (an example for ISAM was for Gen IV reactor) before wide use is proposed (for Gen II and III reactors). It is not enough statement in the report that the method is proposed by IAEA. Namely, even IAEA standards already published are more general in nature than some country specific regulations and do not provide sufficient specific criteria for all areas against which the designs are finally judged (i.e. no reactor has not yet been not licensed fulfilling just IAEA standards).
Also, in the report D30.4 (support material) the following is stated: The ISAM methodology ([15]) can likely help to guarantee the exhaustiveness but nothing proves that this approach is more effective that the conventional methods as suggested, for example by the IAEA SSG-3." (JSI)

If you would support a different approach, please develop and provide references

"Initiating events shall be screened based on PSA relevance independently of deterministic definitions and what is the design base.
Also, concerning chapter 5, success criteria for PSA may be different than for deterministic analysis. For example, in PSA sometimes 1 train of a 2-out-of-4 system may have a supporting function." (AREVA)

"See below (Report 2)." (Risk Pilot Ab)

"Level 1 and Level 2 PSA for internal events have been used for many years for assessing the robustness and independence of each DiD levels following recommendations of accepted international or national PSA standards or guidance." (EDF) "See our comments above and the comments given in the Forsmark review report." (Forsmark) "See answers to previous questions." (IRSN)

Questions Q10 to Q12 are related to the report: "The PSA and Defense in Depth concept - Technical report ASAMPSA_E / WP30 / D30.4 / 2016-26"

Q10 - Do you consider that the report provides adequate guidance for using PSA in assessment of DiD?

Yes / Total non-blank answers	**No** / Total non-blank answers
9 / 13	**4** / 13

If not, please provide your position.

"Instead of guidance, this report is rather a set of examples for using PSA to address the following aspects of a NPP safety assessment during the design or the operation of the plant: - PIE identification and characterization - SCC classification - Safety function assessment - Verification of DiD implementation in the design - Risk monitoring. Some comments are provided in the report" (EDF) "It would be expected to receive guidance on both the need and benefits of using PSA in the assessment of DiD and, secondly, on how to do this in practice. It is recognised by the authors of the report (see, for instance, the executive summary) that the elaboration of a guidance document on how to modify the existing PSA models in order to assess the implementation of DiD in an effective manner could not be achieved in this project. More discussion and experience seems to be needed before developing such guidance (see also the position in the answer to Q12 hereafter)." (BEL V) "See our responses to question 7 and 8 above." (Forsmark) "A detailed methodology should be developed, to guide the use of classical PSA in assessment of DiD." (RATEN ICN) "Remark: It gives adequate information on use of PSA to support assessment of DiD, while direct assessment of DiD levels by PSA is still issue of research. It is described what DiD is and explained that there are several different views of DiD due to the historical development. However, at the end we face only two concepts: original 3-level established in 1967 by US and the five levels (US in 1994 and IAEA in 1996). Three levels concept is important as it was used for designing the current operating reactors, together with deterministic approach. The three levels of DiD were: prevention of initiating events, engineered safety features to prevent accidents and consequence limiting systems to prevent large

releases. The report deals both with initiating events and engineered safety features (through classification of SSC). Finally, Section 5 of report is more oriented to five level DiD, which requires probabilistic approach in addition to deterministic one. But some current regulations relied too much on DBA established more than 30 years ago, and do not require PSA. But this is to be (or is already) changed with regulations based on the best available knowledge from research and operational experience.
Regarding direct assessment of DiD levels by PSA in the report conclusions it is clearly stated that "there are several issues regarding the relationship between PSA and DiD, which could not be investigated in depth in this report and need to be subject of future discussions". From this it is clear that currently further work is needed before PSA will be used also for assessing DiD levels." (JSI)

Q11 - Do you consider that PSA studies should be structured to facilitate the assessment for each level of DiD?

Yes / Total non-blank answers	**No** / Total non-blank answers
4 / 11	**7** / 11

If not, please develop your position.

"Some system functions cannot be assigned to a certain level of DiD. Instead, for each accident sequence it shall be analyzed what possible combinations lead to a certain consequence (for example "core damage")." (AREVA)

"This is not a strong "no". A lot depends on the design. If the DiD concept of the plant is not sufficiently clear, it is of course not possible to structure PSA. Today's PSAs cover well DiD levels 3 and 4. It should be thus possible to assess the strength of these levels. It should be however noted that due to often applied risk criteria for radiological releases (e.g. 100 TBq Cs-137), the effectiveness of DiD level 4 is not fully assessed. An interesting question is to what extent DiD level 2 can be assessed.
We are studying it for time being. It requires further development of PSA. What we can see is that DiD level 2 is not a strong barrier. Systems and functions typically overlap with DiD levels 1 and 3. But for this reason it is interesting to try assess this level of DiD, e.g., to understand whether the current requirements for DiD level 2 are ok" (Risk Pilot Ab)

"It is sufficient that DiD levels are assessed by deterministic methods." (STUK)

"See Q8" (EDF)

"See the answer to Q12 hereafter." (BEL V)

"See our responses to question 7 and 8 above." (Forsmark)

"This will depend on the estimated application of PSA results. If it is desired for PSA to be able to assess the DiD levels, a specific structure for PSA needs to be implemented (one in which the individual levels of DiD can be identified) -the question of necessary resources to do this should be taken into account. The new structure may use the classic PSA, but modifications and a guidance to perform them will be required." (RATEN ICN)

"PSA can provide interesting insights about DiD without being restructured, as illustrated by the example of the WGRISK task on LOOP PSAs." (IRSN)

"There is lack of practical implementations. In the report it is stated: "existing PSA models would have to be modified to comply with the recommendations of this report; …changing the structure of an existing PSA model to fall in line with DiD levels is a significant effort; there is still no clear consensus if the added value justifies the work; both aspects require further discussion"." (JSI)

Q12 - Do you agree with the approach proposed in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers
6 / 12	**6** / 12

If not, please indicate the points you disagree and why.

See above" (AREVA)

"This is not a strong "no". It is not clear what is meant by the statement "it is recommended that DiD and PSA be developed independently of each other". It contradicts with a later recommendation that "PSA should be structured in such a way that the individual levels of DiD can be identified". To my opinion, DID is a fundamental principle which should be reflected in PSA, e.g., when defining initiating events, safety function entries in event trees and in the presentation and interpretation of results.
There is another recommendation "DiD as well as PSA have their own concepts for including or dismissing events or phenomena from their respective analyses. It is not recommended to harmonize these features in order to keep the benefits of diversity. In contrast, any differences in assumptions should be clearly identified and documented." Do you suggest that PSA and DSA should apply different screening principles? If yes, I might disagree. DSA and PSA could very well apply same screening principles even though for practical reasons the sets of considered initiating events and scenarios are not exactly same." (Risk Pilot Ab)

"There is neither new approach proposed, nor practical recommendations in the report." (EDF)

"First of all, it is noticed that the document deals with different types of links between the Defense-in-Depth (DiD) concept and PSA:
- consistency between postulated initiating events and PSA initiating events (see §3);
- classification of SSC (see §4);
- PSA assessment of DiD (see §5).
Although a verification of the first point (consistency between PIE and PSA IE) is (obviously) an aspect to be considered, it should be kept in mind that an inconsistency is not necessarily an issue which should be solved by changing the DiD analysis or the PSA model. For instance: the PIE frequency, if needed (e.g. for attributing PIE to accident classes), could or would be estimated conservatively within the context of a deterministic analysis while the IE frequency would be determined as a best estimate value (as also mentioned in the report). Also, the PIE does not necessarily exactly match the IE of the PSA. Moreover, for existing NPPs, the arguments and information used when making the subdivision of PIE (DBA, DEC...) for licensing purposes are not the same as the information currently available for use in the PSA.
Since no modification of the PSA model is needed to make this evaluation, no further guidance is expected for this

particular aspect as long as it is kept in mind that differences might legitimately exist.
Concerning the classification of SSC and the PSA assessment of DiD, a major remark (also mentioned in the report) should be made: the deterministic and probabilistic approach are fundamentally different since the objectives differ. The deterministic and probabilistic assessments are considered to be complementary. The need to mix both approaches is highly questionable. Indeed, the main question to be raised is whether a possible "verification" (if feasible for that matter) of the DiD levels by PSA will lead to additional insights which are beneficial for safety (in addition to the ones already available when performing the deterministic and probabilistic approach in a classical way, i.e. separately).
Moreover, we believe that a possible evaluation of DiD by PSA might lead to undesirable conclusions if no thorough and nuanced analysis of the PSA models, assumptions, data and results is made. In particular, extreme caution is recommended when applying the following practice suggested in §6 of the document: "...If PSA shows that a particular level of DiD does not contribute significantly to reducing risk, or if PSA indicates that even without a particular level of DiD risk targets can be met, there are arguments to relieve DiD requirements for this particular plant...". The limitations of PSA should not be forgotten when making this kind of decisions which seem to cast doubt on the legitimacy of the deterministic evaluation when not evaluated using probabilistic techniques.
It appears to be clear that the subject needs more research, experience and discussion. Unless it is proven otherwise in the future by applying the method (which should still be further developed, see also the answer to Q10 above), we believe that a fundamental change of the existing PSA models is not worthwhile and should not be given priority.
As a final (general) comment, it is also noticed that the specific topic discussed in the document does not seem to have been identified explicitly in the recommendations issued from the initial survey related to PSAs end-users needs. Hence, the need for this topic in the ASAMPSA_E project should be clarified." (Bel V)

"See our responses to question 7 and 8 above." (Forsmark)

"There is no proposal for steps that may be followed in order to transform the PSA study to assess the DiD levels (considering the performance of a specific level or the performance over several levels, and the needs for checking the "adequacy", the "compliance", the "independence" and the "existence of adequate margins")." (RATEN ICN)

"The interest and feasibility of a PSA modelling exactly each DiD level (especially levels 1 and 2) have to be investigated." (IRSN)

If you would support a different approach, please develop and provide references.

"We need a better approach to define and group initiating events. This is a common challenge for PSA and DSA. Secondly, we could try to pay more attention in DiD level 2. We are working with these topics and plan to publish preliminary ideas next year within Finnish SAFIR research programme.
Use of PSA's logic model in deterministic assessments such as safe shutdown analyses should be promoted. There are several publications on such analyses, see e.g. PSAM conference papers." (Risk Pilot Ab)

"See Q9." (EDF)

"See our responses to question 9 above." (Forsmark)

2.1.3.2 Feedbacks from reviewers

Concerning **Report 1** "The PSA assessment of Defense in Depth – Memorandum and proposals - Technical report ASAMPSA_E / WP30 / D30.4 (support material) / 2016-15", proposals and comments have been received from Bel V, EDF, Forsmark, IRSN, JSI, RATEN ICN, Risk Pilot Ab and VUJE.

Comments on **Report 2** "The PSA and Defense in Depth concept" -Technical report ASAMPSA_E / WP30 / D30.4 / 2016-26" have been received from AREVA, Bel V, EDF, Forsmark, IRSN, JSI, RATEN ICN, Risk Pilot Ab and STUK.

The most important comments and proposals are the following:

- No operating plant has been evaluated against the process proposed for the assessment of the safety architecture implementing DiD (Report 1 and Report 2);
- Practical application, interest and feasibility demonstration and validation of the approach are needed (Report 1 and Report 2).

One respondent (RATEN ICN) considers that: "the two reports needs to be integrated, and the resulting one should provide a detailed methodology that may be followed to transform the PSA study to assess the DiD levels (considering the performance of a specific level or the performance over several levels, and the needs for checking the "adequacy", the "compliance", the "independence" and the "existence of adequate margins")."

2.1.3.3 Synthesis

Concerning **Report 1** "The PSA assessment of Defense in Depth – Memorandum and proposals - Technical report ASAMPSA_E / WP30 / D30.4 (support material) / 2016-15", although three quarters of respondents consider that the document constitutes a relevant support material, two-thirds consider that PSA studies should not be restructured accordingly. Interest and feasibility of the approach have to be investigated.

Workshop conclusions:

(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation in Excel by WP10, comments in the report)

(2) Keep this report separately from the D30.4 deliverables

(3) Add reference to the EU council directive 2014 (the concept of DiD is fundamental, …., art 8b)

(4) Modify the title of the report: add "investigation" and precise in the text that the objective of the report is related to "investigation"

(5) Add example of OJT applications (JANSI for Japan reactors)

(6) Take into account reviewers comments and IRSN comments (at the end of the report).

Concerning **Report 2** "The PSA and Defense in Depth concept" -Technical report ASAMPSA_E / WP30 / D30.4 / 2016-26", three quarters of respondents consider it give adequate information on the use of PSA to support assessment of defense in depth. However, only half of respondents agree with the approach proposed in the report.

Workshop conclusions:

(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation in excel by WP10, comments in the report)

(2) Agglomerate the different positions and propose activities for the future

(3) Consider the following question: how to prove as far as possible DiD application?

(4) Discuss deterministic approach / application of existing/classical PSA and benefit of restructured PSA (for DID implementation application).

Follow-up activities identified during the workshop: on the methodologies available to demonstrate that DiD is appropriately implemented.

2.1.4 RISK INFORMED DECISION MAKING

The report "Recommendations on Extended PSA and its Use in Decision Making - Technical report ASAMPSA_E / WP30/D30.6/2016-28" is a preliminary document. It has two main objectives: firstly to integrate the conclusions and recommendations derived in other ASAMPSA_E reports for extended PSA development (e.g. initiating events identification, risk measures for an extended PSA, PSA insights for DiD assessments) and secondly, to discuss the use of insights from extended PSA for risk-informed decision making (RIDM).

It also includes an attempt to define common safety objectives.

2.1.4.1 Answers to the questionnaire

DM1 - Do you consider that the report provides adequate guidance for using PSA in decision making?

Yes / Total non-blank answers	**No** / Total non-blank answers
3 / 6	**3** / 6

If not, please provide your position. Synthesis of answers:

"This technical report mainly integrates summaries of the other reports, includes very few information about current state of RIDM. For EDF, this report does not include information about possible adaptation or evolution of RIDM to integrate extended PSA. The main Risk-Informed Applications, except global risk assessment and cost-benefit method are not mentioned in the report. As a consequence, acceptibility criteria are also not mentionned." (EDF)

Numeric values of acceptability criteria or targets used in RIDM have to be written in D30.6/7. "So further work needs to be done." (EDF)

"Improvements are necessary. There is no specific guidance provided on decision making criteria and on the differences induced by an extended PSA on specific cases. It will be beneficial to detail and to provide examples

on this. At least the cases of decisions regarding technical specifications changes, design modifications, or prioritization of activities should be presented." (RATEN ICN)

DM2 - Do you agree with the considerations related to safety objectives proposed in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers
3 / 5	**2** / 5

If not, please develop your position.

Proposal to "add the section 7 with the criteria for spent fuel pool damage frequency, if such criteria is used." (SE Zaporizhzhya NPP)

"Position (authors point of view) consisting in "we can consider FDF instead of CDF but apply the previous CDF numeric objective" cannot be endorsed by EDF. EDF disagrees with aggregation of SFP PSA result with classical CDF. So we suggest an alternative which is to present result from SFP PSA separately. Moreover applying an existing CDF numeric objective to FDF results in defining a more stringent objective without analyzing industrial impact of this change and without assessing the opportunity to define a new safety objective taking into account the extension of considered risk. Then considering also that this objective is not for one plant but for all the units on a site would result also in a more stringent objective. At this stage, other possibilities must be considered." (EDF)

DM3 - Do you agree with the approach proposed in the report to improve decision making using extended PSA?

Yes / Total non-blank answers	**No** / Total non-blank answers
3 / 4	**1** / 4

If not, please indicate the points you disagree and why.

One organization (RATEN ICN) has given no YES-NO answer but provided-comments.

"The report does not include significant proposal about using extended PSA in RIDM." (EDF)

"The extended scope of the PSA models will allow for a better understanding of the risk profile of the plant and site, thus bringing additional value to ALARA investigations, but no detailed discussion on this is included in the report. It will be beneficial to detail and to provide examples on this. At least the cases of decisions regarding technical specification changes, design modifications, or prioritization of activities should be included." (RATEN ICN)

If you would support a different approach, please develop and provide references.

"Some preliminary needs and explanation about the different existing situations have been presented at the first End-Users work shop (see EDF presentation from Pascal BRAC). We suggest to include in the deliverable some examples of numeric values of acceptability criteria or targets used in existing RIDM and to discuss the opportunity

and necessity to apply or adapt them to extended PSA context. So important further work is still needed for this deliverable." (EDF)

"The pure deterministic approach is very effective to achieve a very high safety level. The used or assumed simplicity and predictability also somehow helps in decision making. However, its main disadvantage is that it is not efficient regarding the use of resources (human, financial, others) according to the impact on risk. The decisions produced by deterministic design principles usually have a very high range of conservatism. This is natural, because the same criteria are applicable for high-risk systems and low risk systems. In addition, it is possible to recognize that some practical situations are too complex to clearly identify what is conservative and what is not. An action that is good from one side may be bad from another side (e.g. possible safety-security conflict for decision making)." (LEI)

2.1.4.2 Feedbacks from reviewers

Feedbacks have been mainly provided through answers to question DM3 (see above) and also in the commented version of the report sent by Forsmark.

RATEN ICN also sent the following comments and proposals:

"- It is not needed to include in the report summaries of the project deliverables: the first part of the document may be deleted;

- the document should underline what type of results/applications of PSA and Extended PSA are suitable to be used in decision-making process;

- the attributes that should be fulfilled by inputs to decision-making process should be highlighted;

- some examples will be beneficial (cases of decisions regarding technical specification changes, design modifications, or prioritization of activities)."

2.1.4.3 Synthesis

D30.6 was a preliminary report. Few answers and reviewers' feedbacks have been received for this document. Answers and comments point out that improvements are required to obtain adequate and commonly accepted guidance. In particular, main risk-informed applications need to be described as well as numeric values of acceptability criteria or targets used in RIDM.

Workshop recommendations:

(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation in excel by WP10, comments in the report)

(2) The future report D30.7 shall be a very different version from D30.6 to reflect all reviewers' comments and discussions during the workshop:

- Remind the PSA applications RIDM

- Comment the impact of extended PSA

- Comment the uncertainties issues of rare IE frequency and the link with PSA development

- Comment the PSA criteria to be used for multi-unit site

(3) Contact IAEA to be informed on draft standards/TECDOC that could be referenced in the ASAMPSA_E report (coordinator)

(4) It is recommended to consider a TECDOC report on DEC approach: Assessment of Vulnerabilities of Operating Nuclear Power Plants to Extreme External Events. The draft report has been provided to the workshop participants.

Follow-up activities identified during the workshop: RIDM and extended PSA will need further exchanges of information at international level.

2.2 SELECTING HAZARDS FOR PSA

2.2.1 LIST OF EXTERNAL HAZARDS TO BE CONSIDERED IN ASAMPSA_E

The report "List of external hazards to be considered in ASAMPSA_E - Technical report ASAMPSA_E / WP21 / D21.2 / 2015-10" presents an exhaustive list of external hazards posing potential threats to nuclear installations. It includes both, natural and man-made external hazards and also possible correlations between the external hazards.

The list is regarded comprehensive including all types of hazards that were previously cited in documents by IAEA and WENRA-RHWG.

The hazard list is used as a basis to select a limited number of hazard types for detailed discussion with specialists of the informed scientific community outside ASAMPSA_E and the development of guidance for hazard characterization by ASAMPSA_E (D21.3).

In the report, end-users needs expressed in responses to the initial survey (see [2]) and results from in-depth discussions at the 1st End-Users Workshop in Uppsala in May 2014 have been taken into account.

2.2.1.1 Answers to the questionnaire

Q13 - Do you consider that the list of natural external hazards is exhaustive?

Yes / Total non-blank answers	**No** / Total non-blank answers
13/ 15	**2** / 15

If not, please specify what should be added.

"The list is comprehensive. But some hazards treated separately should be grouped. For instance regarding extreme temperature, air temperatures, cooling water temperature, ground temperature are treated separately. But generally, a high/low ground temperature or cooling water temperature could not happen without a low/high

air temperature. They all are the consequence of a "meteorological situation" leading to these extreme temperatures.
Another example: wind-blown debris should be grouped with Tornadoes and High wind/Storm. Indeed, all the effects of a phenomenon should be grouped in only one hazard in order to facilitate the screening analysis.
On another hand, high and low air temperature are grouped in one hazard while this is 2 different phenomena which effects on the plant are really different, so that they should be treated separately. Besides in the table of the hazards combinations, high and low temperatures are separated. Finally, there should be just 2 hazards: extreme high temperature and extreme low temperature. And all the effects on the plant of each one should be grouped to be into a single analysis." (EDF).

"Low river/lake water level (as sources for water supply of some NPPs) should be added to the list." (TUS).

Q14 - Do you consider that the list of man-made external hazards is exhaustive?

Yes / Total non-blank answers	**No** / Total non-blank answers
13/ 15	**2** / 15

If not, please specify what should be added.

"The list is comprehensive. Some hazards treated separately should be grouped. For instance Industry and military accidents." (EDF)

"The following hazards should be added: Fire to M11 (transportation accident explosion, fire), M12 (transportation accident chemical release, fire); Agricultural Aircraft crash to M16 (military, civil and agricultural); Soil particles (with salt content) and seawater spray carried by the wind to M20 (Industrial or with soil particles or seawater spray contamination....) - these pollutants are also assessed for external high voltage insulation in outdoor switchgear and power lines, depending on location of some plants (Japan, UK)." (TUS)

Q15 - Do you consider that all the hazard combinations have been correctly identified in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers
11/ 12	**1** / 12

If not, please give details on this issue.

"1) The combinations of independent phenomena are not specified in the report.
2) The combination paragraph is only focused on the positive correlation between hazards (e.g hazards that enhance the probability to observe simultaneously other hazards). Nevertheless, some hazards are impossible to occur simultaneously (typically High air temperature, Icing). These negative correlations should be identified in the correlation chart.
3) As it is presented, this correlation chart should be symmetric with the line of symmetry as the diagonal line. The relationship between the causes and effects of the hazards should be reflected in both halves of the chart

(top and bottom). Otherwise it is not clear why some cells have been completed in the upper half but others have not. In addition, some of the cells completed in the upper half are not filled with the same coding as the equivalent cell in the lower half. To focus on the example of Vibratory ground motion (N1), the upper part of the chart informs that this hazard is a prerequisite for N3, N4, and N5. The lower part of the chart informs that this hazard may cause N3, N4, N5. As it is stated in chapter 3.1, the relation "A is a prerequisite for B" includes "A may cause B". In these conditions, only the first relation is necessary to be presented. Moreover, this correlation chart leads to count twice some hazards dependences in the figures 1 to 4.
4) The correlation chart alone is not comprehensive. Extended explanations are required as done in §2.2 for phenomena." (EDF)

"Yes, but without consideration of the combinations between the external hazards and internal hazards, occurred independently or as a result of the external hazards." (TUS)

"No missing combinations have been identified by Bel V (but we did not make an exhaustive verification). It is noticed that the guidance on hazard combinations is quite limited in this report, and mostly restricted to some examples. On the other hand, in the topical reports (e.g. external flooding, extreme weather), the guidance is further developed and, in addition, some methods for the assessment of hazard combinations are given (FSA method, EAA method). It could be useful to refer to the topical reports for further guidance on this topic." (Bel V)

Q16 - Do you consider that the hazard correlation map is reflecting correctly the reality or not?

Yes / Total non-blank answers	**No** / Total non-blank answers
9 / 12	**3** / 12

In case when you are not satisfied with it, can you please specify how it can be improved?

"All Swedish reactors are based on the NPSAG report 001-03 (SKI 02-27) and it should be an important reference to the ASAMPSA_E-reports. The description of a methodology to classify events in rapid and slow should be added (it is important for the event trees in the PSA) and also ways to identify events seasonal distribution including uncertainty distribution for such events if they are modelled by a mean value and seasonal variation is not included." (Forsmark)

"The table is quite extensive, therefore it is rather difficult to answer question, but seems good. Nevertheless, M3 - missiles from rotating equipment is prerequisite for: M1 - Industry: explosion and M5 - Military: chemical release. Question, why not also M2 and M4?" (JSI)

"It is necessary to fill all the cells of the Table 4. Currently, the right part of the table is filled only for combinations A N13 - B N60, A N40 - B N43, A N40 - B N44 and A N40 - B N45. In Table 4, there are contradictions. Currently, in the Table 4 for the combinations A N13 - B N60, A N40 - B N43, A N40 - B N44 and A N40 - B N45 indicated that A is prerequisite for B. At the same time, for combinations B N40 - A N43, B N40 - A N44 and B N40 - A N 45 indicated that B may cause A. I think in this case it is necessary to specify the same legend." (SE "Zaporizhzhya NPP")

"Same as Q15." (EDF) "Yes, for the direct consequences of certain hazards." (TUS)

2.2.1.2 Feedbacks from reviewers

The report has been reviewed by EDF, Tractebel, TUS and JSI. In addition to comments and proposals presented in 2.2.1.1, the following feedback from EDF and JSI can be mentioned: the list of 97 hazards is very long and quite extensive and leads to a very complex and not convenient cross-correlation chart of combinations (table with 101 rows and 101 columns).

This feedback suggests that the approach could be improved. Hazards with similar types of impact on the NPP could be grouped, and/or ranking of combinations and separation in the table of several cross-correlation charts depending on severity of impacts.

2.2.1.3 Synthesis

Almost all respondents consider that the lists of natural and man-made external hazards are exhaustive and that hazards combinations have been correctly identified. The report covers all types of hazards cited in documents by IAEA and WENRA-RHWG and the recommended 10 most important external hazards for the End-users. It could be mentioned that the list of hazards is quite detailed and it is difficult to be reflected in the screening analysis. The Cross-correlation chart for combinations of hazards is not fully filled.

As open issues should be indicated the lack of methods for assessment of hazard combinations, with the exception of methods proposed in some topical reports.

Workshop recommendations:

(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation in excel by WP10, comments in the report).

(2) Separate extreme temperature in extremely cold temperature and extremely warm temperature (due the very different type of impacts).

(3) Comment the link between the hazards to be considered in PSA with the design IE (and their amplitude)
In real case, a limited number of external hazards have to be considered. This should be explained in the report and also the global process: complete list ⇒ a selection for one site ⇒ an aggregation of hazards which have similar impact ⇒ screening ⇒ final list for PSA.

(4) Add comments for the assessment of correlated hazards. It seems that the highest importance and difficulty is for extreme weather conditions (see the real events report - D10.3). Insist more on the importance of the correlations with internal hazards which are risk significant.

Workshop recommendation for follow-up activities:

A project of method for hazards combination modelling could be built for some specific examples (extreme weather correlated events seem to be a good candidate).

2.2.2 SELECTION OF INITIATING EVENTS

The report "Methodology for Selecting Initiating Events and Hazards for Consideration in an Extended PSA – Technical report ASAMPSA_E / WP30 / D30.3 – 2016-13" is presenting the methodology for selection of initiating events and hazards for the development of an extended PSA, and provide some good examples and discussions of practices for selection.

The proposed methodology includes the following steps: Q*ualitative screening*; *Quantitative screening*; *Impact analysis and bounding assessment* for all applicable events and scenarios; *Probabilistic analysis* of all retained events at the appropriate level of detail.

The concluding part of the document presents the main qualitative and quantitative screening criteria, the structure of the screening process, considerations on the PSA quality, on transition from rough screening towards detailed PSA models, and link with the situations that should be practically eliminated.

2.2.2.1 Answers to the questionnaire

Q17 - Do you believe that the screening process (including qualitative and quantitative screening criteria) have been adequately presented in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers
10 / 12	**2** / 12

If not, what should be added?

One organization (BEL V) has given no YES-NO answer but provided-a comment. Two other comments were made, and the synthesis of answers is given below:

"Report should provide a clear list of criteria (qualitative and quantitative) and also guidance for their application based on examples." (EDF, BEL V)

"In its current form, the report provides long discussions and is hard to be followed." (EDF)

"Screening process - well elaborated, but quite demanding to implement it in practice, because "plant response analysis" and "bounding analysis" seem to require a simplified bounding PSA, which is a step that might go well beyond the original scope of a screening process. Moreover, in the subsequent sections 6.4 to 6.7, this quantitative screening process does not seem to be mentioned or further illustrated." (BEL V)

"Screening process - especially quantitative screening criteria - too unrealistic to be relevant for the existing NPPs - leads to the selection of numerous hazard scenarios especially as bounding analysis have many conservative assumptions" (EDF), and external events have large uncertainties in establishing a proper probability (FKA). The adoption of a relatively simple screening method with realistic thresholds would be better.

A clear separation between the screening phase, and the PSA analysis itself is needed. The screening phase must be an efficient way of selection without conservative vocation, and associated with a cliff-edge effect analysis for the quantitative criteria (matter of resources). (EDF)

"The selection should be verified by performing benchmarking with other PSAs or with a Peer review for PSA." (FKA)

Q18 - Do you consider that the report provides adequate guidance for selection of initiating events/scenarios to be considered in single unit PSA?

Yes / Total non-blank answers	**No** / Total non-blank answers
13 / 13	**0** / 13

If not, what is missing or should be detailed more?

Only one comment was made:

"The part devoted to initiating events is too large. The report should be more focused on hazards." (EDF)

Q19 - Do you consider that the report provides adequate guidance for selection of external hazard scenarios to be considered in single unit PSA?

Yes / Total non-blank answers	**No** / Total non-blank answers
10 / 12	**3** / 12

If not, what is missing or should be detailed more?

One organization (BEL V) has given no YES-NO answer but provided a comment. Three other comments were made, and the synthesis of answers is given below:

"Steps given for selection are relevant, but not associated with such quantitative criteria. The adoption of a relatively simple screening method with realistic thresholds would be better. Report should provide a clear list of criteria (qualitative and quantitative) and also guidance for their application based on examples." (EDF)

"The basis for risk assessment is that all data are best estimate and have similar uncertainty levels. If this is not the case, if developing a best estimate PSA aspect is not covered in the selection, we will have an unbalanced PSA that will be difficult to assess and difficult to be accepted." (FKA)

"One of the most important work for identifying IE scenarios is to identify secondary failures that can lead to events that initiate scram and also degrade safety functions. ASAMPSA_E shall give support to these assessments and shall recommend benchmarking to similar plant to strengthen identification of such secondary effects of hazards (failure of non-safety systems)." (FKA)

"Attention should be paid on the specific impact on severe accident mitigation systems. Also, the seasonality criterion appears too much qualitative; it should be more quantified or abandoned." (IRSN)

Q20 - Do you consider that the report provides adequate guidance for selection of correlated hazards scenarios to be considered in single unit PSA?

Yes / Total non-blank answers	**No** / Total non-blank answers
11 / 12	**2**/ 12

If not, what is missing or should be detailed more?

One organization (BEL V) has given no YES-NO answer but provided a comment. Three other comments were made, and the synthesis of answers is given below:

"It does not address the issue of frequency definition for combined hazards. The guidance allows the development of a matrix of all reasonnable combinations of hazards deemed applicable to the site but on the other hand demands to consider rare events and their frequency. The application of the qualitative and quantitative criteria to correlated hazards should be discussed (not clear that they really apply)." (EDF)

"The correlated hazards have larger uncertainties - the consequences of this have to be examined in the understanding of the resulting risks." (FKA – commented yes)

"Not only combination of (correlated) external hazards should be mentioned but also the combination of external+internal hazards (e.g. in the case of an earthquake leading to an induced fire or flooding). Also, the "C6" combination elimination criterion (if single hazard has too low frequency) is only convenient in a methodology where frequency is the main elimination criterion for combination (not considering the weight of potential impacts…)." (IRSN)

"The section is quite general; the screening of combinations of hazards needs further details." (BEL V)

Q21 - Do you consider that the report provides adequate guidance for selection of initiating events to be considered in multi-unit PSA?

Yes / Total non-blank answers	**No** / Total non-blank answers
9 / 11	**2** / 11

If not, what is missing or should be detailed more?

One organization (BEL V) has given no YES-NO answer but provided a comment. Two organizations (EDF and IRSN) have given a YES and NO answer and provided comments. The synthesis of answers is given below:

"The method proposed is far too complex for a screening phase. Multi-unit aspects could be taken into account in the selection process for hazards especially for LERF evaluation that could be impacted by the impact of the whole site. In this cases, specific criterion should be proposed." (EDF)

"It is quite demanding to implement, because "plant response analysis" and "bounding analysis" seem to require a simplified bounding PSA, that might go well beyond the original scope of screening process. The quantitative

screening does not seem to be mentioned or illustrated in the section dedicated to selection of initiating events/hazards to be considered in multi-unit PSA. A screening process which requires a huge effort would not stimulate the development of multi-unit PSA." (BEL V)

"Attention should be paid also on combination of external+internal hazards and on specific impact on the severe accident mitigation systems." (IRSN)

Q22 - Do you agree with the recommendations developed in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers
10 / 12	**2** / 12

If "No", please indicate which ones and why?

Two comments were made. Synthesis of answers:

"The report provides some envelope good practices for each selection step, but each step must be adapted and simplified where necessary to be effective enough to be able to identify predominant hazards eligible to extended PSA. Some recommendations go far beyond what should be found in a selection process." [...] "Not agree with recommendations on quantitative screening criteria. Plant response and hazard impact analysis shall be based on relatively simple analysis, referring to existing studies, often qualitative and using engineering judgment. Realistic assumptions can be used as well as bounding assessments." (EDF)

"The realization of bounding assessments grouping and considering conservative assumptions on frequency and plant response could not reasonably lead to low risk quantification which can be screened out. The summation of the bounding assessments that should be lesser than 10% of the overall risk to validate the PSA seems not reachable." (EDF)

"Detailed recommendations to avoid an unbalanced output are needed." (FKA)

Q23 - Do you consider that the report has successfully covered every useful aspect of the topic?

Yes / Total non-blank answers	**No** / Total non-blank answers
10 / 12	**2** / 12

If "No", please indicate which ones and why?

One organization (BEL V) has given no YES-NO answer but provided a comment. Two other organizations made comments. The synthesis of answers is given below:

"The selection for correlated hazard scenarios and multi-source scenarios is not sufficiently developed. Research on determination of adequate frequency occurence or conditional probability values and a first concrete application are needed." (EDF)

"Treatment of uncertainties needs to be detailed. An unbalanced PSA will be difficult to assess and difficult to get acceptance on from the operators." (FKA)

"Recommendations on support systems assessments, with examples on such dependencies are needed, as well as benchmarking to similar plant to strengthen identification of such secondary effects of failure of non-safety systems." (FKA)

2.2.2.2 Feedbacks from reviewers

Tractebel, JANSI, EDF, ENSI and IRSN have reviewed the report. The comments and suggestions received have been related both to the content and the format of the report.

The proposals and comments related to improvement of the report content are summarized below:

- Lot of information -report could be considered as state-of-the-art review rather than practical and industrial guidance. Feasibility of hazard screening process proposal should be assessed and its benefit to safety should be demonstrated. (EDF)
- When dealing with external hazards, risks are highly driven by the frequency of the hazards themselves and the proposed thresholds would be largely ineffective to screen out any hazards. Thus, the screening process would be unable to identify key hazards. (EDF)
- The screening process is inherently iterative in order to limit the number of cases for more detailed PSA models. If the number of selected scenarios is large it could be necessary to set priorities for the detailed PSA models and bounding could be useful for that purpose. A too high level of detail and complexity could lead to PSA models very difficult to build and to use for practical applications. (IRSN)

The editorial suggestions for improvement of the report are presented below:

- Separate the actual methodological proposals from both the rationale and the analysis of existing methods (EDF)
- Is better to move chapter 5 (or at least section 5.2, with the approaches in different countries) into an Appendix (BEL V)
- Compliance with end-user recommendations should be checked and the conclusions about it should be developed and included in the report (RATEN ICN)
- Reorganize the list of references (e.g. public (IAEA, US NRC, WENRA...), conference proceedings, technical reports, ASAMPSA project specific references..., and check if they are up-to date and publicly available (EDF)
- A particular emphasis is given to IAEA documents. EPRI Report 1022997 "Identification of External Hazards for Analysis in Probabilistic Risk Assessment" provides a very detailed guidance and should be more reflected in the document, either in section 5.1 (similar to the ASME/ANS Standard) or in section 5.2.21 (USA). (BEL V)
- Restructure some report chapters into explicit sub-sections to facilitate reading (EDF). In section 6.6, the first part deals with the selection of external hazard scenarios -the second part seems to be applicable to both internal and external hazards. It will be appropriate to have a new section (common to internal and external hazard scenarios) (BEL V).

- Check the English
- Check for text mistakes and avoid missinterpretations:
    - In conclusions, in Qualitative screening criteria is mistakely written as criterion for screening- event has the potential to induce catastrophic damages on the plant and regional scale offsite consequences (p. 113);
    - Direct estimations - even based on expert judgment - of the 95% percentile at a 95% uncertainty level for the event frequency will likely lead to results at an appropriate level of accuracy and conservatism for screening. Unclear;
    - In Qualitative screening criteria less relevant,

      B. event has a very low frequency of occurrence (e.g. 10^{-7} / yr) - not a qualitative but a quantitative screening criterion ;

      C. The event has a low frequency of occurrence and several trains of relevant safety systems are available. Taken literally, this criterion excludes most of the events generally included in the PSA. The safety systems shall not only be available but their operation shall remain unimpacted by the event (ENSI);
    - The first step of bounding analysis will be the estimation of the frequency of occurrence of the initiating event or hazard scenario, when the conditional probabilities for severe consequences should be assumed to be 1. This means that there is another quantitative screening criterion on frequency (ENSI);
    - If the event or scenario cannot be screened out on frequency alone, estimates on the PSA Level 1 risk metric have to be made with an adequate level of sophistication. At this stage, CLRP and CERP should be assumed to be 1. Nevertheless, with all these conservative assumptions, the frequency threshold is < 10-8/yr, which is irrelevant (ENSI).

2.2.2.3 Synthesis

Based on the questionnaire and review, it was concluded that:

- The report presents some good examples and discussions of practices for selection;
- Guidance for screening criteria application based on examples is needed;
- Screening phase should be associated with a cliff-edge effect analysis for the quantitative criteria;
- Application of the qualitative and quantitative screening criteria to correlated hazards is needed;
- Application of qualitative and quantitative screening criteria to multi-source scenarios (with distinct reference to spent fuel pool) is needed;
- Discussions on the uncertainties treatment needed;
- The compliance of document with end-user recommendations should be checked.

The recommendations to achieve the report as agreed during the Vienna workshop, are the following:

(1) Consider all reviewer's comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation in excel by WP10, comments in the report).

(2) Introduce a discussion on the structure of PSA: separated models for each external hazard or a fully integrated PSA model

(3) Try to explain better how to do a bounding analysis (such analysis is supposed to be simple in the context of screening)

(4) Give 2 definitions of the screening objective: to identify the most important hazards that contribute to the risks or to identify the hazards for which it is useful to develop a PSA (EDF approach shall be summarized)

(5) Explain what is the difference between the screening criteria proposed in the report and other criteria commonly applied in countries

(6) Add screening criteria based on IE frequency and comment its appropriateness (see EDF comments)

(7) Recommend to add some warning in PSA summary report on what has been screened out

(8) Comment the link between screening criteria and uncertainties on the frequency of external events

(9) Check the consistency with all topical reports for screening criteria

(10) Consider, in the screening methodology, the impact of external hazards on non-safety system and secondary effects.

Workshop proposal for follow-up activities: Benchmark on the importance of non-safety system and secondary impacts in external hazards assessment.

2.3 TECHNICAL GUIDANCE FOR EXTENDED PSAS DEVELOPMENT

2.3.1 TOPICAL REPORT ON EARTHQUAKE

The first report “Review of existing practices to model and implement SEISMIC hazards in extended PSA - Technical report ASAMPSA_E / WP21 / D21.3-1 / 2016-27” provides guidance on how to derive quantitative values for the assessment of seismotectonic hazards, as input for Level 1 & Level 2 PSAs. The objectives of this report are to:

- review existing guidance;
- identify good practices and challenges in hazard assessment;
- provide links to relevant regulatory, technical, and scientific literature.

The second report “Report 1: Guidance document - Implementation of SEISMIC hazards in Extended Level 1 PSA - Technical report ASAMPSA_E / WP22 / D22.2-3 report1/ 2016-19” provides guidance on practices to model and implement seismic hazards in extended PSA. It includes:

- some considerations for the extension of seismic PSA: combinations/correlations/dependencies of hazards, possible secondary effects, multi-unit response, mitigating and aggravating factors;
- approaches to model mobile equipment;
- approaches for building hazards curves and fragility curves;
- post-seismic analyses.

2.3.1.1 Answers to the questionnaire

Q24 - Do you consider that the **first r**eport provides adequate guidance regarding earthquake **hazard assessment methodologies?** If not, please give details about what should be added/ modified.

After analyzing the comments (for answers "No"), it appeared that except for 2 participants, answers were related to the second report:

- one participant answered "Yes";
- one participant answered "No": Description of "hazard deaggregation" is desired;
- other answers are analyzed and merged with Q25.

Q25 - Do you consider that the report**s** provide adequate guidance regarding **implementation of earthquake in PSA?** If not, please give details about what should be added/modified.

Answers to Q24 and Q25 have been analyzed and merged:

- for 1 participant: important aspects (fragility analysis, correlation of seismic failures) of seismic PSA are overlooked while unlikely combinations of events are considered with a disproportionate attention;
- for 2 participants: it is important to adopt a graded approach for Seismic PSA: no relevance to use complex methodologies if a simplified analysis gives sufficient and representative insights;
- for 1 participant: description of potential sequences from the external correlated hazards and their impact on the plant should be more detailed;
- for 1 participant: it is important to give recommendation on the frequency for up-dating a seismic PSA to cope with latest knowledge about occurrence and about resistance;
- for 1 participant: the document doesn't detail the elaboration of a basic seismic PSA and focuses mainly on the implementation of an extended seismic PSA (i.e. looking at the consequences for the site in its globality, taking into account its environment);
- for 1 participant: the following topics should be added:
    - general description of convolution of hazard and fragility, Concept of plant fragility, Use of UHRS (Uniform Hazard Response Spectrum), Explanation of HCLPF capacity (High Confidence of Low Probability of Failure), How to estimate fragility parameters of SSCs (e.g. generic data, test-based, data base);
- 1 participant asks why the report distinguishes the 2 sections "(INTERNAL) SEISMIC INITIATING EVENTS" (4.1.1) and "(INTERNAL) SEISMICALLY INDUCED INITIATING EVENTS" (4.1.2);
- 1 participant proposed to add references to IAEA documents (contain information regarding specific steps of seismic hazard analysis.

Q26 - Do you consider that the report**s** provide adequate guidance regarding assessment and implementation of **combinations of hazards in PSA?**

Yes / Total non-blank answers	**No /** Total non-blank answers
7 / 13	**6 / 13**

If not, please give details about what should be added/ modified. Synthesis of answers:

Answers “Yes”	• for 1 participant: the documents give guidance to start the elaboration of an extended seismic PSA. Practically, the combination of several hazards would probably need more guidance.
Answers “No”	• the combination of external and internal induced hazards from earthquake should be added; • the report gives only very general guidance regarding combination of hazards in PSA, without defining a methodology; • the report provides extensive guidance regarding assessment and implementation of combinations of hazards in PSA. However, the scope is so broad that the word "adequate" doesn't seem appropriate; • the report is too general as guide for assessment of the impact on NPP site of outside events provoked by earthquake; • proposition to add a section concerning earthquake aftershocks which can increase risks and disturbs mitigating actions in severe accident scenario; • one respondent answered “No” but did not provide any detail.

Q27 - Do you consider that the reports provide adequate guidance regarding multi-unit assessment for earthquake?

Yes / Total non-blank answers	**No /** Total non-blank answers
8 / 11	4 / 11

One respondent answered YES and NO.

If not, please give details about your point of view. Synthesis of answers:

Answers “Yes”	For 1 participant : this aspect is not very detailed in the document but should be sufficient
Answers “No”	• the report gives only very general guidance regarding multi-unit assessment for earthquake, without defining a methodology - should be detailed; • the presented multi-unit sites in §4.4 (Walkdowns) is not enough informative; • since this hazard will induce for sure an impact on all the units of a site, the multi-unit aspects should be detailed in a separate chapter (now they are mentioned together with spent-fuel pool); • one respondent answered “No” but did not provide any detail.

Q28 - Do you agree with the conclusions / recommendations developed in the reports? If “No”, please indicate which ones and why?

Conclusions and recommendations are not explicitly given in the second report. Comments from participants are however given:

- improvements are necessary (see Q25-Q27);
- focus should be on the correlations assessment;
- 1 participant disagrees with the use of quantitative screening criteria in order to produce a relevant extended PSA on existing NPPs; development of Seismic Extended PSA must be conditioned to the ability to ultimately obtain a representative risk analysis: graded approached can be chosen.

Q29 - Do you consider that all open-issues have been correctly identified?

Yes / Total non-blank answers	**No /** Total non-blank answers
8 / 12	**4** / 12

If "No", is there something that you wish to add? Synthesis of answers:

- A list of issues to be mentioned in the report have been highlighted:
  - combination of external and internal induced hazards from earthquake;
  - the extension of the mission time and the involved uncertainties;
  - methodology for quantitative assessment of impact on NPP site from outside earthquake damages;
  - impact of aftershocks on risks and SAMG.

Q30 - Do you consider that the reports will be useful in your activity?

Yes / Total non-blank answers	**No /** Total non-blank answers
11 / 12	1 / 12

If "No", please indicate why. Synthesis of answers:

- "*No if it is not updated based on our comments*"

2.3.1.2 Feedbacks from reviewers

Report 1 ("Review of existing practices to model and implement SEISMIC hazards in extended PSA - Technical report ASAMPSA_E / WP21 / D21.3-1 / 2016-27")

Three partners have reviewed the report:

- Reviewers agree with recommendations
- Reviewers propose some editorial improvements :
  - complements are provided from reviewers in the text
  - few questions are asked (e.g. in relation with earthquake intensity and duration)
  - minor remarks have to be taken into account : typos, references, terminology (use «UHRS» instead «UHS» …)

- For one reviewer, the title of the report is ambiguous, as the document focusses on seismic hazard assessment and doesn't speak about PSAs :
    - the reviewer suggests to merge this report with the document « Report 1 - Guidance document on practices to model and implement SEISMIC hazards in extended PSA »

Report 2 ("Report 1: Guidance document - Implementation of SEISMIC hazards in Extended Level 1 PSA - Technical report ASAMPSA_E / WP22 / D22.2-3 report1/ 2016-19")

Seven partners have reviewed the report:

- Scope of the report:
    - "*A less ambitious guidance, focusing on correctly quantifying the direct effects of earthquakes, as well as the most obvious indirect effects (such as fire and flood) might face a less aggressive opposition from the nuclear licensees and provide a more insightful risk picture*".
- Issues raised:
    - Each step of the methodology shall be adapted and simplified given the industrial choices made to develop these PSA models (graded approach vs. detailed PSA)
    - Internal hazard induced by earthquake (fires, explosion, floods) (§4.1.2) : relevant only if we can evaluate with a realistic manner the conditional probability of fire /ignition source/flood for each level of earthquake, and not only a possible scenario. This statement highlights the necessity to discuss the way to obtain these conditional probabilities
    - in step 1, it should be checked if the correlated hazards induce other IE than the ones already modelled
    - More information could be included on the extension of mission time, as well as on the using of mobile equipment
    - Post-seismic PSA : the case of multi-unit context should be included
- Clarifications / editorial improvements :
    - Add some EPRI references
    - Internal seismic initiating events (§ 4.1.1) / Developing event trees (§4.7): these sections mention only small LOCA - many seismic PSA consider several categories of LOCA and also other initiating events (i.e. LOOP)
    - Justification of suitability of non-seismic scenario for seismic conditions should make reference to the level of stress, and to human error probabilities changes (4.7.3)
    - The possibility of multiple failures (CCF) should be highlighted (§4.1.2.1 and 4.1.2.2) and something more detailed should be included
    - Fragility analysis (§4.6) : severity factors are introduced without explanations or references

- Hazard and fragility analysis PSA tool (§4.6.7): content summarizes the technical elements of the RiskSpectrum HazardLite tool. This section should not be the description of specific computer codes
- Initiating events screening (§4.5.1): quantitative values are used without a clear justification – this paragraph should be better explained / justified
- Multi-unit effects (§4.10.4): it seems that a multi-step methodology is proposed, but only step 1 is mentioned - text should be reformulated.

- Structure of the document :
  - Summary of step 1 (§4.1.4) : proposition to move it to the concluding part and to develop a summary for all the methodological steps
  - Concluding notes developed for fragility analysis (§ 4.6.6) : proposition to moved it to the concluding part.

2.3.1.3 Synthesis

The recommendations to achieve the reports as agreed during the Vienna workshop are given below.

Report 1 ("Review of existing practices to model and implement SEISMIC hazards in extended PSA - Technical report ASAMPSA_E / WP21 / D21.3-1 / 2016-27"):

(1) Consider all technical remarks in the questionnaire answers. Consider comments provided directly by IRSN expert (O. Scotti)

(2) Modify the report title to limit confusion with WP22 report

(3) Modify the organisation of the references (to be done by topic, with a number)

(4] Explain what is hazard desegregation (identify which source has the most impact ...)

(5) Explain how temporal signals that are representative for seism class can be elaborated (see with IRSN for practical example from UHS)

(6) Add a chapter on site effect modelling

(7) Explain in the report that a new tendency is now coming: industry starts to apply physical modelling of fault rupture; the softwares can be validated on real events and open as an alternative to the statistical/historical data: check that the report gives enough information on the technics available to identify active faults in the vicinity of a NPP

Follow-up activities:

(1) Aftershocks modelling (probabilities of occurrence, amplitude …)

(2) Application of fault rupture modelling for PSA.

Report 2 ("Report 1: Guidance document - Implementation of SEISMIC hazards in Extended Level 1 PSA - Technical report ASAMPSA_E / WP22 / D22.2-3 report1/ 2016-19"):

(1) Consider all technical remarks in the questionnaire answers

(2) There are so many technical comments that VUJE propose to organize a brief workshop in Slovakia to improve the report with the 5 or 6 main reviewers, based on an updated version of the report. Such an approach has been considered as very good by the workshop participants

(3) Add examples for fragility analysis ("classical approach" or more advanced using temporal signal - IRSN will provide an example of research in this area). In general help of experts involved in structural analysis will be welcome here

(4) Introduce the concept of graded/simplified approach (with the help of EDF) and discuss its validity

(5) Propose a set of recommendations in the next version of the report for approval by the project partners

(6) Comment statement: in general, the ASAMPSA_E project reports shall indicate what shall be examined in the context of extended PSA and promote pragmatic solutions that make the work easy (a minima feasible) for the industry

Follow-up activities:

(1) Specific method to calculate the probability of fire induced by earthquakes

2.3.2 TOPICAL REPORT ON EXTERNAL FLOODING

"Report 2: Review of existing practices to model and implement FLOODING hazards in extended PSA - Technical report ASAMPSA_E / WP21&22 / D21.3-3 &-D22.2-3 report2/ 2016-20" provides a review of existing practices to model and implement external flooding hazards in existing level 1 PSA. The objective is to identify good practices on the modelling of initiating events (internal and external hazards) with a perspective of development of extended PSA and implementation of external events modelling in extended L1 PSA, its limitations/difficulties as far as possible. The views presented in this report are based on the ASAMPSA_E partners' experience and available publications.

It gives a state of the art of practices giving a sound basis for modelling of flooding event and their consequences.

But it is recognized that difficulties and open issues remain such as the uncertainties in hazard frequency estimation due to sparse and not always accurate data, the development of SSCs fragility curves and the methodology to be used to assess combinations of hazards.

2.3.2.1 Answers to the questionnaire

Q31 - Do you consider that the report provides adequate guidance regarding external flooding hazard assessment methodologies?

Yes / Total answers	**No** / Total answers
7 / 10	**3** / 10

If not, please specify what should be added/modified. Synthesis of answers:

"A hierarchy should be added: 1. estimation of hazard, 2. assessing/modelling direct consequences, 3. hazard combinations/HRA/etc." (ENSI)

"More information about flooding in lakes could be added. Also, if possible more data from various EU countries could be provided. Only France and UK are mentioned in data collection subsection 3.2.2." (Lithuanian Energy Institute)

"From EDF industrial end-user perspective, one must keep in mind that the development of an External Flooding probabilistic analysis must be conditioned to the ability to ultimately obtain a representative risk analysis. The guidance does not promote this condition. Moreover the guidance only focuses on a very detailed PSA (e.g. SSC fragilities development...). From EDF industrial end-user perspective, the PSA methodology must be proportionate to the importance of risks. The adoption of a graded approach for External Flooding PSA would better focus resources and direct them to identify and address issues that present the highest significance to NPP Risks and Safety. Therefore, there is no relevance to use complex methodologies if a simplified analysis gives sufficient and representative insights." (EDF)

Q32 - Do you consider that the report provides adequate guidance regarding implementation of external flooding in PSA?

Yes / Total answers	**No** / Total answers
10 / 11	**1** / 11

If not, please give details about what should be added/modified. Synthesis of answers:

"See Q31" (EDF)

Q33 - Do you consider that the report provides adequate guidance regarding assessment and implementation of combinations of hazards in PSA?

Yes / Total answers	**No** / Total answers
8 / 10	**2** / 10

If not, please specify what should be added/modified. Synthesis of answers:

"The numerical screening criteria given in chapter 3.7.2 is based on adapting a typical mission time (either 24 or 72 hours). This is seen as an optimistic approach e.g. for those hazards causing damages on a large scale, which may not be eliminated in a short term. Hazard combinations being capable to lead to core damage should be checked more carefully to identify potential cliff-edge effects. Note that also uncertainties of the physical phenomena and the frequency distribution according to hazard's magnitude are important to be considered during the screening phase." (STUK)

"The report gives only very general guidance regarding combination of hazards in PSA, without defining a methodology." (EDF)

Q34 - Do you consider that the report provides adequate guidance regarding multi-unit assessment for external flooding?

Yes / Total answers	**No** / Total answers
8 / 9	**1** / 9

If not, please give details about your point of view. Synthesis of answers:

"The way multi-unit aspects must be taken into account is certainly more complex as there are shared teams, equipment ... Assessing multi-unit complex interactions could be a great challenge." (EDF)

Q35 - Do you agree with the conclusions / recommendations developed in the report?

Yes / Total answers	**No** / Total answers
10 / 11	**2** / 11

One respondent (Forsmark) answered YES and NO.

If "No", please indicate which ones and why?

"From EDF industrial end-user perspective, one must keep in mind that the development of External Flooding probabilistic analysis must be conditioned to the ability to ultimately obtain a representative risk analysis. The guidance does not promote this condition. The guidance only focuses on detailed PSA. From EDF industrial end-user perspective, the PSA methodology must be proportionate to the importance of risks. The adoption of a graded approach for External Flooding PSA would better focus resources and direct them to identify and address issues that present the highest significance to NPP Risks and Safety. Therefore, there is no relevance to use complex methodologies if a simplified analysis gives sufficient and representative insights. Some methodological issues have been presented in this guidance. This guidance could be presented as a survey to propose potential methodological elements to assess External Flooding Risk. It should be opened enough to leave the opportunity for the end-user to adapt the methodology to his context, operational feedback, necessities ..." (EDF)

"FKA support that the main problem is to verify the uncertainty in the estimation of different flooding hazard levels. FKA rely on assessment performed by national meteorological institutes in Finland and Sweden.
Using results from them the plant will never have flooding exceeding the design basis level. That should indicate that we can screen out external flooding event.
Based on this we think that the most important issue for PSA-assessment will be to understand if there exist any weak system design that will fail or create a flooding event even if the water level is beneath the design limits. There exist examples from plants that system for handling drainage water are designed in such a way that if they break they can transfer water into safety system areas." (Forsmark)

Q36 - Do you consider that all open-issues have been correctly identified?

Yes / Total answers	**No** / Total answers

8 / 10	**2** / 10

If “No”, is there something that you wish to add?

“The given issue 8 is not correct to point out here (see the chapter 8), because "HVAC" is not even mentioned anywhere else in the external flooding hazards document (the issue is handled at least in the extreme weather hazards guidance document).” (STUK) ”Difficulty to estimate the flooding hazard, taking into account the various phenomena.” (ENSI)

Q37 - Do you consider that the report will be useful in your activity? If “No”, please indicate why?

Yes / Total answers	**No** / Total answers
11 / 11	**1 / 11**

One respondent (Forsmark) answered YES and NO with the comment “Partly”.

2.3.2.2 Feedbacks from reviewers

Comments have been received from ENSI, EDF, ENSI and STUK.

For ENSI, more emphasis should be put on the importance of hazard characterization and the possible impact of a lack of realism in the modelling (e.g. Taking account of possible failures of water control structures and phenomena like sedimentation, erosion, transportation of debris (branches, leaves,…), failure of bridges and locations for log jams, etc. to avoid underestimation).

For EDF, the guidance focuses on detailed PSA. It should be opened enough to leave the opportunity for the end-user to adapt the methodology to his context, operational feedback, necessities, etc. The concept of graded approach should be promoted.

For ENSI, many important issues are described in this report. However, a clear hierarchy is missing in this guidance; a step-wise approach should be used. It is the reviewer's view that many items are discussed in too much detail. Additionally, many items are repeatedly described (e.g. description of modelling the events/consequences (SSCs in event trees). This makes the guidance quite tedious to read and understand.

A few mistakes were noticed by STUK in given reference numbers:
3.3.3.1 on page 33, find: Dixon and Tawn, 1994 [36] ⇒ [37] is correct
3.7.1 on page 50, find: SKI Report 02:27 [47] ⇒ [48] is correct
3.7.1 on page 50, find: Table 3-3 : Screening criteria [47] ⇒ [48] is correct
6.1 on page 59, find: "Safety Reference Levels for Existing Reactors" [2] ⇒ [3] is correct
6.1 on page 59, find: within the above documents [2] ⇒ [3] is correct.

2.3.2.3 Synthesis

The report gives a good and detailed state of the art of practices giving a sound basis for modelling of flooding events and their consequences. However, it focuses on very detailed PSA developments and some parts will need to be improved / completed as the methodologies are still under development.

The recommendations to achieve the report as agreed during the Vienna workshop are given below:

1) Consider all technical remarks in the questionnaire answers (see INR synthesis, Excel WP10 answers compilation and in the report review)

(2) The report will be completed to introduce in appendix the concept of "graded approach". EDF will provide a summary of its own definition

(3) A hierarchy of the most important issues to be analyzed in a flooding PSA will be proposed: IE frequency assessment, protection failure, etc.

(4) The consistency between screening criteria presented in this report with those given in D30.3 will be checked

(5) The importance of non-safety system (ventilation ducts as water path,), how the operator close the doors, the doors tightness, etc. will be discussed in the report.

Ideas of follow-up activities as agreed during the Vienna workshop are given below:

(1) Multi unit issues

(2) Combination of hazards assessment and modelling

(3) Uncertainties in the assessment of flooding event frequency for the different causes

(4) Assessment of SSCs fragilities for flooding (e.g.: water propagation modelling).

2.3.3 TOPICAL REPORT ON EXTREME WEATHER

“Report 3: Guidance document - Implementation of EXTREME WEATHER hazards in extended PSA - Technical report ASAMPSA_E / WP22 / D22.2-3 report3/ 2016-21” consists of two parts:

- WP21 part is dedicated to extreme weather hazards assessment including:
    - Hazards data sources and quality analysis,
    - Hazards assessment methodologies consideration (hazards parameters identification, data preparation & analysis, uncertainties and methodological limits analysis etc.),
    - Examples of different ways/methods for hazard assessment,
    - Presentation of possible hazard combinations and methods for evaluation,
    - Open issues,
- WP22 part proposes structure and solutions for extreme weather PSA including:
    - Solutions to the interface with L1 PSA building,

- Failures of equipment modelling (building resistance consideration, calculation of fragility or failure probability, walk downs and plant specific part, uncertainties, L1PSA-L2PSA questions),
- HRA for the extreme weather PSA,
- Additional emergency response (considering post Fukushima measures, mobile equipment and emergency measures accounting),
- Multi-unit for the extreme weather PSA,
- Consideration of state-of-the-art methodology for extreme weather PSA,
- Open issues.

The guidance covers two possible ways, which depends on data availability and software capabilities:

- discretization of the hazard and the fragility curves using a limited number of hazard intensities,
- use of continuous hazard and fragility curves for the whole range of hazard intensity of interest.

A way for modelling possible additional secondary effects and aggravating/mitigating factors was proposed in the guidance and it was concluded that there are no difficulties in PSA model's logic and structure building for external hazards.

2.3.3.1 Answers to the questionnaire

Q38 - Do you consider that the report provides adequate guidance regarding extreme weather hazards assessment methodologies?

Yes / Total non-blank answers	**No** / Total non-blank answers
11 / 13	**2** / 13

If not, please give details about what should be added/ modified. Synthesis of answers:

"…Extreme Weather Hazards probabilistic analysis must be conditioned to the ability to ultimately obtain a representative risk analysis. The guidance does not promote this condition.
…the guidance only focuses on detailed PSA. …there is no relevance to use complex methodologies if a simplified analysis gives sufficient and representative insights." (EDF)

"…The report does not give specific recommendations on how to model the selected events. The report gives only examples of used methods and discusses their strength and weaknesses. … Although it is recommended to not use the EVA-methods for weather events, it is not clear why…
…One of the most important parts of the PSA assessment shall be to understand the risk for safety system degradations in these weather conditions as well as the risk for CCF-on safety system and simultaneous loss of offsite power under these conditions." (Forsmark)

Q39 - Do you consider that the report provides adequate guidance regarding implementation of extreme weather hazards in PSA?

Yes / Total non-blank answers	**No** / Total non-blank answers
10 / 12	**3** / 12

One respondent (IRSN) answered YES and NO.

If not, please give details about what should be added/ modified. Synthesis of answers:

"The report could be more concrete in the evaluation of SSC fragilities due to extreme weather (wind, temperature, snow…): what kind of safety system is involved and how the probability of failure could be estimated taking into account uncertainties?.. …The report gives as example the Risk Spectrum methodology (methodology already presented in other ASAMPSAE_E reports) but seems silent about other methods as EPRI one." (IRSN) Two other comments by EDF and Forsmark are referring to the responses on the Q38.

Q40 - Do you consider that the report provides adequate guidance regarding assessment and implementation of combinations of hazards in PSA?

Yes / Total non-blank answers	**No** / Total non-blank answers
10 / 12	**2** / 12

If not, please give details about what should be added/ modified. Synthesis of answers:

"Combined hazards are too complex to be summarized in a so small section." (EDF) "The report points out difficulties but does not end in a recommendation." (Forsmark)

Q41 - Do you consider that the report provides adequate guidance regarding multi-unit assessment for extreme weather?

Yes / Total non-blank answers	**No** / Total non-blank answers
9 / 11	**2** / 11

If not, please give details about your point of view. Synthesis of answers:

"The proposal made on that guidance is untrue for extreme external hazards where the site CDF equals one unit CDF only... Assessing multi-unit complex interactions could be a great challenge." (EDF) "This is still research…" (Jožef Stefan Institute)

Q42 - Do you agree with the conclusions / recommendations developed in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers
12 / 13	**2** / 13

One respondent (Forsmark) answered YES and NO.

If "No", please indicate which ones and why? Synthesis of answers:

The same as Q39, Q40 + "...This guidance could be presented as a survey to propose potential methodological elements to assess Extreme Weather Risk…" (EDF) "Both yes and no. No because we think the list of open issues shall be longer and we doubt that existing guidance gives best estimate inputs to the PSA results. See also responses to Q38." (Forsmark)

Q43 - Do you consider that all open-issues have been correctly identified?

Yes / Total non-blank answers	**No** / Total non-blank answers
13 / 14	**2** / 14

One respondent (Forsmark) answered YES and NO.

If "No", is there something that you wish to add? Synthesis of answers:

"It is written in the conclusions: "The list of open issues described before the conclusions present few limitations, but there is no evidence that it is a complete list"" (IRSN) "Open issues number 6 and 9 could be better justified…" (IRSN) "Yes because we support the one specified. No because lack important issues as indicated in the summary." (Forsmark)

Q44 - Do you consider that the report will be useful in your activity?

Yes / Total non-blank answers	**No** / Total non-blank answers
14 / 14	**1** / 14

One respondent (IRSN) answered YES and NO.

If "No", please indicate why? Synthesis of answers:

"This guide is not specific enough to the extreme weather PSAs." (IRSN)

2.3.3.2 Feedbacks from reviewers

Many proposals and comments have been received from BEL V, EDF, TUS, IRSN, RATEN ICN, ENSI and Forsmark. Only most important ones are presented here.

"The section 3.2.2 "Calculation of fragility or failure probability" is very generic. It would be helpful to include references to methodologies for calculating wind fragilities based on building parameters." "It could be interesting (in an annex?) to precise in case of extreme weather what kind of safety systems are involved (HVAC, heat sink…) and how their fragility curves could be estimated, for instance, with wind strength and uncertainty parameters" (IRSN).

"It should be clarified how those continuous hazard and fragility curves are implemented. Is there any other guidance document (ASAMPSA_E deliverable or another reference) where this is explained?" (RATEN ICN)

"The flowchart needs to be discussed. Detailed analysis is included in the plant response analysis - no need for a separate step in the flowchart." (RATEN ICN)

"The subject is discussed in a separate paragraph (§3.5 «Solution to model – multi-unit for the extreme weather PSA») and is mainly based on a paper (reference [41]). In the topical report about external flooding PSA, the same text is used, however with a few additional comments which might also be useful for extreme weather PSA. The reading of the paper references is needed in order to decide if sufficient guidance is given. In any case, it is probably not easy to be more explicit due to site-specific elements: site, design of the installations (redundancy/diversity...), PSA model (how common items are modelled)...
On the other hand, it should be checked whether the guidance on multi-unit assessment in the different topical reports and other ASAMPSA_E deliverables (related to "general issues" for PSA) is provided in a consistent way" (Bel V).

"In the general algorithm proposed to model the accident sequence, the step: "change in event trees (if necessary) related to the selected initiating events" should be placed before: "change in probabilistic model fault trees considering vulnerable equipment"." (RATEN ICN)
"The open issues are presented in chapter 4 and in the conclusions - is better to have them presented in one place (the same for all reports)." (RATEN ICN)

Questions regarding multi-units issues were also raised by other reviewers.

2.3.3.3 Synthesis

Most of active End-users consider that the report provides adequate guidance on extreme weather hazards assessment methodologies and implementation in PSA and agree with its conclusions / recommendations. However, some improvement needs have been identified.

The recommendations to achieve the report as agreed during the Vienna workshop are given below:
(1) Consider all technical remarks in the questionnaire answers (see SSTC synthesis, Excel WP10 answers compilation and in the report review)
(2) It appears from the review that the report does not provide any recommendations for the assessment of combinations of hazards. It is highly recommended that the partners involved in WP21 complete the report and make the links with the geoscience community activities. This was one objective of the project and explains why ASAMPSA_E has done effort towards EGU conference. During the WS, it was explained that single hazards were appropriately assessed but not the combined ones, which is absolutely NOT APPROPRIATE in a risk assessment study. The report has to be completed to explain the gap that exist between what scientific are doing and the need
(3) Credibility of data: ENSI explains that extreme weather studies were done in Switzerland but credibility of values is questionable. Forsmark requests to explain in ASAMPSA_E what shall be done when high uncertainties exist on numerical value of PSA data. JANSI explains that in that case sensitivity analysis can be done and that PSA numerical results are not so important. It is highly recommended to modify this ASAMPSA_E report (and other) in

that sense: when reliable numerically cannot be obtained, then the PSA development may not be an appropriate solution for risk assessment/management. More straightforward approach (including sensitivity analysis and plant reinforcement feasibility) can be preferred

(4) Strategic views: the PSR approach /periodic update of meteorological data/climate change impact management shall be introduced in the report. It is suggested to distinguish between new NPP (reinforcement shall in theory not be needed if the design is appropriate) and old NPP (we know many NPPs have to be reinforced). Nevertheless, it is argued that on a new site, all events cannot be predicted in advance (?)

(5) Fragility analysis: it is recommended to improve the information on fragility analysis in the report (for example SSC behaviour at very hot temperature)

(6) It is recommended to consider a TECDOC report on DEC approach: Assessment of Vulnerabilities of Operating Nuclear Power Plants to Extreme External Events. The draft report has been provided to the workshop participants.

Open issues for follow-up activities as agreed during the Vienna workshop:

(1) Applicable methodologies to predict extreme weather conditions obviously need further research activities, especially on combined extreme weather events

(2) Considering the slow progress in this area and the limited reliability of data for PSA, PSA cannot be a recommended approach and alternative approach shall be preferred for risk identification and management. This may need some further clarification.

2.3.4 TOPICAL REPORT ON BIOLOGICAL HAZARDS

"Report 4: Guidance document - Implementation of BIOLOGICAL INFESTATION hazards in extended PSA - Technical report ASAMPSA_E / WP21 & WP22 / D21.1 & D22.1 / D22.2-3 report4/ 2016-22" covers the assessment of biological hazards. It provides an overview of the available data and approaches to assess biological hazards and their combinations and identify best practices in modelling this type of hazard. The following have been concluded:

- Probabilistic analyses were very rarely carried out in order to quantify the risk induced by biological hazards even though history has shown that this hazard can happen and can be highly safety significant. Screening out this event must be done with great care;
- The overall analysis approach for Level 1 PSA for internal events can be used for the biological hazards with some care to take into account the nature of the hazard as it impacts many systems at different times and durations;
- Slow occurring biological phenomenon require to take appropriate protective actions. Expert judgment is used if a specific input data is insufficient or when there are no continuous variables to describe the phenomenon (e.g. biological blockage);
- Biological phenomena in water and air, including biological contamination should be considered in regulatory requirements on external hazards PSA;

- Severe biological infestations may impact all the units at a same site at different times and degrees and it may happen in combination with other hazards (flooding, strong winds). Combination and correlation of wind and biological infestation could lead to loss of ultimate heat sink and loss of offsite power which are challenging events for NPP safety;
- Further emphasis should be put on two aspects of PSA modelling: Multi-unit impact scenarios and biological infestation hazard combinations with other external hazards (such as wind, or flooding, or rainfall). They need further methodological and guidance developments as well as additional support studies.

2.3.4.1 Answers to the questionnaire

Q45 - Do you consider that the report provides adequate guidance regarding biological infestation hazards assessment methodologies?

Yes / Total non-blank answers	**No** / Total non-blank answers
8 / 10	**2** / 10

If not, please give details about what should be added/ modified.

3 comments were made for this question. Synthesis of answers is given below:

"Different levels of biological infestation: progressive biological infestation that occurs frequently on a plant (e.g. daily infestation); massive biological infestation due to predictible seasonal phenomena (e.g. algae infestion due to equinoctial tide); extreme biological infestation due to exceptional events (e.g. massive amount of vegetable materials blocking the pumping station) should be considered in hazard assessement." (EDF)

"More knowledge is needed to develop realistic consequences of different level of biological hazards." (Forsmark)

"Biological hazards result in complete loss of the ultimate heat sink – is this consequence almost impossible (like is assumed in FSAR and the licensing document)? In most scenarios the safety systems need only 5 to 10% of the capacity of the cooling water systems." (Forsmark)

Q46 - Do you consider that the report provides adequate guidance regarding implementation of biological infestation hazards in PSA?

Yes / Total non-blank answers	**No** / Total non-blank answers
8 / 10	**2** / 10

If not, please give details about what should be added/ modified.

2 comments were made for this question. Synthesis of answers:

"Specific models (event trees or fault trees) for assessing PSA initiating events due to biological hazard should be proposed. It could be useful to have the reactor operating time associated with the generic data provided (section 3.6), to evaluate the order of magnitude for generic hazard frequencies." (EDF)

"More knowledge is needed to develop realistic consequences of different level of biological hazards." (Forsmark) "Biological hazards result in complete loss of the ultimate heat sink – is this consequence almost impossible (like is assumed in FSAR and the licensing document)? In most scenarios the safety systems need 5 to 10 % of the capacity of the cooling water systems." (Forsmark)

Q47 - Do you consider that the report provides adequate guidance regarding assessment and implementation of combinations of hazards in PSA?

Yes / Total non-blank answers	**No** / Total non-blank answers
7 / 10	**3** / 10

If not, please give details about what should be added/ modified.

3 comments were made for this question. Synthesis of answers:

"Guidance not specific to biological infestation hazards." (EDF) "This is one of the two open issues identified into the report, which need further development - a combination of biological infestation with other external hazards (such as wind, or flooding, or rainfall)." (INRNE) "More details needed. For instance, something similar with text from 12.2 -Screening Criteria for Combined External Events could be included." (RATEN ICN)

Q48 - Do you consider that the report provides adequate guidance regarding multi-unit assessment for biological infestation?

Yes / Total non-blank answers	**No** / Total non-blank answers
7 / 10	**3** / 10

If not, please give details about your point of view.

3 comments were made, and the synthesis of answers is given below:

"Guidance is not specific to biological infestation hazards." (EDF) "Need further development." (INRNE) "More details are nedeed." (RATEN ICN)

Q49 - Do you agree with the conclusions / recommendations developed in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers
10 / 10	**1** / 10

One respondent (Forsmark) answered YES and NO.

If “No”, please indicate which ones and why?

Only one comment was made:

“Support the given recommendations but lack conclusions related to the comments made for: combination of biological infestation with other external hazards; multi-unit; different levels of infestation.” (Forsmark)

Q50 - Do you consider that all open-issues have been correctly identified?

Yes / Total non-blank answers	**No** / Total non-blank answers
9 / 10	**2** / 10

One respondent (Forsmark) answered YES and NO.

If “No”, is there something that you wish to add?

2 comments were made, and the synthesis of answers is below:

“Lack conclusions related to the comments above (combination of biological infestation with other external hazards; multi-unit; different levels of infestation).” (Forsmark)
“The uncertainties regarding estimation of occurrence frequencies need to be discussed. The uncertainties level need to be mentioned also.” (RATEN ICN)

Q51 - Do you consider that the report will be useful in your activity?

Yes / Total non-blank answers	**No** / Total non-blank answers
9 / 10	**1** / 10

If “No”, please indicate why?

2 comments were made. Synthesis of answers:

“Knowledge exchange among experts on this issue is important as this will create more harmonized view of the consequences of different degrees of biological hazards. There is a need for benchmarking in this area to stimulate exchange of knowledge.” (Forsmark)
“No need to develop a specific PSA's for this hazard – it may be taken into account in the PSA internal events in the initiator Loss of Ultimate Heat Sink or Loss of Offsite Power, including a proponent multi-units, or in a PSA extreme weather e.g. if an extreme wind impacts multiple initiators.” (IRSN)

2.3.4.2 Feedbacks from reviewers

The comments and suggestions received have been related both to the content and the format of the report.
The proposals and comments related to improvement of the report content are summarized below:

- The massive biological infestation by water hazard is in general included in the PSA for internal events as part of the loss of last heat sink initiating event. However, the initiating event is generally modelled using the internal events PSA basic assumptions (24hr sequence time, one unit, potential combination of hazards not considered, interaction between reactor and spent fuel pool not considered). In the hazard assessment it should be considered different levels of biological infestation: progressive biological infestation that occurs frequently on a plant (e.g. continuous corrosion or daily infestation); massive biological infestation due to predictable seasonal phenomena (e.g. algae infestation due to equinoctial tide); extreme biological infestation due to exceptional events (e.g. massive amount of vegetable materials blocking the pumping station) (EDF);
- It should be verified if the approach proposed is consistent with the other ones proposed for other hazards (BEL V);
- There are some open issues (defined within the report) that need further development - a combination of biological infestation with other external hazards such as wind or flooding or rainfall and multi-units impact (INRNE);
- A kind of synthesis document could be made to integrate the common elements of all documents (some aspects are maybe in a more detailed or better way explained in other documents). In this synthesis document, the main differences or specificities for certain hazards could be highlighted (BEL V);
- We may create a separate deliverable "Glossary", in which all definitions are grouped, and which is used as a reference for all other ASAMPSA_E deliverables (BEL V);
- The document is very long, general and presenting high level considerations, often already known (from IAEA documents) (IRSN);
- There is no real guidance about the practical use of theses inputs (as provided for example by EPRI guides), and the report cannot be considered as guide (IRSN);
- We can find a lot of information about the hazards as initiating events (description, standards, sometimes frequency, etc.) but few information concerning the consequences for the installations (impact on SSCs, fragility, accident scenarios, etc.) which would be necessary for performing a PSA (IRSN);
- Some practical examples provided by participants having really carried out (at least partly) some extended PSA would be a valuable input for improving the ASAMPSA_E documentation (IRSN).

The editorial suggestions for improvement of the report were formulated as follows:

- Reorganize the list of references in the report (e.g. public (IAEA, US NRC, WENRA...), conference proceedings, technical reports, ASAMPSA project specific references...), and check if they are up-to date and publicly available (EDF);
- Restructure some report chapters into explicit sub-sections to facilitate reading (EDF);
- Check the English (EDF);
- Chapter 2 should be deleted - All these documents should be used as references in the report – there is no need for a special chapter (RATEN ICN);
- All the info from 3.x points is not referring to data bases, but to examples from operating experiences – they should be merged with 1.3 and moved there (RATEN ICN);

- Text from “Example of site-specific Hazard assessment” could be moved into an annex. (RATEN ICN)
- “Methods for the Assessment of Hazards Combinations” (4.8) is better to be moved under Hazard combination chapter (5) (RATEN ICN);
- The methodology for assessment of combination of hazards needs to be detailed. Something similar with text from 12.2 -Screening Criteria for Combined External Events could be included (RATEN ICN);
- Appendix C is referring to “Event consequences analysis” (check the name) (RATEN ICN);
- Regarding the compliance of the report with the PSA End-Users Needs – maybe we need to develop this aspect in the report (RATEN ICN);
- Whenever the ASAMPSA_E topical reports are specified in text, a reference should be given (RATEN ICN);
- The open issues need a separate chapter for all topical reports or they should be included in the conclusions only? The way of presenting them should be decided and should be the same for all topical reports (RATEN ICN);
- Contribution from WP40 (Appendix D) may be included in the actual report (not in appendix);
- Separate the actual methodological proposals from both the rationale and the analysis of existing methods or reports (EDF).

2.3.4.3 Synthesis

Most of active End-users consider that the report provides adequate guidance on biological infestation hazards assessment methodologies and implementation in PSA. Almost all respondents agree with its conclusions / recommendations. However, some improvement needs have been identified:

- what is described in the report needs to be made more specific to biological infestation hazards;
- combined/correlated hazard scenarios should be more developed;
- multi-source scenarios should be more developed (with distinct reference to spent fuel pools);
- more considerations on uncertainties specific to biological hazard is necessary;
- providing examples of assessments may be useful, if feasible.

The recommendations to achieve the report as agreed during the Vienna workshop, are the following:

(1) Consider all technical remarks in the questionnaire answers (see WP10 synthesis, Excel WP10 answers compilation) and in the report review

(2) Provide examples in the report, in particular for LUHS and make the link with D10.3 (real external events)

(3) For a new site, it may be difficult to predict in advance which biological infestation event can occur

(4) Remind that PSA is not the only things to do to reinforce plant safety.

Proposal for follow-up activities as agreed during the Vienna workshop:

(1) Organize a benchmark on existing PSA with regard to LUHS: risk quantification and UHS design comparison (with backfiring examples).

2.3.5 TOPICAL REPORT ON LIGHTNING

"Report 5: Guidance document - Implementation of LIGHTNING hazards in extended PSA" is a joint deliverable of ASAMPSA_E WP21 (Initiating events modelling) and WP22 (How to introduce hazards in L1 PSA and all possibilities of events combinations) that's so called "Technical report ASAMPSA_E / WP21 & WP22 / D21.1 & D22.1 / D22.2-3 report5/ 2016-23".

The report introduces feasible approache based on already existing guidelines dealing with the implementation of external hazards in L1 PSA. In general the report summarizes the lessons learnt from existing standards, existing gaps and possibility for future development with regards to scope of WP21 and WP22. Main outcome of this report is focused on development of extended lightning PSA discussing details regarding implementation of such extended PSA.

The scope of this report is to provide guidance on implementation of LIGHTNING hazards in extended level 1 PSA with aims:

- to update the list, characteristics and modelling of the already introduced external hazards in the existing guidance, in particular with the lightning hazards;
- to identify and promote exchanges of some good practices on the implementation of external events in L1 PSA;
- to outline the approach, structure and content as basis and in a perspective development of extended PSA, in particular to lightning.

The report also includes the End-users' recommendations and results from discussions at the 1st End-Users Workshop hold in Uppsala in May 2014.

2.3.5.1 Answers to the questionnaire

Q52 - Do you consider that the report provides adequate guidance regarding lightning hazards assessment methodologies?

Yes / Total non-blank answers	**No** / Total non-blank answers
9 / 10	**3** / 10

Two respondents (Forsmark and IRSN) answered YES and NO.

If not, please give details about what should be added/ modified. Synthesis of answers:

"The report clearly describes lighting phenomena and presents a list of method that may help the analyst to compute lightning hazard frequency. Nevertheless, there are few information about dangerous events that may be considered when dealing with lightning hazards and the way to assess the SSC list, their failure modes with regards to lightning effects and the way to estimate their failure rate." (IRSN)

"The report give a good basis for the describing the lightning hazards. Some minor comments - the report does not include assessment of other electrical disturbances or events resulting in high voltage surges or high frequencies transferred into the plant. Several events at Forsmark have been based on such failure modes with rather serious consequences. This action should include such failure modes. At least these failure modes should be discussed in the introduction and in the summary of the report." (Forsmark)

"The report doesn't develop enough lightning hazards assessment. Description of the standard KTA 2206 and the criterion for the assessment are missing." (EDF)

""EXISTING GUIDANCE USEFUL FOR LIGHTNING PSA" should be deleted; 1.2 (Scope) contains a text which is more a structure of the document; The flowchart needs to be checked, it seems that the screening part is missing; In appendix 3 - the example given for fragility may be given only as a reference, not necessary to be detailed, since in any case it presents the seism. Instead "open-issues" are mentioned possible further directions for improvement." (RATEN ICN - as FREE comments)

Q53 - Do you consider that the report provides adequate guidance regarding implementation of lightning hazards in PSA?

Yes / Total non-blank answers	**No** / Total non-blank answers
6 / 9	**4** / 9

One respondent (Forsmark) answered YES and NO.

If not, please give details about what should be added/modified. Synthesis of answers:

"Chapter 8 of the report is not enough detailed to be an adequate guidance regarding the implementation of lighting hazards. This chapter is presented summarized now in 8 steps in the report. Only step 4 - fragility analysis is more detailed. In this chapter, it would have been interesting to present an example to illustrate lightning hazards PSA. This example could have been useful to recall, for each step of PSA analysis, the existing guidance that may be used, to list the questions that should be answered when performing lightning hazards PSA and to indicate the limitation of such an analysis and all potential difficulties." (IRSN).

"A discussion should be introduced on lightning hazard as initiator event of PSA to see:
- if this new initiator is not already included in internal event PSA (for instance LOOP initiator)
- or if it has a negligible frequency versus frequency of an equivalent internal initiator event
- or if its consequences are feeble versus consequences of similar scenario in internal event PSA (I&C) damages from lightning strike." (IRSN).

"More focus should be given to nuclear facilities. How lightning hazard was considered in the original design? What are possible accidents due to lightning hazard and what could be the worst consequences?" (JSI)

"The flowchart needs to be checked, it seems that the screening part is missing." (RATEN ICN)

Q54 - Do you consider that the report provides adequate guidance regarding assessment and implementation of combinations of hazards in PSA?

Yes / Total non-blank answers	**No** / Total non-blank answers
8 / 10	**3** / 10

One respondent (IRSN) answered YES and NO.

If not, please give details about what should be added/ modified. Synthesis of answers:

"Chapter 5 and 6 deal with such a subject but these chapters are not finished. In Chapter 6.4, the information given about IAEA Fault sequence analysis Methodology and Extreme Event Analyser Methodology is too general so that we do not really understand how to assess hazard combinations." (IRSN)

"The information on a bit more than half page is very general and more detailed information would be beneficial. Currently one can get similar brief information on possible correlations also from report D21.2." (JSI)

Q55 - Do you consider that the report provides adequate guidance regarding multi-unit assessment for lightning?

Yes / Total non-blank answers	**No** / Total non-blank answers
5/ 9	**4** / 9

If not, please give details about your point of view. Synthesis of answers:

"It does not seem that this subject is specifically stressed as it should be when dealing with lightning hazards. To do so, a specific chapter could be written on this subject and example of dangerous events could be given. Nothing is introduced on that subject in the report." (IRSN)

"There is no chapter for this in the report, possibly because the impact of lightning is localized. This should be mentioned in the scope of the report and in conclusions." (RATEN ICN)

Multi-unit assessment is not mentioned/developed in the report. (JSI/EDF)

Q56 - Do you agree with the conclusions / recommendations developed in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers
8 / 9	**1** / 9

If "No", please indicate which ones and why? Synthesis of answers:

"The report should be improved to better point out the open issues." (EDF)

"Recommendations are too general (for example regarding fragility analysis), also more specifically, "no specificities can be highlighted for lightning hazards L2 PSA". For my point of view, an analysis is needed, before

acceptation of that conclusion, to assess the damages by lightning strikes of containment barriers and mitigation SSC used in severe accidents." (IRSN)

"The conclusion indicates what should still be done, but it has not been explained what have been the obstacles not to include the information into report." (JSI)

Q57 - Do you consider that all open-issues have been correctly identified?

Yes / Total non-blank answers	**No** / Total non-blank answers
7 / 10	**4** / 10

One respondent (Forsmark) answered YES and NO.

If "No", is there something that you wish to add? Synthesis of answers:

"Wild fire induced by lightning: Information on the operating experience for this hazard, how it influences plant safety systems - which initiating events can cause it, is not presented in the report." (JSI)

"It should be noticed that they are not specifically identified in the report as "open-issues", only mentioned as possible further directions of improvement. The way of presenting them should be decided and should be the same for all topical reports." (RATEN ICN)

See comments of previous questions and on the document (IRSN, EDF, Forsmark).

Q58 - Do you consider that the report will be useful in your activity?

Yes / Total non-blank answers	**No** / Total non-blank answers
9 / 10	1 / 10

If "No", please indicate why? Synthesis of answers:

"There are too many open issues." (EDF)

2.3.5.2 Feedbacks from reviewers

Here is presented a synthesis of the main comments and of proposals for the guidance report improvement received from reviewers (EDF, Forsmark, JSI, RATEN ICN).

EDF proposed improvements with the following considerations:

- In most NPPs, protection against lightning "is done at the building level following IEC 62305-3 or KTA 2206. Most buildings of NPPs are in reinforced concrete which plays a part as Faraday cage to conduct and devise lightning current but also as shield against LEMP. Furthermore the lines between buildings are laid in galleries or have beside them equipotential conductor that reduces a lot the overvoltage which may occur. The residual risk from

lightning hazard should be assessed. The methodology has to be built. Regulatory guidance to address design and implementation practices for lightning protection systems in NPPs should be developed. Afterwards an assessment of lightning hazard risk towards extended PSA could be developed";

- "The most of electrical and electronic equipment are in concrete buildings. The earthing network reduces overvoltage on lines between buildings. This protection should be improved to be sure that the NPP is protected against reference level of lightning hazard";

- "Lightning frequency may change with the climate";

- Comparison of methodologies: "The IEC 62305-2 seems to be a method easy to apply but it calculates loss and not risk. Thus a realistic link is to be done between the information which it delivers and L1 PSA issues. Another methodology based on the safety demonstration about lightning resilience seems to be more satisfying but it still needs further work".

From Forsmark, it should be verified that the following lightning phenomena and consequences are included in the report: "case of an indirect cause related to the lightning, namely a switch overvoltage with or without resonance at the plant. The basis for this is a line disconnection in the off-site power because of a ground fault in the of-site power. Another phenomenon is that the lightning affects the ground grid which then affects the NPP".

From JSI - there are mainly corrections in the text and these will be taking into account in the final version.

From RATEN ICN:
- "Paragraph "EXISTING GUIDANCE USEFUL FOR LIGHTNING PSA" should be deleted";
- "Section 1.2 (Scope) contains a text which is more a structure of the document";
- "The flowchart needs to be checked, it seems that the screening part is missing";
- "In appendix 3 - the example given for fragility may be given only as a reference, not necessary to be detailed, since in any case it presents the seism";
- "The "open-issues" are not specifically identified in the report, only mentioned as possible further directions for improvement. The way of presenting them should be decided and should be the same for all topical reports."

2.3.5.3 Synthesis

Most of active End-users consider that the report provides adequate guidance on lightning hazards assessment methodology and a majority of respondents consider it provides adequate guidance for implementation in PSA. Almost all respondents agree with its conclusions / recommendations. Improvements needs have also been identified.

The recommendations to achieve the report as agreed during the Vienna workshop are the following:

(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation by WP10, comments in the report)

(2) Find additional contributors able to complete/improve the report (TUS and VUJE are the main contributors, this is not sufficient on this topic)

(3) Complete the report with Forsmark experience as presented during the Upsalla workshop (many NPP modifications, link with the low power system, ...)

(4) Recognize in the report the difficulty to identify failures scenarios for a NPP, induced by lightning impact, position the topic and discuss how to handle it.

Proposal for follow-up activities as agreed during the Vienna workshop:

(1) In relation with PSA activities (or RIDM) discuss calibration of lightning protections and compare protections solution in different area (data server -e.g. google, military applications, communication devices, airplane traffic, ...).

2.3.6 TOPICAL REPORT ON MAN-MADE HAZARDS AND AIRCRAFT CRASH

"Report 6: Guidance document - MAN-MADE hazards and ACCIDENTAL AIRCRAFT CRASH hazards modelling and implementation in extended PSA - Technical report ASAMPSA_E / WP21 & WP22 / D21.3 & D22.2-3 report6/ 2016-24" consists of the following parts:

- Identification of data for hazards characterization,
- Hazards assessment methodologies consideration,
- Consideration of possible hazard combinations and methods for an assessment of them,
- Structure and solutions for man-made hazards and accidental aircraft crash PSA,
- Solution to model HRA for man-made hazards and accidental aircraft crash PSA,
- Solutions to model additional emergency response (considering mobile equipment and emergency measures),
- Solutions to model multi-unit for man-made hazards and accidental aircraft crash PSA.

It was identified few basic questions that should be answered before performing a man-made hazards and accidental aircraft crash (MM&AAC) PSA in a framework of the study:

- Are there any connections between MM&AAC hazards and other external events, like seismic events, wildfires, etc.?
- What are the connections between MM&AAC PSA and internal event PSA?
- How to take advantage from internal event PSA already done?
- Can MM&AAC initiating events be reduced to internal initiating event or other type of external initiating events already analysed?

It was concluded that an important feature of man-made and aircraft crash hazards is the fact that often either they can induce or they can be associated with other hazards. This leads to the type of analysis when the events under consideration are not independent. Also it was declared that there is no doubt that the aircraft crash PSA should be a part of standard PSA study for external initiating events. The study emphasizes that the need to incorporate other external man-made hazards, like accidents with flammable, explosive or toxic substances strongly depends on the location of the NPP and preventive measures undertaken.

It was concluded that the most dangerous situations are, obviously, combination of hazards (like fire and explosion) and such an analysis should be performed, if possible with the connection to internal events PSA studies already done.

2.3.6.1 Answers to the questionnaire

Q59 - Do you consider that the report provides adequate guidance regarding man-made hazards and accidental aircraft crash assessment methodologies?

Yes / Total non-blank answers	**No** / Total non-blank answers
9 / 9	**1** / 9

One respondent (KAERI) answered YES and NO.

Q60 - Do you consider that the report provides adequate guidance regarding implementation of man-made hazards and accidental aircraft crash in PSA?

Yes / Total non-blank answers	**No** / Total non-blank answers
6 / 8	**2** / 8

If not, please give details about what should be added/ modified. Synthesis of answers:

"FKA as well as other NPPs in Sweden /Finland are not including Air-craft crashes into the PSA. Such events are screened out to be too rare for the plant. We don't support recommendations to add assessment of air-craft crashes into the common PSA. Risk assessment will not gain by adding these scenarios into the PSA. See more information in the Forsmark review report." (Forsmark)
"The man-made hazards and accidental aircraft assessment are closely related to security. Accordingly, PSA should be implemented in a safety-security common framework. Do we currently have such a framework (including an estimation of occurrence probabilities in the PSA framework)?" (KAERI)

Q61 - Do you consider that the report provides adequate guidance regarding assessment and implementation of combinations of hazards in PSA?

Yes / Total non-blank answers	**No** / Total non-blank answers
7 / 8	**1** / 8

If not, please give details about what should be added/ modified. Synthesis of answers:

The same as above response from KAERI (see Q60).

Q62 - Do you consider that the report provides adequate guidance regarding multi-unit assessment for man-made hazards and accidental aircraft crash? If not, please give details about your point of view.

Yes / Total non-blank answers	**No** / Total non-blank answers
8 / 8	**0** / 8

Q63 - Do you agree with the conclusions / recommendations developed in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers
8 / 9	**1** / 9

If "No", please indicate which ones and why? Synthesis of answers:

"See comments to question 60" (Forsmark)

Q64 - Do you consider that all open-issues have been correctly identified?

Yes / Total non-blank answers	**No** / Total non-blank answers
5 / 7	**2** / 7

If "No", is there something that you wish to add? Synthesis of answers:

"See the above comments." (KAERI) "It is necessary to complement the "List of open issues" in accordance with what it identified earlier in the report." (ZNPP)

Two organizations (Forsmark and RATEN ICN) have given no YES-NO answer but provided-comments.

"…FKA lack statements regarding the quality of data for assessing these events in a common PSA that will be used for different risk metrics." (Forsmark) "The open issues (specified at 14.) seems to be mainly related to aircraft crash, it is necessary to have something specific to man-made hazards in general; there are open issues specified also in HRA chapter - they need to be summarized in one place (the same for all topical reports)." (RATEN ICN)

Q65 - Do you consider that the report will be useful in your activity? If "No", please indicate why?

Yes / Total non-blank answers	**No** / Total non-blank answers

8 / 8	**0** / 8

2.3.6.2 Feedbacks from reviewers

Many proposals and comments have been received from Forsmark, SSTC NRS, JSI, SE "Zaporizhzhya NPP" and RATEN ICN. Only most important ones are presented here.

"It seems reasonable to consider and refer to NEI 07-13, "Methodology for Performing Aircraft Impact Assessments for New Plant Designs," Revision 8, Nuclear Energy Institute, Washington, DC, April 2011 in the Report. This document specifies a number of uncertainty sources during aircraft impact evaluation." (SSTC NRS)

"The flowchart needs to be discussed - to decide if we need detailed analysis as a separate step. In any case, we need to be consistent within all the reports with the diagram steps." (RATEN ICN)

"Check the relevance of Appendix 3 for the report - text provided does not seem related to emergency response." (RATEN ICN)

2.3.6.3 Synthesis

Most of active End-users consider that the report provides adequate guidance on man-made hazards and accidental aircraft crash assessment methodologies and implementation in PSA, agree with its conclusions / recommendations and find it useful for their activities. However, one respondent (Forsmark) does not support recommendations to add assessment of air-craft crashes into the common PSA. Open issues seem to be mainly related to aircraft crash, it is necessary to have something specific to man-made hazards in general.

The recommendations to achieve the report as agreed during the Vienna workshop are the following:

(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop , questionnaire answers and their compilation in excel by WP10, comments in the report)

(2) Consider NEI 07-13 Methodology aircraft Impact assessment for new plant design

(3) Include Koeberg NPP experience in the report (proposed by EDF that can contact them)

(4) In the recommendations: discuss in an open way the need to develop an aircraft crash PSA (depend from one site to the other - see airplane traffic) and identify open issues for man-made hazards

2.4 SPECIFIC ISSUES RELATED TO L2 PSAS

2.4.1 IMPLEMENTATION OF EXTERNAL EVENTS MODELLING IN EXTENDED L2 PSA

Report "External Events in L2 PSA - Technical report ASAMPSA_E/WP40/D40.4/2016-14" provides guidance in the implementation of external events modelling in extended L2 PSA and is a complement of the ASAMPSA2 guidelines in this area.

It concludes that:

- from the point of view of procedures/methods/approaches used currently in L2 PSA, there is no need of new methodologies in terms of plant damage states (PDSs), accident progression event trees development and evaluation;
- the present guidelines identify the need of additional vulnerability/fragility analyses of systems, structures and components (like spent fuel pool, reactor containment, instrumentation, filtered containment venting system, etc.) needed for severe accident management (SAM) strategies application in relation to all external hazards of various degrees of loads and intensity. From the point of view of HRA more and higher stressors should be taken into account, e.g. within HRA models that use shaping factors;
- from the point of view multi-unit site analyses, it was concluded that no practical methodology exists to treat the problem, no completely INDEPENDENT units on sites with several units are in operation, new methodology is necessary to be developed, simplification of models is inevitable;
- from the point of view of proper analysis of results, it was found to be useful to assign one additional identification character to the PDS codes keeping track of each and every internal and external hazard in order to make it possible to analyse at the end the contributors to the total risk by initiator related to the given PDSs;
- from the point of view of proper analysis of results an application of proper risk metrics is necessary in order to make the best possible use of the PSA findings, especially to identify the main sources of risks and to support well founded decision making. In this respect an integral risk metric like e.g. the common risk target (CRT) method could be helpful.

2.4.1.1 Answers to the questionnaire

Q66 - Do you consider that the report provides adequate guidance regarding implementation of external hazards into Level 2 PSA?

Yes / Total non-blank answers	**No** / Total non-blank answers
10 / 11	**2** / 11

One respondent (KAERI) answered YES and NO.

If not, please give details about what should be added/ modified. Synthesis of answers:

"This report presents some technical issues related to the implementation of external events into L2 PSA without real distinction between hazards and without gradation of the analysis depth according to the importance of risks.
Potential Impacts (if any) of external events on Source Term evaluation and release categories definition are not addressed in this report (except for multi-unit site analysis).
Proposal for a L2 PSA for multi-unit site seems interesting but needs further developments to be used as it is presented.
The part of the report on the DiD should be put in report WP30/D30.4." (EDF)

"Relating to the L2 PSA for External Events, the report seems be missing the two following items:
1. HRA methodologies should be defined and developed for external events L2 PSA
2. Accident progression analysis methodologies should be defined and developed for multi-units L2 PSA." (KAERI)

One organization (LEI) who answered "YES" also provided the following comment:

"Quite strong statements (self-criticism) regarding PSA can be unusual for non PSA experts. Examples: In spite of the IAEA definitions and requirements, the results are currently depending on PSA objective, and "risk" evaluation complying with one of the IAEA fundamental principles is currently performed in various ways because there is no common understanding of the "adverse effect". The deficiency related to L2 PSA results is, that no common harmonized risk comparative parameter (safety goal) exists to compare the level of safety. As a surrogate, currently a frequently used parameter is LERF (Large Early Release Frequency), which is only semi-quantitative without an exact definition of "Large" and "Early" without harmonized values of frequency throughout the European countries." (LEI)

Q67 - Do you agree with the conclusions / recommendations developed in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers
10 / 11	**1** / 11

If "No", please indicate which ones and why?

"We don't think that fragility analyses should be performed for all hazards and all SCCs: it is neither economically nor technically feasible. Proposal for a L2 PSA for multi-unit site seems interesting but needs further developments to be used as it is presented." (EDF)

Two organizations (LEI and STUK) who answered "YES" also provided the following comment:

"Our view is that L2 does not require additional (compared to L1 PSA) methods or tools for external hazards." (STUK) "Taking into account the specific PSA end-users needs, namely "ASAMPSA_E shall address methodology for simultaneous accident progression in core and SFP" (and the issue, that "this wish by end-users cannot be addressed because a common approach for accidents in core and in SFP has not yet been developed. No state-of-the-art exists, and it would be premature to define something like "best practice") there is possible to mention the ongoing relevant deterministic research and conclude/recommend for the future to pay more attention to this important issue." (LEI)

2.4.1.2 Feedbacks from reviewers

Proposals and comments have been received from EDF, KAERI, LEI and STUK. Only most important ones are presented here.

End-user recommendations or wishes sometimes exceed current development and research.

Interest for integrated or separate model: the report should give also recommendations related to the need of several types of models (wrong decisions, lack of best estimate data, uncertainties, low validity data).

Recommendations for new methods should be supported by reference to demonstration case (e.g. multi-units).

The end users do not support methods/analyses which are neither economically nor technically feasible (e.g. that fragility analyses should be performed for all hazards and all SCCs).

For research conclude/recommend for the future to pay more attention (e.g. methodology for simultaneous accident progression in core and SFP).

2.4.1.3 Synthesis

Most of active End-users consider that the report provides adequate guidance regarding implementation of external hazards into Level 2 PSA and agree with its conclusions / recommendations. Proposal for a L2 PSA for multi-unit site seems interesting but needs further developments

The recommendations to achieve the report as agreed during the Vienna workshop are the following:

(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation in excel by WP10, comments in the report)

(2) Promote "graded" approach for the development of L2 PSA for external events

(3) Introduce the discussion on low quality data for rare IE events (natural hazards) and how it should be considered for L2 PSA development (shall we exclude such IE from L2 PSA?, how to be consistent in risk metrics applications? Shall ASAMPSA_E promote full-scope integrated PSA (all IE in one PSA) or promote separated PSA (one PSA for each type of IE, to avoid mixing situations with different quality in IE data))

(4) Comment more precisely the choice to be done between L1-L2 integrated or separated methodologies in the context of external hazards

Workshop thinking for follow-up activities:

(1) It appears that a limited experience in external IE L2 PSA exists. This topics shall be considered later for international cooperative actions.

2.4.2 OPTIMISATION OF SAMG STRATEGY BY L2 PSA

The report “Guidance on the verification and improvement of SAM strategies with L2 PSA - Technical report ASAMPSA_E / WP40 / D40.5 / 2016-16” proposes a comparison of objectives in the different countries in terms of SAM strategies verification and improvement. The report summarizes also experience of each partner, addressing:

- SAM modeling in L2 PSA;
- Positive and negative aspects in present SAM practice;
- Discussion on possible criteria related to L2 PSA for verification and improvement;
- Review with a perspective of verification and improvement on the main SAM strategies;
- SAM strategies to be considered in context of an extended L2 PSA.

The report is developed by the partners’ experience and contains following parts:

- Introduction;
- High level objectives of SAM strategies verification and improvement;
- Identification of SAM strategies;
- Technical features of a L2 PSA for SAM strategies verification and improvement;
- Conclusion / Recommendations.

Main recommendations/conclusions of the report are related to the following:

- Emergency team activation, rooms habitability, instrumentation,
- Human actions,
- Feeding steam generators with water,
- Corium cooling / water injection strategy,
- RPV depressurization,
- Control of flammable gas,
- Containment function (isolation, ventilation/filtration of auxiliary buildings …),
- Containment pressure control,
- SAM strategies for SFP.

2.4.2.1 Answers to the questionnaire

Q68 - Do you consider that the report has successfully covered every useful aspects of the topic?

Yes / Total non-blank answers	**No** / Total non-blank answers
8 / 9	**1** / 9

If "No", please give details about what should be added/ modified. Synthesis of answers:

"Our conclusion from reading and assessing the report - the most important part for the PSA team supporting SAMG -development - will be to confirm that the latest knowledge related to understanding severe accident phenomena is used in the level 2 PSA, in the FSAR and in the development of SAMGs. It is important that all these information is consistent and accepted by all. In areas with large uncertainties or were disagreement is valid it will be of importance to initiate projects or research to come to common positions. Our comments also reveal areas we do not fully support the recommendations in the report. The report with detail comments will be sent to you. A more common European praxis has to be developed similar to the US FLEX strategy." (Forsmark)

One organization (SSTC) who answered YES also provided the following comment.

"It is recommended to provide some specifics related to equipment qualification for SA conditions. This question is important in terms of potential failure of unqualified equipment to perform its intended function and considering these failures in PSA-2 and SAMGs." (SSTC)

Q69 - Do you agree with the conclusions / recommendations developed in the report?

Yes / Total non-blank answers	**No** / Total non-blank answers

8 / 9	**1** / 9

If “No”, please indicate which ones and why? The same comment as above was made by Forsmark.

2.4.2.2 Feedbacks from reviewers

Many proposals and comments have been received from ENSI, Tractebel and Forsmark. Only most important ones are presented here.

“Additional information about re-evaluation of hydrogen hazards in 2014 for Switzerland NPPs was added” (ENSI).

Question to EDF L2 PSA modelling related to radiological analyses for room habitability: “Is the check for radiological feasibility valid for all time frames or only for a specific one (e.g. before venting, or before reactor vessel failure)?” (ENSI)

Question from Tractebel to actions related to prevent containment failure due to DCH or vessel uplift: “Also pressure pic in containment due to RCS content blow-down at vessel failure? Included here?”

Question from Tractebel to actions related to SAM for ex-vessel phase: “Is a “containment depression” possible and worth considering here?”

Question from Tractebel to chapter 4.11 “SAM strategies for spent fuel pools (SFPs)”: “How about dry storage?”

"Information of Swedish practice and BWR information is missing" (Forsmark).

2.4.2.3 Synthesis

Most of active End-users consider that the report successfully covers the topic and agree with its conclusions / recommendations.

The recommendations to achieve the report as agreed during the Vienna workshop are the following:

(1) Take into account the reviewers' comments

(2) ENSI proposes to provide information for H2 management on Switzerland NPPs (the Authors shall contact ENSI)

(3) Add risk of excessive pressure peak in the containment in case of RCS content blow-down

(4) Complete the reports for BWRs SAM (the author shall contact FKA)

(5) Complete the report with details on the FLEX approach (example of application Slovenia, Spain, in addition to US - the authors shall contact JSI and IBERDROLA)

(6) Remind that research shall be promoted where uncertainties are too high

(7) Complete the report on equipment qualification issues.

The following issues have been identified and agreed during the Vienna workshop for follow -up actions:

(1) Practices exchanges on SA qualification: which environmental conditions shall be defined,

(2) Implementation of FLEX strategy and link with L2 PSA

(3) Dry spent fuel storage risk assessment.

2.4.3 COMPLEMENT FOR SHUTDOWN STATES OF REACTORS, SFP AND RECENT R&D RESULTS

The objectives of the report "Complement of existing ASAMPSA2 guidance for shutdown states of reactors, Spent Fuel Pool and recent R&D results - Technical report ASAMPSA_E / WP40 / D40.6 / 2016-25" are to provide following:

- complementary guidance for Level 2 PSA for the shutdown states of reactors;
- complementary guidance for the modelling of risks associated to the spent fuel pools;
- and information on the recent Research and Development (R&D) useful for Level 2 PSA development.

The report aims at completing the existing ASAMPSA2 guidance for L2 PSA

- in part of shutdown states:

- Accident sequences with RPV head closed,
- Accident sequences with RPV head open.

- in part of Spent Fuel Damage:

- Fuel degradation process, including energy and fission product release from melting spent fuel into containment;
- Hydrogen generation in spent fuel pool and its distribution in containment;
- Heat load from the melting spent fuel to structures above (e.g. to the containment roof);
- Release pathway for radionuclides from degrading spent fuel to environment;
- Concurrent accident progression in spent fuel pool and reactor system;
- Core concrete interactions for spent fuel pool accidents;
- Criticality;
- Safety assessment of spent fuel pool during decommissioning.

- and in part of recent R&D:

- Analysis of fuel melt process in spent fuel pool with integral code (e.g. MELCOR);
- Deterministic and probabilistic analysis of accidents caused by external hazards in full power state;
- Conditional probability of containment loss of tightness after an earthquake;
- Source term assessment for L2 PSA;
- Analysis of the complexity of severe accident phenomenology by code simulation, ASTEC and MELCOR;
- Analysis of heavy load drops into the SFP;
- Investigation of the IVR by external cooling of reactor vessel for VVER-1000 type reactors;
- Accident progression and possible off-site consequences;
- Spent Fuel Pool Rupture Characterization Based on Water Level Monitoring.

Main recommendations/conclusions of the report are related to the following:

- Accident sequences with RPV closed,
- Accident sequences with RPV open,
- Containment issues,
- Reactor - SFP interactions,

- SFP melt interaction with surrounding buildings,
- Particular heat transfer mechanisms for SFP,
- SFP melt interaction with building atmosphere.

2.4.3.1 Answers to the questionnaire

Q70 - Do you consider that the report has successfully covered every useful aspects of the topic?

Yes / Total non-blank answers	**No** / Total non-blank answers
8 / 9	**1** / 9

If "No", please indicate which ones and why? Synthesis of answers:

"About the Spent Fuel Pool part, it would be preferred to get some suggestions/propositions on the fission product release assessment, given the fact that the calculation codes are not always of satisfying performance regarding this." (Tractebel)

Q71 - Do you agree with the conclusions / recommendations developed in the report? If "No", please indicate which ones and why?

Yes / Total non-blank answers	**No** / Total non-blank answers
9 / 9	**0** / 9

Q72 - Do you identify additional topics which would need further activities?

Yes / Total non-blank answers	**No** / Total non-blank answers
3 / 9	**7** / 9

One respondent (Forsmark) answered YES and NO.

If "Yes", please indicate which ones and why? Synthesis of answers:

"SFP: A guidance for probabilistic accident progression modeling in case of SFP accidents (i.e., SFP Level 2 PSA)." (KAERI) "Based on our experiences we still consider it is more important to focus future research and development into other areas related to level 1 PSA for operation state than those listed in this report." (Forsmark)

2.4.3.2 Feedbacks from reviewers

Many proposals and comments have been received from Tractebel, SARNET and IRSN. Only most important ones are presented here.

"On what can we base ourselves for the FP release quantification and categorization, in practice? On MELCOR calculations, for instance? Because I understood from Spent Fuel Pool projects that the fuel degradation

progression and FP releases are not easy to model by calculation codes, and the results are with quite high uncertainty." (Tractebel)

SARNET to §4.1.2 about ASTEC and MELCOR: "Probably the text could be shortened since it describes general features of both codes. Moreover it includes some SARNET2 outcomes that should be replaced by CESAM/FP7 ones. It is maybe better to underline only the recent modelling improvements, let us say since ASAMPSA2's end (thus from 2014 to 2016)".

SARNET to §4.1.3 about IVMR:

- "Here only the INRNE work in last years is described. Their work does not really represent a consensus or an exhaustive view on recent R&D, it is more an example of the type of work that is being performed with ASTEC on a VVER-1000. Does such example give really an increase in value to ASAMPSA_E community?"
- Page 63, lines 12-21: "useful to present some work planned in future in the IVMR/H2020 project?"
- "We suggest adding (in the final report) some outcomes on R&D main needs coming from the international Workshop in Aix-en-Provence in early June. IRSN is currently writing a 10-page paper that could be used as basis."

SARNET to §4.1.4 about source term:

- "The whole § has been entirely taken from Ref.56, with very little reprocessing: maybe it should be more explicitly explained…"
- Page 64, last statement of 2nd paragraph "This will be treated …": "useful to present some work planned in future?"
- "§4.1.4.8 is entirely focused on ASTEC (logical since PSA2 results from IRSN). But other codes, like MELCOR, COCOSYS and even MAAP, are also doing an effort to update source term models according to the latest results obtained in PHEBUS and since then. It is a rather partial view that distorts a bit the actual situation. Maybe a few short sentences should be added in this sense."

SARNET about ex-vessel corium behavior:

- "Many reports were published since 2012: SOAR/MCCI, OCDE/SERENA-2 project, papers published at ERMSAR-2013 and 2015 (SES/PULIMS tests, MOCKA tests, debris bed coolability…)."
- §4.3 on knowledge gaps and future needs : "the SAFEST/FP7 roadmap and the OECD TOP on steam explosion could be added."

SARNET §4.2 about SFP:

- "While ASAMPSA_E recognizes the importance of filling large knowledge gaps for accidents at SFPs, not much is indeed done beyond the identification of areas to be further developed or investigated. Concerning thermal-hydraulics, phenomena related to de-watering, hydrogen generation, fuel degradation and possible release pathways are only briefly mentioned.
- Concerning the treatment of criticality safety, fundamental aspects are dealt with very briefly for PWR types, and only marginally for BWRs that are characterized by a potentially higher risk level.
- While the SFP damage frequency may be lower than for reactor cores, the health consequences of severe accidents to SFPs may be higher.

- §4.2.3 and 4.2.4 could be merged under the title "Simulation tools" with 2 parts, one on CFD and one on severe accident codes (or other solution: their titles should be clarified, e.g. §4.2.3 as “CFD simulation tools”).
- §4.2.4: it seems that some useful conclusions from the proceedings of the last seminar of the OECD/NEA SFP Project are missing.
- Some comments should be added on the high uncertainty that remains about simulation codes. Particularly, when comparing codes in AIR-SFP (see just below), we see that everything is quite uncertain and that even little assumptions by the code user lead to substantial differences in the results. By the way it is not a code issue, since the same code produces rather scattered results depending on the model built by the user.
- An overview of recent or ongoing research in the area of safety of SFPs is included, even if it cannot be considered exhaustive. For example, the AIR-SFP R&D project in frame of NUGENIA+/FP7 (that ends in Sept.2016) should be briefly mentioned in §4.2.5.”

2.4.3.3 Synthesis

Most of active End-users consider that the report successfully covers the topic and agree with its conclusions / recommendations. Improvement needs have been pointed out. In particular, It would be preferred to get some suggestions / propositions on the fission product release (from SFP) assessment, given the fact that the calculation codes are not always of satisfying performance regarding this. Section 4 is not enough complete and not quite up-to-date: additional R&D related information should be provided.

The recommendations to achieve the report as agreed during the Vienna workshop are the following:

(1) Consider all reviewers' comments (WP10 synthesis presentation during the workshop, questionnaire answers and their compilation in excel by WP10, comments in the report)

(2) Provide some order of magnitude of Source term assessment in case of SFP accident and explanation on the technical basis to be used, describe better the accident progression in case of SFP accident

(3) Complete the application of PSA with Forsmark experience: yearly application of PSA for each outage: risk management for the operations to be done depending on which system is (un)available during outage

(4) For integral codes to be used for source term assessment, complete the information available on ASTEC by information equivalent for MAAP and MELCOR

(5) Provide information from the AIR-SFP project (this should end in September 2016)

(6) Indicate in which condition the spent fuel can be cooled with air circulation (contact NRG which has performed recently an assessment)

(7) Contact SARNET management board for the complements to be added on recent R&D results

(8) Indicate additional specific SFP configurations example (e.g. 2 SFP in a same reactor hall - VVER440).

Proposal of issue for follow-up actions agreed during the Vienna workshop:

(1) Which conditions allow SFP stabilization in case of accident?

3 GENERAL EVALUATION AND FOLLOW-UP ACTIVITIES

3.1 GENERAL EVALUATION

Q73 - Do you consider the overall ASAMPSA_E documentary structure is suitable?

Yes / Total non-blank answers	**No** / Total non-blank answers
13 / 13	**2** / 13

Two respondents (EDF and Forsmark) answered YES and NO.

If "No", please indicate why?

"Globally, the overall structure is suitable. The six hazards families' reports which group information about hazard characterisation and PSA modelling are especially welcome. However, this structure makes complicated the writing of methods, characteristics, common to several, but not all, hazards." (EDF)

"... There is a lack of a report giving an overall strategy for expanding PSA level 1 and 2 into an extended PSA. It is important to position the purpose for this expansion and what is the gain by doing such expansion.
It will be of importance to specify overall and common demands on the extended PSA. These demands shall be enough detailed to be able to understand if the proposed methodologies fulfil these demands.
It will be of importance to specify demands related to collect data in one model as well as requirements/quality of data for accepting to enter into the used model.
It will also be of importance to understand the value of assessing the external and internal hazards in a PSA or by risk methods compared to using deterministic assessment or design criteria. It is important to understand in which way the PSA complement and support the FSAR assessments. It is important to understand the benefits to be able to support the cost and time related to develop best estimate data.
When such report is developed it will also be of importance to assess if the presented methodologies can support the demands.
On the other hand it is difficult to understand why the reports on DiD are included." (Forsmark)

One organization answered YES and provided the following comment:

"Nevertheless, some possibilities for improvement have been identified by Bel V (see Bel V comments in the WORD documents and in this questionnaire)." (BEL V)

Q74 - Do you consider that some Type A End-Users recommendations (see Appendix 1) are not sufficiently addressed?

Yes / Total non-blank answers	**No** / Total non-blank answers

5 / 9	**4** / 9

One respondent (LEI) answered YES and NO.

If not, what recommendations you feel not treated with enough details?

EDF sent a document where End-User recommendations that are not, or not sufficiently, addressed and that EDF considers interesting to address in the future are identified.

Forsmark also sent an exhaustive review of the coverage of the end-users recommendations in ASAMPSA_E-reports. This review is included in Appendix 3.

The following recommendations are highlighted by respondents:

- R1: which type of cost/time analysis is acceptable to limit resources needed for external/internal hazards PSAs (EDF, Forsmark)
- R4: internal fires, floods and explosions, heavy load drops, high energy line break (HELB), missiles, chemical releases (EDF)
- R8 (Type B/C): Provide guidance to model long lasting accident (RATEN ICN)
- R9: methodology for simultaneous accident progression in core and SFP (EDF, RATEN ICN, LEI: should be "possible to mention the ongoing relevant deterministic research and conclude/recommend for the future to pay more attention to this important issue")
- R11: discuss the level of conservatism (same level in all PSA parts …?) (EDF, Forsmark, RATEN ICN)
- R12 (Type B): guidance on the place of extended PSA in risk informed approach and decision-making. How to consider hazards if related PSA are not mature yet? (EDF)
- R13: Guidance on results presentation / interpretation / use (EDF, RATEN ICN)
- R14 (Type B): PSA "capability" concept (closely associated with PSA application) may be used instead of quality (EDF)
- R15: how to include mobile equipment in PSA (EDF, Forsmark, RATEN ICN)
- R17: clarify the vocabulary on "mission time", "scan time" (EDF)
- R18: how and when "seasonal PSA (winter/summer)" must be developed (EDF, Forsmark, RATEN ICN)
- R19: existing screening guidance have to be adapted or completed for each application. ASAMPSA_E shall examine why and how to do this adaptation/complement/ examine how to reduce heterogeneity in quantitative screening (Forsmark with the following comment: "More precise criteria is requested that are less subjective to the user)
- R21: examine PSA practices for modelling induced internal floods and internal fires (EDF)
- R22: examine SFP accident screening practices (EDF)
- R23: discuss link between screening criteria and design basis conditions (Forsmark)
- R25: examine what to do if the sciences cannot provide information for low frequencies events or extremely high uncertainties on their amplitude (Forsmark: "…There is a lack of overall strategy related to this issue …. This is one of the main issues for the Extended PSA")
- R26: deficiencies on internal hazards modelling shall be covered in ASAMPSA_E (EDF)

- R28: existing methods for external hazards modelling shall be presented and compared including uncertainties (Forsmark: "OK- This action is performed. On the other hand Forsmark lack a consistent review of the methods and its affect in a common PSA and on risk metrics. This includes also a characterization of the degree of conservatism and uncertainties the different methods give")
- R30: ASAMPSA_E shall introduce the effects of climate changes and present available methodologies. Need for updating PSA (Forsmark, RATEN ICN)
- R34: in a region with low seismicity like Sweden, an earthquake M 8 is "possible" (and observed in paleo history) with a return period 1 million years …ASAMPSA_E shall examine how can such information be presented in a PSA Forsmark: "…we lack recommendations related to seismic PSA for areas with low level of seismic activities….")
- R35: insist on the need to update periodically the design-basis hazards curve (Forsmark)
- R36: identify some best practices for external hazards SCC fragility analysis (EDF, Forsmark)
- R37: examine (on examples) importance of non-safety systems (ex. in extreme cold T° conditions, ventilation) (EDF, FORSMARK)
- R41: guidance on induced internal hazards: potential source of conservatism (if included), of non-conservatism (if not included) (EDF, Forsmark)
- R47: examine existing containment venting strategies optimization versus L2PSA results (Forsmark: "ASAMPSA_E is only partly covering this issue and there is a need for more work related to this issue")
- R54: examine HRA modelling demand for multi-unit PSA (EDF)
- R56: how to improve HRA modelling for external hazards conditions (EDF)
- R57: ASAMPSA shall examine methodologies to develop modelling of "warning" for slowly developing external events (EDF, Forsmark, RATEN ICN)
- R60: ASAMPSA_E guidance shall explain how to introduce in L1-L2PSA a more diverse modelling of internal and external electrical disturbances (Forsmark).

Q75 - Do you consider that the project reports meet the initial needs identified by End-Users?

Yes / Total non-blank answers	**No** / Total non-blank answers
10 / 12	**2** / 12

If "No", please indicate why?

"The reports meet only partially the initial End-Users needs. Several End-Users recommendations have not been addressed (see Q74). The main reason seems to be the very large scope of the ASAMPSA_E Project compared to limited budget and resources." (EDF)

Q76 - Are you going to use the project deliverables?

Yes / Total non-blank answers	**No** / Total non-blank answers
13 / 13	**1** / 13

One respondent (Forsmark) answered YES and NO.

If “Yes”, please indicate which ones?

“All of them.” (INRNE, Risk Pilot Ab).
“External hazards evaluation methodologies; PSA modelling approaches; other." (SSTC NRS)
“…mostly those related to level 1 PSA.” (RATEN ICN)
“Mainly guidance documents on specific hazards (Extreme weather, Seismic, etc.).” (AREVA GmbH)
“List of external hazards to be considered in ASAMPSA_E” (Zaporizhzhya NPP, with a focus on combinations of external hazards)
”Methodology for Selecting Initiating Events and Hazards” (SSTC NRS, Tractebel, KAERI)
“Review of existing practices to model and implement SEISMIC hazards in extended PSA” (KAERI, Tractebel)
“Implementation of SEISMIC hazards in Extended Level 1 PSA” (AREVA GmbH, Tractebel)
“Practices to model and implement MAN-MADE HAZARDS AND AIRCRAFT CRASH in extended PSA” (Zaporizhzhya NPP)
“External Events in L2 PSA” (KAERI)
“Guidance on the verification and improvement of SAM strategies with L2 PSA” (KAERI)
“Complement of existing ASAMPSA2 guidance for shutdown states of reactors, Spent Fuel Pool and recent R&D results” (KAERI)
“Link between the Defense-in-Depth Concept and Extended PSA” (KAERI)
“Risk Metrics and Measures for an Extended PSA (including Multi-units and site level risk metrics)” (KAERI, SSTC NRS, Tractebel)
“…the project deliverables provide a library of research documents and provide good state of the art knowledge. So EDF would use the deliverables considering they have status of research documents.“ (EDF)
“The ASAMPSA_E documents which have been examined by Bel V within the context of this review will very probably be used for extension of the PSA models. …The interest for the other documents will be assessed during further assessment of the documentation (later).” (Bel V)
“Can not identify yet. Documents are suitable as reference material.” (STUK)
“We will assess the report when they have been up-dated and assess if some of the recommendations will be used.” (Forsmark)

If “No”, please indicate why?

“… as previously mentioned (see § 5.1.3 of the questionnaire), the documents related to DiD (D30.4) will not be used for the time being.” (Bel V)
“It is doubtful is some specific recommendations will be used.” (Forsmark)

3.2 FOLLOW-UP ACTIVITIES

Q77 - Do you identify some areas or open issues that need follow-up activities (additional guidance, benchmarking exercise, development/comparison of tools or methods, research project …) in order to improve the quality and the applicability of PSA studies?

Yes / Total non-blank answers	**No** / Total non-blank answers
8 / 13	**5** / 13

In case of a positive answer, please specify which areas and what type of activities.

Several open issues are identified in the reports (indicated in appropriate reports in part of "Limitations and gaps") are already long-term projects. (SSTC NRS, STUK)

“Methodology for simultaneous accident progression in core and SFP” (RATEN ICN); “guidance (methods) to perform a single model of PSA level 2 for the reactor and spent fuel pool (in case if spent fuel pool is located inside the containment)” (Zaporizhzhya NPP).

“Methodologies for multi-unit sites L1-L2 PSA.” (RATEN ICN)

“Modelling long-lasting accident progression (extended analysis times in the reliability models, consideration of recovery possibilities, mobile equipment, HEP).” (RATEN ICN)

“PSA for internal hazard, mainly fire.” (EDF)

“Assessment of human performance following extreme external events; -HRA in case of external hazards combinations occurrence.” (RATEN ICN)

“L2 PSA guidance on assessment of releases into the waters and ground and related source term characteristics.” (RATEN ICN)

“Treatment of uncertainties (for combination of external hazards, rare events).” (RATEN ICN)

“Risk aggregation.” (EDF)

“Risk-informed decision process. Best practice to use PSA, to interpret and present the results” (RATEN ICN); “Risk-Informed Applications and PSA model capability (in relation with recommendation R13 not sufficiently addressed)” (EDF).

“DiD topic is important for the whole industry” (RiskPilot Ab); “Practical PSA modelling for DiD assessments (optimize the safety performances of nuclear installations)” (RATEN ICN).

LEI has also mentioned the following project:

PROJECT TITLE: Time-dependent Risk Estimation Considering Uncertainty in Reliability (Abreviation: T-RECUR)
Technical issues that the project is addressing for the European nuclear industry:
- New NPPs design; Aging of plants; Plant life management;

- Integrated risk-informed decision making;
- Uncertainty in reliability data;
- Risk monitoring;

Work Breakdown Structure:

- Review of State-of-the-Art methods
- Improvement of methods for parameters estimation
- Software tools and/or models development for demonstration of application
- Guidelines preparation for time-dependent risk estimation

Q78 - In the event of a new proposal on this topic, are you interested to participate?

Yes / Total non-blank answers	**No** / Total non-blank answers
12 / 12	**0** / 12

Comments

"We will be glad to participate in new proposals." (INRNE)

"The interest on these topics is the view of EDF's researchers and PSA experts. So at this stage we cannot guarantee that EDF Decision Committees would allocate resources for working on these topics." (EDF)

"Depends on the topic and resources." (STUK)

3.3 FREE COMMENTS AND PROPOSAL

From EDF: "The ASAMPSA_E reports under review contain a lot of information and could be considered as state-of-the-art review rather than practical and industrial guidance.

Feasibility of some proposals should be assessed and their benefit to safety be demonstrated (e.g. the hazard screening process).

As this project was dominated - in number - by organizations which are not NPP Operators, EDF considers that some chapters of the deliverables are far away from industrial reality. Some partners may have find few interest in recommendation number one about "acceptable cost/time analysis to limit resources needed for external and internal hazards PSAs".

For example, EDF does not completely agree with the definition of what should be an extended PSA.

"An extended PSA (probabilistic safety assessment) applies to a site of one or several Nuclear Power Plant(s) (NPP(s)) and its environment. It intends to calculate the risk induced by the main sources of radioactivity (reactor core and spent fuel storages, other sources) on the site, taking into account all operating states for each main source and all possible relevant accident initiating events (both internal and external) affecting one NPP or the whole site." If the 2 words "all possible" were replace by the 4 words "the most risk significant", the definition would be more realistic.

In terms of editorial quality and report presentation, we would suggest:

- to check the use of American or British English
- to reorganize the list of references in the reports (e.g. public (IAEA, US NRC, WENRA...), conference proceedings, technical reports, ASAMPSA project specific references...), and check if they are up-to date and publicly available
- to restructure some report chapters into explicit sub-sections to facilitate reading
- to separate the actual methodological proposals from both the rationale and the analysis of existing methods or reports."

From Bel V: "It seems that in the technical guidance documents made for each hazard, several elements are practically the same (which is logical). For instance (not checked in all documents): the different steps of the PSA (with flow chart), the way of dealing with hazard combinations, the description in §2.3.6 of the document on extreme weather about *HazardLite* which refers to earthquakes to illustrate some principles...
Some suggestions are given hereafter.
1) It should be verified if the approach proposed for each hazard is consistent with the other ones.
2) A kind of synthesis document could be made to integrate the common elements of all documents (some aspects are maybe in a more detailed or better way explained in one of the documents).
3) In this synthesis document, the main differences or specificities for certain hazards could be highlighted.
In some but not all ASAMPSA_E reports, a list of definitions is given. For example:
- in D30.3, section 3, definitions are given which are used or introduced in this and other ASAMPSA_E documents;
- in the 6 Topical Reports, a general list of IAEA and USNRC definitions is added;
- in D30.6, a "Glossary" with still other definitions is given, without repeating the definitions of D30.3 (although that would have been very useful for D30.6).
Hence, a suggestion could be to create a separate deliverable "Glossary", in which all definitions are grouped, and which is used as a reference for all other ASAMPSA_E deliverables."

From RATEN ICN: "General comments:
-Whenever the ASAMPSA_E topical reports are specified in text, a reference should be given.
-Regarding the compliance of the report with the PSA End-Users Needs - maybe we need to develop this aspect for all the reports (D40.4 report has an appendix for it)
-For all topical reports - The results of sensitivity analysis should be used to provide relevant information on the influence of different sources of uncertainty on the PSA results. Where is included the sensitivity analysis or it has not been taken into account?
-The open issues need a separate chapter for all topical reports or they should be included in the conclusions only? The way of presenting them should be decided and should be the same for all topical reports.
-Contribution from WP40 for topical reports may be included in the actual report (not in appendix)?"

4 LIST OF REFERENCES

[1] EC-ASAMPSA2, 2013. *ASAMPSA2 Best-practices guidelines for L2 PA development and applications. Volume 1 – General. Volume 2 - Best practices for the Gen II PWR, Gen II BWR L2PSAs. Extension to Gen III reactors. Volume 3 - Extension to Gen IV reactors ASAMPSA2 WP2-3-4/D3.3/2013-35 (www.asampsa2.eu or www.asampsa.eu)*

[2] ASAMPSA_E - Synthesis of the initial survey related to PSAs End-Users needs – Technical report ASAMPSA_E/WP10/D10.2/2014-05 - IRSN PSN-RES/SAG/2014-00193, Jan. 2015

[3] Methodology of Common Risk Target Assessment and Quantification for Severe Accidents of Nuclear Power Plants based on INES Scale. Slovak University of Technology in Bratislava, Faculty of Electrical Engineering and Information Technology, Institute of Nuclear and Physical Engineering, Bratislava May 2014.

APPENDIX 1

This appendix presents the recommendations issued from the initial survey related to PSAs End-Users needs ([2]), reviewed by the Uppsala workshop participants who have also defined a priority level based on the following scale:

- Type A: most important end-users needs (for which the project should produce adequate guidance),
- Type B: intermediate needs (which the project will address if possible),
- Type C: less important needs (not to be addressed by the project).

Recommendations related to general considerations on extended PSAs:

1. ASAMPSA_E shall examine which type of cost/time analysis is acceptable to limit resources needed for external/internal hazards PSAs (type A).
2. ASAMPSA_E shall address risk monitoring and training applications of extended PSA (type C).
3. ASAMPSA_E shall address PSA communication towards public (type C).
4. ASAMPSA_E shall at least address the 10 most important external hazards for the End-users (type A):
    - Earthquake,
    - Flooding,
    - extreme air temperatures,
    - snow pack,
    - lightning,
    - storm (tornadoes, hurricane, …),
    - biological infestation,
    - aircraft crash,
    - external fire,
    - external explosion.

    ASAMPSA_E shall consider also:
    - internal fires, floods and explosions,
    - heavy load drops, high energy line break (HELB), missiles, chemical releases;
    - other extreme weather conditions,
    - transport of dangerous substances, accidents in facilities located in the vicinity of NPP,
    - releases into the waters and ground.

    ASAMPSA_E shall also examine the interest of integrated (all hazards and IE) or separated PSA model.
5. Some End-Users have expressed interest on best practices to model ageing in PSA. The End-Users workshop participants have considered that it is not feasible to handle this difficult topic in the framework of ASAMPSA_E (type C).
6. ASAMPSA_E shall consider a modification of the definition of extended PSA based on End-Users remarks: “An extended PSA (probabilistic safety assessment) applies to a site of one or several Nuclear Power Plant(s) (NPP(s)) and its environment. It intends to calculate the risk induced by the main sources of radioactivity (reactor core and spent fuel storages, other sources) on the site, taking into account all operating states for each main source and all possible relevant accident initiating events (both internal and external) affecting one NPP or the whole site.”

7. ASAMPSA_E shall provide practices and methods to model the combinations/correlations/dependencies of hazards (in terms of both occurrence and impact on SSCs) (type A).
8. Concerning the combinations/correlations/dependencies of hazards, some different rules can be provided depending on the time frame (for example, addition of independent hazards may be considered for long lasting accident) (type B/C).
9. ASAMPSA_E shall address methodology for simultaneous accident progression in core and SFP (type A).
10. ASAMPSA_E shall group the list of hazards to develop its guidance (type A).
11. ASAMPSA_E shall discuss the level of conservatism (same level in all PSA parts …?) (type A).
12. ASAMPSA_E shall provide guidance on the place of extended PSA in risk informed approach and decision-making (type B).
13. Concerning result presentation (type A) :
    - Risk aggregation guidance will be useful,
    - Results shall be understandable,
    - Risk targets are useful but not essential,
    - Treatment of uncertainties is essential (for external hazards, low probability events with high uncertainties),
    - Need for guidance for results interpretation and use.

    Introduction of uncertainties in L1 PSA may be crucial (?)
14. ASAMPSA_E shall address specific guidance on quality of extended PSAs (type B).
    Associated to quality, the necessity to be aware of risks should be clearly emphasized in the application of extended PSAs: this is the main product of PSAs (extended) and must be associated to communication, training of operators, decision-making on plant safety.
    PSA "capability" concept (closely associated with PSA application) may be used instead of quality.
    (ASAMPSA_E shall examine the methodologies (to perform PSA) to be applied depending on the PSA application (see also IAEA standards, US-NRC regulatory guides)).
15. ASAMPSA_E shall examine how to include mobile equipment in PSA (type A).
16. ASAMPSA_A shall clarify the vocabulary on "mission time", "scan time". "Mission time" for NPP may be the time needed until stable state conditions are reached. "Mission time of each equipment" can be different (type A).
    ASAMPSA_E shall examine what does it means for L1PSA, L2PSA and provide guidance to model long lasting accident.
17. ASAMPSA_E shall develop a glossary, common for all PSAs (type A).
18. ASAMPSA_E shall precise how and when "seasonal PSA (winter/summer)" must be developed. An example could be useful (type A).

Recommendations related to hazards screening and modelling

19. According to the End-Users survey, existing screening guidance have to be adapted or completed for each application. ASAMPSA_E shall examine why and how to do this adaptation/complement (type A).

ASAMPSA_E shall examine how to reduce heterogeneity in quantitative screening criteria (collect and examine the screening values).

ASAMPSA_E shall examine which hazards must not be screened out and why.

ASAMPSA_E shall comment how far the impact of the hazards must be considered in the screening out process (in case of cliff edge effect, no screening out …?).

20. ASAMPSA_E shall examine the relevance of conditional core melt probabilities and conditional containment failure probabilities (and conditional LER probability) in the screening criteria (type A).
21. ASAMPSA_E shall examine PSA practices for modelling induced internal floods and internal fires (type A).
22. ASAMPSA_E shall examine SFP accident screening practices (type A).
23. ASAMPSA_E shall discuss the link between screening criteria and design basis conditions (type A):
    - PSA should focus on area that are not in the design basis – example : specific combinations like hazards + induced effects,
    - PSA should include hazards in the design basis (useful for PSR for example).
24. ASAMPSA_E shall discuss the sum of hazards frequencies (final comparison with numerical safety target) (type B).
25. ASAMPSA_E shall examine what to do if the sciences cannot provide information for low frequencies events or extremely high uncertainties on their amplitude (type A).
26. Deficiencies on internal hazards modelling shall be covered in ASAMPSA_E (type A):
    - More realistic assessment of the hazard frequency or consequences have to be developed for internal fire and flooding assessment
    - No specific methodologies exist for internal explosion, missiles or quantification of internal hazards due to inappropriate human actions
    - The methods for hazard curves and fragility curve constructions are not described.
27. In ASAMPSA_E project, uncertainties assessment methodology for internal hazards shall be compared and good practices identified (type A). Is the fragility curves approach always relevant (example: spurious signal in case of fire)?
28. In ASAMPSA_E, existing methods for external hazards modelling shall be presented and compared including uncertainties (type A).
29. ASAMPSA_E shall examine how experts' judgement shall be used for external hazards characterisation and how uncertainties can be considered (type B).
30. ASAMPSA_E shall introduce the effects of climate changes and present available methodologies. Need for updating PSA (type A).
31. ASAMPSA_E shall examine the role of statistical analysis method (e.g. EVT) based on observation in comparison with approaches trying to identify which combination of factors can lead to the worst meteorological events (not observed) (type A).
32. ASAMPSA_E shall examine how PSAs can introduce information coming from meteorological modelling. Example: variations from past worst cases? (type A)

33. ASAMPSA_E shall provide information on activities performed to assess catalogue completeness and reliability, on how to assess the maximum possible earthquake (Mmax), identify, analyse and assess (potentially) active faults relevant to the safety of the site …(type A).
34. In a region with low seismicity like Sweden, an earthquake M 8 is "possible" (and observed in paleo history) with a return period 1 million years … ASAMPSA_E shall examine how can such information be presented in a PSA (type A).
35. ASAMPSA_E shall insist on the need to update periodically the design-basis hazards curve (type A).

Recommendations related to introduction of hazards in L1 PSAs

36. ASAMPSA_E shall identify some best practices for external hazards SCC fragility analysis
    - At which temperature an electronic device fails,
    - Shaking tables for active equipment …,
    - Fragility curves database

    ASAMPSA_E shall share opinion on available information related to fragility of equipment (database ….). Emergency diesels are so important that related methodologies / data should be specifically analysed in ASAMPSA_E (type A).
37. ASAMPSA_E shall examine (on examples) the importance of non-safety systems robustness/behaviour/positive vs negative impact in case of external hazards on final CDF/RF (example, in extreme cold temperature conditions, ventilation can accelerate pipe freezing if not stopped) (type A).
38. For seismic PSA, ASAMPSA_E shall examine the interest of advanced PSA methodologies using "earthquake signal" (temporal ground motion parameters) impacts on SSCs and interest in comparison with "classical" methodologies (PGA …) (type A).
39. Seismic PSA may be based on the use of generic fragility curves for components … How can the PSA End-Users justify their use? ASAMPSA_E guidance shall comment this issue from partner experience (type A).
40. SFP specific issues for earthquake to be considered in ASAMPSA_E (type A):
    - Fragilities of the pools, racks.
    - Sloshing of the pool water (one combination of hazards, what are the consequences for accident progression? See TEPCO presentation during End-Users workshop in Uppsala),
    - Loss of cooling.
41. The following topic shall be discussed in ASAMPSA_E (guidance needed): induced internal hazards are potential source of conservatism (if included), of non-conservatism (if not included) (type A).
42. For flooding (type A):
    - ASAMPSA_E shall compare some applications for flooding assessment in EU stress-tests before developing guidance,
    - fragility of equipment may be easily presented (failure in case of room flooding) (according to some experts in Uppsala workshop),
    - ASAMPSA_E shall present methodology to address long term flood
    - The uncertainties may be higher for natural than for man-made hazards (according to some experts in Uppsala workshop).

43. ASAMPSA_E shall develop guidance to assess frequencies of LHS events (how to arrive from an external hazard to an IE?) (type B).
44. ASAMPSA_E shall develop guidance to calculate frequencies of LOOP and recovery time (these frequencies shall be updated with grid modernization). How to consider the recovery time of grid? (type B).

Recommendations related to introduction of hazards in L2 PSAs

45. ASAMPSA_E shall identify issues associated to external hazards that may need significantly differences in comparison with L2PSA methodologies for internal IE (type A), e.g.:
    - Induced effects (internal hazards) by external hazards,
    - Earthquake aftershocks,
    - External hazards impact on containment function …
46. For ASAMPSA_E guidance on L2 PSA (type A) :
    - Extended L2PSA shall include long term management of radioactivity in the containment and release in environment.
    - ASAMPSA_E shall consider in long term strategies both in-vessel retention and ex-vessel retention
47. ASAMPSA_E shall examine existing containment venting strategies optimization versus L2PSA results (status today: different strategies, depending on NPPs – is it consistent with L2PSA results?) (type A).
48. ASAMPSA_E shall examine SAMG sufficiency, especially for shutdown state (SAMG needed to develop event trees …) (type B).
49. For shutdown states of reactor, ASAMPSA_E shall propose guidance for open RCV or RCS situations: FP release (effect of air ingress), thermal radiation effect on the containment integrity (open RCV case, heat load) (type A).
50. ASAMPSA_E shall examine how can be calculated the conditional probability of SFP fuel degradation after core melt (depending on common system core/SFP, on location of SFP – inside vs outside containment). ASAMPSA_E shall examine how far, in case of SFP fuel degradation (inside a containment), the containment function can survive (depending on pressurisation, hydrogen production, thermal radiation load …). ASAMPSA_E will need to map the NPP configurations of reactor core versus SFP (independence) (type A).

Recommendations related to common issues for multi-units PSA (for external hazards)

51. ASAMPSA_E shall clearly identify deficiencies of single units PSA and promote development of multi units PSA (type A).
52. ASAMPSA_E shall examine if a new set of risk metrics for multi-units is necessary (type B).
53. ASAMPSA_E shall consider experience of countries like Canada having already developed multi-units PSA (type B).
54. ASAMPSA_E shall in particular examine HRA modelling demand for multi-unit PSA (e.g. team sufficiency if shared between units, site management complexity, equipment restoration possibilities, inter-reactor positive or negative effects …) (type A).
55. For comments in ASAMPSA_E guidance (type C):

- Earthquake can affect multi-units. The ground motion is correlated but can be different for each reactor (this is an issue examined in Japan).
- True for other external hazards.

Recommendations related to common issues for HRA modelling (for all external hazards)

56. ASAMPSA_E shall examine how to improve HRA modelling for external hazards conditions to tackle the following issues (type A):
    - The high stress of NPP staffs,
    - The number of tasks to be done by the NPP staffs,
    - The impossibility, for rare events, to generate experience or training for operators actions (no observation of success/failure probability, e.g. simulator),
    - The possible lack of written operating procedures (or non-precise procedures),
    - The possible wrong information in the MCR or maybe the destruction of the MCR,
    - The methodologies applicable to model mobile barrier installation (for slow developing event),
    - The methodologies available to model use of mobile equipment (pumps, DGs) and conditional failure probability (human and equipment),
    - The methodologies applicable to model equipment restoration (long term accident sequences, specific case of multi-units accidents …).
57. Methodologies to develop modelling of "warning" for slowly developing external events (type A).
58. ASAMPSA_E may organize a workshop with HRA specialists (type C).
59. ASAMPSA_E guidance may address error of commission (type B/C).

Recommendations related to specific issues of interest from experience of past real events

60. ASAMPSA_E guidance shall explain how to introduce in L1-L2PSA a more diverse modelling of internal and external electrical disturbances. The Forsmark NPP experience presented during the ASAMPSA_E End-Users workshop in Uppsala shall be considered as a starting point (include in PSA voltage surge on plant grid (e.g. lightning)) (type A).
61. ASAMPSA_E guidance shall precise methodologies available to quantify the frequency of loss of heat sink due to natural hazards (e.g. clogging effect). An additional question that can be addressed is criteria (from PSA perspective) from which a design change can be needed? The Cruas NPP example provided by EDF (loss of heat sink) during the ASAMPSA_E End-Users workshop in Uppsala shall be considered as a starting point (type A).
62. From Le Blayais NPP example, ASAMPSA_E shall precise for external flooding PSA that :
    - Conditional CDF can be calculated depending on event flooding amplitude,
    - Initiating flooding event (amplitude, frequency) can be modelled separately.

    This can be a starting point for some ASAMPSA_E guidance on external flooding (type A).

APPENDIX 2

Fastställd av: TBJ

Forsmarks Kraftgrupp

VATTENFALL

	Dokumenttyp / Document type	Klassificering / Classification	
	Rapport	Företagsintern	
Författare / Author Hultqvist Göran	Granskad av / Checked by JPI	Dok nr / Doc no FTT-2015-1558	Rev 0
Fastställd av / Approved by cFTT	Datum / Date 2015-09-23	Projektnr / Project no	Systemnr / System no

Comments on Report on lessons of the FKS Dai-ichi

Summary

The main purpose of the comments are that we as a end-user believe that PSA is an important tool for assessing and prioritize safety issues but PSA have limitations both today and will also have so in the future. Göran Hultqvist has on the behalf of Forsmark NPP read and comment the ASAMPSA-report "Lesson of the Fukushima DAI-ICHI accident for PSA"1.

The overall comment on the report is that we think that the recommendations put too much burden on the PSA and PSA developer. The PSA is a good tool for risk assessment but it will never be perfect and therefore it is important to recognize its limitations. One major limitation of the PSA for external events is the high degree of uncertainties in frequency estimations. Another limitation is that the impact of external events can be demand great resources to be able to model a realistic response of the pant. It is important that the ASAMPSA_E recognize and stress the limitations of PSA and recommend a feasible scoop of the PSA and how the limitations of the PSA can be handled without spend a large amount of resources.

Basic demands on PSA and lesson learned from Fukushima

To make a PSA useful for applications and decision making the following is important aspect have to be fulfilled:

Realistic and Balanced: Data and models in PSA shall be specified with best estimate data with minimum of conservatism. Use of any kind of optimistic or conservative data will result in skewness in the risk ranking. When realistic data are not available it is important specify these areas as threaten in a different way in the result presentation. Otherwise can the contribution to the overall risk either get too large importance or be neglected.

Common data for Safety Assessment: It is important that different kind of safety assessment respect boundary data used in other assessments. Basic data for performing deterministic assessment, for developing EOPs/SAMGs, PSA must use the same data source to be consistent with each other. It will be of importance to identify important boundary data used for all kinds of safety assessments and assesses if they are valid for the site. It is therefore also important recognize that the PSA-developer cannot use other data then what is developed for the FSAR of the plant. If a data source is questionable or not will not be identified be PSA on its own. Reassessment of possible external event and data sources should be part of a period safety review and PSA could be part of such a review.

EOPs action in PSA: PSA should model the established EOPs the PSA developer cannot assume changes in these documents. PSA experts can propose changes but not assume that they will be implemented until the changes have been implemented.

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Fastställd av: TBJ

Dokumenttyp / Document type	Klassificering / Classification	Dok nr / Doc no	Rev
Rapport	Företagsintern	FTT-2015-1558	0

SAMGs in PSA: SAMG include actions that are not specified in procedures, its nature is to be flexible and therefore provides a high degree of uncertainty. Before including actions related to SAMGs and mobile equipment it is important to discuss the purpose of the PSA of SAMG. PSA modelling of SAMG and mobile equipment could be useful if one wants to identify improvements in the SAMG or the mobile equipment, but since there are large uncertainties the SAMG should not be part of the overall risk assessment. If the SAMG countermeasures are modelled in an optimistic way these countermeasures could hide weaknesses in the systems installed to protect the containment.

Alternative ways to assess risk for events that have been excluded in PSA based on lack of realistic data:

ASAMPSA_E has to discuss all kinds of external event and give recommendations on how to include these in risk assessments. For some events the lack of realistic data should exclude them to be part of the basic PSA. It will then be of importance to find ways to cover the risk related to the event by other means.

Specification of DiD and possible ways to asses this with PSA.

The report several times discuss and ask for deeper assessment of the plant design according to demands related to defense in depth (DiD).Such assessment need a clear methodology related to which system are allowed to be used for different assessment in DiD-assessment of different layers. This is not the normal praxis within PSA to exclude certain available system –permanent installed or mobile – in the assessment. Contrary the praxis is to use all available systems and components in the PSA. To develop an assessment of the DiD- strength there is a need for a guidance how that should be performed. Such praxis could learn from the Japanese that assess the containment success in PSA level 1.5 as a step in such assessment.

Positive effects at Fukushima

To develop realistic PSA it will also be of importance to learn from Fukushima from positive effects as battery time, interconnection of unit 5 and 6, operation and communication in the dark, positive effects of multi-unit sites, and perhaps more.

It is important to specify all positive effects identified in the Fukushima scenarios relative praxis in PSA-modelling. The most important is improve the severe accident codes with data from Fukushima. PSA must take lesson learn from these to increase the realism in the PSA outputs.

Failure-modes:

It is understood by assessing the Fukushima accident that existing codes did not correctly model the different scenarios. Therefore it cannot be expected that the PSA can represent the risk in a correct way. The following is areas in which existing codes have failed:

- overheating of containment,
- time to vessel penetration,
- hydrogen spread to reactor building, steam explosions

These phenomena cannot be modelled by any realism as existing codes are not accurate in respect to these phenomena. Instead of including them in PSA it would be better to include a qualitative

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assessment of the risk related to these phenomena and also discuss the possibility of other missing scenarios. Even more critical is the time between core damage and reactor vessel penetration. Existing codes do predict this time with very high uncertainties. This transferred large uncertainties into level 2 PSA-outputs.

Comments of the conclusions

The report has 87 conclusions. Below are they grouped in 22 different categories. See below. For each category I have include one or several comments related to the way these categories are discussed in the report.

1 Hazard frequencies (1, 2, 3, 4, 8, 16, 18)

To assess external event with frequencies lower than 10-4 /year including events with frequencies as low as 10-7/year need for each event category acceptable methods for identify the possible extreme vales in these frequencies ranges. In my personal view after listening to experts in seismology and meteorology is that it is impossible to develop such data with high confidence since there is not enough information. In meteorology there is also limitation how old data can be used since the climate is changing. Existing PSA studies are not based on a common methodology for expanding 100 years or 1000 years data to cover 100 000 or 1 000 000 years. Many projects are ongoing in specific areas to better develop methodologies to specify such data. The basic demands for a PSA to be realistic cannot be fulfilled or verified if data with low quality related to realism are included. Since the uncertainties are great the PSA specialist cannot develop better data than any other national institutes or experts are doing in this field. With the knowledge that these data have low quality and can destroy the realism in both level 1 and level 2 PSA it will be of importance in ASAMPSA_E to discuss if assessment of these events shall be performed in a separate risk assessment or even to be excluded from PSA and assessed by alternative methods. ASAMPSA_E have to develop a more consistent approach on how to tackle the problem of lack of qualitative data in certain low frequency domains for the external events. The realism within the PSA may not be destroyed by expanding the scope to cover areas with “bad data” and optimistic data could give the impression that the risk is manageable.

2 Hazard dependencies (10, 22, 47, 51)

It is possible to develop understanding of dependencies between different hazards by looking at historical data. We can learn from data close to the site and even to site with similar geographical situation. This will give us data to cover event frequencies down to 10^{-3} or 10^{-4}/year. There exists no commonly accepted theory for expanding data to lower frequencies. If such data are included in the PSA it will no longer represent a realistic assessment. It represents the opinion of some “experts” and includes large uncertainty. Based on the above insights it is important that ASAMPSA-E respect the difficulties and as pointed out in point 1 discuss alternative ways to perform risk assessment for these hazard dependencies related to plant risks.

3 Frequencies for reassessing External events (4)

Based on the knowledge that existing methods and data for external event frequencies are under development and that such data also are affected by other effects global warming and human influences it is important that ASAMPSA_E stipulate that PSA and other risk assessment that include external event assessment are not valid for more than 5 to 10 years and there is therefore

no need to include climate changes. The external hazards should anyhow be reassessed in the periodic safety review

4 Scope of hazards (5, 17, 18, 43, 47, 49, 57, 60, 61)

The list of external events is very long. Events have different importance depending of the geographical position of the plant. Therefore it is important to develop a methodology that based on the geographical position give relevant data for each external event. It is important that each plant assess all possible external events and develop frequencies for extreme conditions for each for them. As pointed out before it is of importance that such assessment are based on the knowledge of the national experts in this field and that the same data are used for deterministic assessments and probabilistic assessment. It will be of importance to develop a priority/ranking of all the possible external events before allocating assessment resources to the different events. As it is very time and resource consuming to assess each specific event it is very important to allocate the resources to the event which mostly affects the plant risk. It will be unreasonable to put resources in seismic events in areas with low seismic activity as well as putting resources to cold weather in the warm climate. It is important that most resources for each plant are spent on data and methodologies to deal with the most important risks for the specific plant. This issue has also a strong coupling to methods used to screen out events. – See point 10.

5 Extrapolation of frequencies/uncertainties (6, 7)

As partly discussed in point 1 above there will be a need for extrapolation of event frequencies for frequencies lower than 10^{-4}/year. The PSA experts have to assess if the needed realism of the PSA can be guaranteed when extrapolated data are included. It could be better to exclude some phenomena in PSA when data are very uncertain. The risk impact will instead be evaluated by separate risk methods or a separate PSA that are used for specific applications. The same strategy should be valid for other data including high uncertainties.

6 Mission time (27, 31, 50, 58, 63)

A risk assessment of the plant shall include all part of a scenario until a stable end-state is reached. Based on the praxis to use 24 and 48 hour in PSA it will be of importance to identify all scenarios that have not reach a stable end-state within these timeframes. For scenarios lasting more than 24 and 48 hours it is important to assess if realistic data can be developed for these scenarios. If any data related to frequencies, failure probabilities or human errors are deemed to have large uncertainties and that realistic data difficult to specify it will be of importance that the PSA evaluates the value of including the specific scenario in the PSA. The risk connected to such scenarios will then be assessed with other methods and discussed in the result assessment.

7 Lack of data (6, 7,19)

Concerning frequencies for external event it is clear that there is a lack of data especially for establishing frequencies for low frequent events. Work is ongoing among experts in different fields to develop better data. Based on this PSA are only valid for a short period if it includes data for external events. –See also point 3. To extend data to include data related to external events far away from the plant will reduce the realism of the data and the uncertainty increases. If data far away from the plant is used to develop realistic event frequencies it will be of importance to get

an expert view on the relevance of the data. It is of importance that if conservative data are introduced in the PSA it has to be identified and reassessed in the result presentation.

8 Using worldwide data (8)

World wide data is very useful for identifying different kind of events and event combinations but less useful for identify frequencies. Using worldwide data for develop frequencies for specific external event at a specific plant for external event will not give realistic data for the PSA. The consequences of using any kind of worldwide data for establishing event frequencies must be discussed in detail in the PSA study and transferred to the result presentation. ASAMPSA_E shall assess if it would be better to exclude events that need worldwide frequencies for external event and perform risk assessment with separate methods.

9 Scope of plant (9, 20, 21)

A PSA shall by definition include all sources for radioactive releases. If any sources are excluded it shall be specified in a "screen out"- assessment. Any excluded source of radioactivity that is excluded can be handled in a separate assessment decoupled from the basic PSA.

10 High consequences- low frequencies/screening criteria (7, 11, 12, 13, 14, 16, 44)

See also text in point 4 above. With the aim to develop a realistic PSA that include external event the first important task will be to develop a list of all possible external events. Each of them shall be given an evaluation of possible characteristics. Develop for each characteristic a first guess of the event frequency bases on existing knowledge within the PSA-team and the plant owner organization. All listed characteristics shall be given a rough assessment of the consequences of the event when no countermeasures are initiated. The characteristics that lead to core damages shall be assessed one step further. The assessment shall be based on knowledge of event frequencies at the specific plant. All listed characteristics that result in core damages without countermeasures shall be given a rough assessment concerning available counter measures that will reduce the risk for core damages for the specific external event characteristic. The assessment shall include separate evaluation depending on if only permanent installed equipment is used or if SAMG and mobile equipment is used in the counter measures. Based on this information a screening process shall be initiated. It will be of importance to include all external event and all characteristics in the screening process. The screening process shall identify the risk potential for each characteristic and based on that specify the need for more detailed assessment of each characteristic. The most important output of this process is to allocate available resources to the areas that are most important for developing a realistic PSA-study. For event with very low frequencies that causes core damages and no counter measures are available it will be of importance to find the most meaningful way of evaluate the plant vulnerability for these event and if the safety of the plant is good enough. In many cases the uncertainty in data related to event frequencies of these event makes PSA not to be the best tool for determine such issues. One of the most important demands for ASAMPSA-E is to develop methodologies performing such screening.

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11 Level 2 PSA (15, 43, 44)

As performed in Japan a PSA which develop specific data for the failure mode containment failure give valuable information of the plant status. It is recommended that such assessments are included in each PSA. PSA level 2 are in most cases based on the outputs from severe accident codes. The severe accident codes are still under development and many scenarios are not fully validated. PSA level 2 must be based on this knowledge of the limitations of the existing severe accident codes. Specific attention to such weaknesses in the codes shall be transferred to the result assessment.

12 Demands on regulators (23)

PSA scope and methodologies shall be specified by the user and not by regulators. It is the utility that shall use the knowledge for certain purposes to fulfill its demands. Not the regulators. The user of the PSA much for all issues specifies scope, methods and data for their PSA study. The regulators shall not be claimed for not doing this.

13 Defense in Depths (23, 24, 25, 73) + use of non-safety classed system

A PSA study shall include all available means for avoiding core damages and containment failures. This includes also using all available non-safety classed components. The report make in several places distinction between safety classes and non-safety classed systems. This has to be corrected. The report asks for assessing if the plant is designed with suitable level of Defense in Depths. To perform such an assessment it will be of importance to classify all systems and component into which defense level that are supposed to act. Each system and component may only belong to one defense level. The PSA shall then develop a PSA that restrict system to act in other defense levels that they are specified for. Such assessment have based on my experiences not been performed so far and is not following the basic philosophy for a PSA. If a DiD assessment would be performed several weaknesses in existing plant would be identified. If ASAMPSA-E will ask for a DiD assessment there is a need for to specify a more detailed methodology to perform such assessment.

14 System assessment-FMEA (24,28,33,52,53,54,55,58,62,65,73)

FMEA for a system shall assess the system availability for all possible environmental conditions included in the scenarios covered by the scope of PSA. Any kind of weaknesses shall be identified as well as lack of failure data for specific failure modes. If data are lacking will it be of importance to find methodologies that develop realistic data. If this is not possible it will be important to exclude this scenario from the PSA-scope and transfer such information to the result of the PSA giving reduced scope of the PSA-study. The existing report has to be clearer about this.

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15 HRA + Commission of Errors (26,35,36,38,39,40,41,42,56,74,75,76,77,78)

Several of the recommendations belong to HRA and modeling of Commission errors. Several of these are related to human behavior during severe accident conditions and related to handling of mobile equipment. The report ask for more research and point out the lack of realistic data but still the report recommend that these scenarios and actions are included in the PSA. A PSA that include data with low quality can destroy the realism in the PSA study. Instead of recommending that scenarios including data with lack of realistic data it will be important to develop methodologies for screening out these events in the PSA and to use other methods to understand the importance of these scenarios in the overall safety risk of the plant. Concerning involvement of "Commission errors" in the PSA it is important to develop a common position. Existing praxis is that none or very few commission errors are included in PSA for both level 1 and level 2.There exist no realistic data for commission errors and therefore it should be a boundary condition that such errors are excluded in all PSA. If for certain reason specific commission errors are included these shall be motivated in the boundary condition for the study. The risk for safety consequences of commission errors have to be assessed in complementary assessments in which critical commission errors shall be identified. The strength of specific countermeasures for these critical commission errors have to be discussed in the separate assessments.

16 Dependency of non-safety system (29)

See text in point 13.The basic principles for a PSA are that all systems and resources available shall be included in the PSA. That's the only way to develop realistic risk assessments. This means that both safety classed system and components as well as non-safety classes system and components are included in level 1 and 2 PSA. The repot seems to be based on another approach in which only safety classes equipment are included. The repot have to be up-dated on this issue.

17 Multi-unit effects (32,35,48,59,66,77,78)

It is important that the report better reflect the existing way of including multi-unit effects. Existing capabilities in nearby units are in most cases not included in the existing PSA-studies. That means that existing PSA can be expanded to include the positive effects of nearby units. Even in the Fukushima accident several positive effects of using capacity from sister units was identified. The report must specify these positive effects. It would be of interest that ASAMPSA-E develops a methodology or a specification of when and how the resources of nearby units are included in the PSA. This shall include both positive and negative aspects. The scope of the study is coupled to the usefulness of the study. If it is important to use the PSA to assess multi-unit effects all relevant data shall be included. Multi-unit effects can be assessed by other methods and the benefits by using PSA for this have to be identified by ASAMPSA-E. Perhaps such assessment shall be performed outside the PSA in separate reports.

18 EOP, SAMG, mobile equipment (34,37,38,52,53,54,55,62,64,65,70,71,72)

A common strategy for PSA is that it includes all automatic actions and actions performed from the control room. This means that most of the actions in the EOPs are included in the level 1 and level 2 PSA but in most cases does not include actions in the SAMG or the use of mobile

equipment. This strategy will secure a realistic output as almost all data for such an assessment are realistic.

19 Definition of core damages (45,46,67)

The definition of Core damage state was assessed in the ASAMPSA-2. It was obvious that many different definitions were used for entering a core damage state. ASAMPSA-2 did not try to develop a detailed common definition neither for level 1 nor for level 2 PSA. Existing differences affects the total output for the PSA for specific systems. A more common definition will support harmonization of PSA and PSA-applications. I hope that ASAMPSA_E at least develop a recommended definition that best suit the purpose of both PSA level 1 and level 2.

20 Water releases (68)

It is proposed that specific attention shall be given to the releases of water from containment. The water releases are supposed to be transferred to vessels. Before empting the vessels the radioactive content are supposed to be controlled. Leakages from theses waste management systems will lead to contamination of the surrounding areas. The main consequences of such releases will be access-restrictions close to the affected areas. If these restrictions are followed no harms to human are foreseen. There is a secondary risk that water is leaking out to the sea biosphere. Data related to such releases can be of interest for PSA level 3. I still believe that it will be of low interest for assessing output of level 2 PSA to include the water releases. If this shall be a recommendation it has to be better motivated.

21 Uncertainties in result/outputs (69,83,84)

Adding external event to both level 1 and level 2 PSA affects the realism of the PSA and the uncertainty for the output. Based on experiences from assessment performed in Sweden there is a risk that with existing data related to external event frequencies that these event will dominate the cause of core damages and releases of radioactivity. Other initiating events (internal events including LOCA) will only represent some percent of the dominating failure modes. For many PSA-applications this will result in drastic changes in demands on safety systems and their availability as the importance of safety system will be reduced. Safety system can be out of operation for long periods and still only give minor effects on the plant risk. With the strong effects of external event on the total output of the PSA it is clear that the season variation in initiating event frequencies for the external event will affect the risk at the plant especially when using risk monitors. I am not sure that we shall recommend combining all the event types into one single PSA. The ASAMPSA-E has to evaluate if it is better to develop separate level 1 and level 2-PSA for different events. This is the praxis in USA and this will make it much easier to handle the differences in realism and uncertainties in performing different PSA applications.

22 Use of Result (79,80,81,82,83,84,85,86,87)

Based on the discussion in the above point 21 it is important to develop a common understanding in how the results of a PSA including data for all external event even these lacking confidence on realism and with high uncertainties can be used in different applications. ASAMPSA-E have to assess many different kinds of applications and give recommendation of how the combined data (

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transient, LOCA, fire, External event,…) can be used for the specific application based on the understanding of the difference in quality of data

APPENDIX 3

FORSMARK comments to the coverage of the END-users demand in the ASAMPSA-E-reports.

Focus on Type A demands.

5 General consideration

1 –Type A

ASAMPSA_E shall examine which type of cost/time analysis is acceptable to limit resources needed for external/internal hazards PSAs.
Comment: the ASAMPSA_E response to this recommendation will depend on partners' experience.

Comment from FKA: This issue is not covered in the ASAMPSA- E . some of the comments given by Forsmark relates to this aspect.

4-Type A
Concerning the scope of the ASAMPSA_E project,
ASAMPSA_E shall at least address the 10 more important external hazards for the End users :
- Earthquake
- Flooding
- Extremes air temperatures
- Snow pack
- Lightning
- Storm (tornadoes, hurricane, …)
- Biological infestation
- Aircraft crash
- External fire
- External explosion.

ASAMPSA_E shall consider also :
- Internal fires, floods and explosions,
- heavy load drops, high energy line break (HELB), missiles, chemical releases;
- Other extreme weather conditions,
- transport of dangerous substances, accidents in facilities located in the vicinity of NPP,
- Releases into the waters and ground.

ASAMPSA_E shall also examine the interest of
- Integrated (all hazards and IE) or separated PSA model

Comment from FKA: OK

7 –Type A

ASAMPSA_E shall provide practices and methods to model the combinations/correlations/dependencies of hazards (in terms of both occurrence and impact on SSCs).

Comment from FKA: OK-still some of the Forsmarks comments relates to this issue

9-Type A

ASAMPSA_E shall address methodology for simultaneous accident progression in core and SFP.

Comment from FKA: OK

10 –Type A
ASAMPSA_E shall group the list of hazards to develop its guidance

Comment from FKA: OK

11 –Type A

ASAMPSA_E shall discuss the level of conservatism (same level in all PSA parts …?)

Comment from FKA: Several of the comments from Forsmark relates to this issue. It will be of importance to develop better and more concise recommendations related to this issue.

13-Type A

Concerning result presentation
- Risk aggregation guidance will be useful,
- Results shall be understandable,
- Risk targets are useful but not essential,
- Treatment of uncertainties is essential (for external hazards, low probability events with high uncertainties),
- Need for guidance for results interpretation and use.

Introduction of uncertainties in L1 PSA may be crucial (?)

Comment from FKA: OK- But still several of Forsmarks comments relates to the usefulness of result when mixing data with different quality

15-Type A

ASAMPSA_E shall examine how to include mobile equipment in PSA.

Comment from FKA: Partly Ok-but with the position that failuredata for using mobil equipment have low quality and it is recommended to initiate research to get better data Forsmark think that other conclusions shall be made related to include mobile function in a PSA that shall be examined by risk metrics.

16-Type A
ASAMPSA_A shall clarify the vocabulary on “mission time”, “scan time”. “Mission time” for NPP may be the time needed until stable state conditions are reached. “Mission time of each equipment” can be different.
ASAMPSA_E shall examine what does it means for L1PSA, L2PSA and provide guidance to model long lasting accident.
Comment from FKA: OK- We support ASAMPSA-E recommendations

17 –Type A

ASAMPSA_E shall develop a glossary, common for all PSAs

Comment from FKA: OK- but we donot agree on the definition of CCI.

18 –Type A
ASAMPSA_E shall examine how and when “seasonal PSA (winter/summer)” must be developed. An example could be useful.

Comment from FKA: Forsmark has not identified any real attempt to include an example. FKA still believe that this is an important issue for supporting correct decisions for operating plants.

6 HAZARDS SCREENING AND MODELLING

19 –Type A
According to the End-Users survey, existing screening guidance have to be adapted or completed for each application. ASAMPSA_E shall examine why and how to do this adaptation/complement.
ASAMPSA_E shall examine how to reduce heterogeneity in quantitative screening criteria (collect and examine the screening values).
ASAMPSA_E shall examine which hazards must not be screened out and why.
ASAMPSA_E shall comment how far the impact of the hazards must be considered in the screening out process (in case of cliff edge effect, no screening out …?).

Comment from FKA: ASAMPSA-E include recommendations on screening we still find it to be very subjective. The output using the specified criteria will still depend on the person that perform the screening. More precise criteria is requested that are less subjective to the user.

20-type A

ASAMPSA_E shall examine the relevance of conditional core melt probabilities and conditional containment failure probabilities (and conditional LER probability) in the screening criteria.

Comment from FKA: Forsmark support the position on ASAMPSA-E

21-type A
ASAMPSA_E shall examine PSA practices for modelling induced internal floods and internal fires.

Comment from FKA: OK-Done

22 –Type A
ASAMPSA_E shall examine SFP accident screening practices.

Comment from FKA: OK-done- Forsmarks praxis could be added.

23-Type A
ASAMPSA_E shall discuss the link between screening criteria and design basis conditions:
- PSA should focus on area that are not in the design basis – example : specific combinations like hazards + induced effects
- PSA should include hazards in the design basis (useful for PSR for example).

Comment from FKA: Forsmark have given comments related to this issue and asked several questions on this issue.

25-type A
ASAMPSA_E shall examine what to do if the sciences cannot provide information for low frequencies events or extremely high uncertainties on their amplitude.
Example: PSA shall present uncertainties as they are, which use of percentile value (%-ile value) is meaningful…?

Comment from FKA: The issue is partly discussed within ASAMPSA-E. There is a lack of overall strategy related to this issue and the consequences related to use such parameters in a common PSA or in separate PSAs as well as the influences such data have on different kind of decision making and its effct on different risk metrics. This is one of the main issue for the Extended PSA and have to get more attention in the actions after the workshop

26-type A
Deficiencies on internal hazards modelling shall be covered in ASAMPSA_E:
-More realistic assessment of the hazard frequency or consequences have to be developed for internal fire and flooding assessment
-No specific methodologies exist for internal explosion, missiles or quantification of internal hazards due to inappropriate human actions
-The methods for hazard curves and fragility curve constructions are not described.

Comment from FKA: OK-Forsmark think ASAMPSA_ have presented existing best practice in this area

27-type A
In ASAMPSA_E project, uncertainties assessment methodology for internal hazards shall be compared and good practices identified.
Is the fragility curves approach always relevant (example: spurious signal in case of fire)?

Comment from FKA: OK- This is not a priority issue for Forsmark in this project

28-type A
In ASAMPSA_E, existing methods for external hazards modelling shall be presented and compared including uncertainties.

Comment from FKA: OK- This action is performed. On the other hand Forsmark lack a consistent reviews of the methods and its affect in a common PSA and on risk metrics. This includes also an characterization of the degree of conservatism and uncertainties the different methods give.

30-type A
ASAMPSA_E shall introduce the effects of climate changes and present available methodologies. Need for updating PSA.

Comment from FKA: This is partly covered, but we think that ASAMPSA-E shall give more precise recommendations related to frequencies of up-dating PSAs

31-type A
ASAMPSA_E shall examine the role of statistical analysis method (e.g. EVT) based on observation in comparison with approaches trying to identify which combination of factors can lead to the worst meteorological events (not observed).

Comment from FKA: OK-performed- but ASAMPSA- should have more precise recommendations on which methods that shall be used for PSA parameters

32-type A
ASAMPSA_E shall examine how PSAs can introduce information coming from meteorological modelling.
Example: variations from past worst cases?

Comment from FKA: OK-performed- but ASAMPSA- should have more precise recommendations on which methods that shall be used for PSA parameters

33-type A
A fact: clear underestimation by the 1999 earthquakes map when compared to recent earthquakes. One reason is that PSHA interprets historical data (based only on 100 years of records). It is need today to introduce faults sources.
ASAMPSA_E shall provide information on activities performed to assess catalogue completeness and reliability, on how to assess the maximum possible earthquake (Mmax), identify, analyse and assess (potentially) active faults relevant to the safety of the site …

Comment from FKA: OK

34-type A
A fact: in a region with low seismicity like Sweden, an earthquake M 8 is "possible" (and observed in paleo history) with a return period 1 million years …
ASAMPSA_E shall examine how can such information be presented in a PSA.

Comment from FKA: Forsmark have given comments to this issue and we lack recommendations related to seismic PSA for areas with low level of seismic activities. Forsmark refer to a work performed within the Nordic PSA-group.

35-type A
ASAMPSA_E shall insist on the need to update periodically the design-basis hazards curve.

Comment from FKA: ASAMPSA-E shall give more distinct recommendations related to this issue.

7 INTRODUCTION OF HAZARDS IN L1 PSAS

36-type A
ASAMPSA_E shall identify some best practices for external hazards SCC fragility analysis
- At which temperature an electronic device fails,
- Shaking tables for active equipment …,
- Fragility curves database

ASAMPSA_E shall share opinion on available information related to fragility of equipment (database ….). Emergency diesels are so important that related methodologies / data should be specifically analysed in ASAMPSA_E.

Comment from FKA: Forsmark lack information's related to this issue in the ASAMPSA-E reports.

37-type A
ASAMPSA_E shall examine (on examples) the importance of non-safety systems robustness/behaviour/positive vs negative impact in case of external hazards on final CDF/RF (example, in extreme cold temperature conditions, ventilation can accelerate pipe freezing if not stopped).

Comment from FKA: Partly performed but we think that this needs more attention and more insights by summing up examples from both real events and from performed PSA-studies. We also believe that Peer reviews and benchmarking with other PSAs is important to catch hidden dependencies.

38 type A
For seismic PSA, ASAMPSA_E shall examine the interest of advanced PSA methodologies using “earthquake signal” (temporal ground motion parameters) impacts on SSCs and interest in comparison with “classical” methodologies (PGA …).

Comment from FKA: Forsmark have not assessed if this is done. It is not an important issue for us.

39-type A
Seismic PSA may be based on the use of generic fragility curves for components … How can the PSA End-Users justify their use?
ASAMPSA_E guidance shall comment this issue from partner experience.

Comment from FKA: Forsmark have not assessed if this is done. It is not an important issue for us.

40-type A
SFP specific issues for earthquake to be considered in ASAMPSA_E:
- fragilities of the pools, racks.
- sloshing of the pool water (one combination of hazards, what are the consequences for accident progression? See TEPCO presentation during End-Users workshop in Uppsala),
- loss of cooling.

Comment from FKA: Forsmark have not assessed if this is done. It is not an important issue for us.

41-type A
The following topic shall be discussed in ASAMPSA_E (guidance needed): induced internal hazards are potential source of conservatism (if included), of non-conservatism (if not included).

Comment from FKA: Forsmark have several comments to this issue. ASAMPSA-E have to examine this issue further and its consequences whenits is used in a common PSA and affect different risk metrics.

42-type A
For flooding :
-ASAMPSA_E shall compare some applications for flooding assessment in EU stress-tests before developing guidance,

-fragility of equipment may be easily presented (failure in case of room flooding) (according to some experts in Uppsala workshop),
-ASAMPSA_E shall present methodology to address long term flood,
-the uncertainties may be higher for natural than for man-made hazards (according to some experts in Uppsala workshop).

Comment from FKA: OK

8 INTRODUCTION OF HAZARDS IN L2 PSAS

45-type A
ASAMPSA_E shall identify issues associated to external hazards that may need significantly differences in comparison with L2PSA methodologies for internal IE, e.g. :
- Induced effects (internal hazards) by external hazards,
- Earthquake aftershocks,
- External hazards impact on containment function …

Comment from FKA: Forsmark have not assessed if this is done. It is not an important issue for us.

46-type A
For ASAMPSA_E guidance on L2 PSA :
- Extended L2PSA shall include long term management of radioactivity in the containment and release in environment.
- ASAMPSA_E shall consider in long term strategies both in-vessel retention and ex-vessel retention.

Comment from FKA: Forsmark have not assessed if this is done. It is not an important issue for us.

47-type A
ASAMPSA_E shall examine existing containment venting strategies optimization versus L2PSA results (status today: different strategies, depending on NPPs – is it consistent with L2PSA results?).

Comment from FKA: The action in ASAMPSA-E is only partly covering this issue and there is a need for more work related to this issue.

49-type A
For shutdown states of reactor, ASAMPSA_E shall propose guidance for :

- Open RCV or RCS situations : FP release (effect of air ingress), thermal radiation effect on the containment integrity (open RCV case, heat load),

Comment from FKA: OK

50-type A
ASAMPSA_E shall examine how can be calculated the conditional probability of SFP fuel degradation after core melt (depending on common system core/SFP, on location of SFP – inside vs outside containment)
ASAMPSA_E shall examine how far, in case of SFP fuel degradation (inside a containment), the containment function can survive (depending on pressurisation,
hydrogen production, thermal radiation load …)
ASAMPSA_E will need to map the NPP configurations of reactor core versus SFP (independence).

Comment from FKA: OK

9 7.2.5 COMMON ISSUES FOR MULTI-UNITS PSAS (FOR ALL EXTERNAL HAZARDS)

51 –type A
ASAMPSA_E shall clearly identify deficiencies of single units PSA and promote development of multi units PSA.

Comment from FKA: OK

54-type A
ASAMPSA_E shall in particular examine HRA modelling demand for multi-unit PSA (e.g. team sufficiency if shared between units, site management complexity, equipment restoration possibilities, inter-reactor positive or negative effects …).

Comment from FKA: OK for this project. Actions on this issue are better performed in other projects.

10 COMMON ISSUES FOR HRA MODELLING (FOR ALL EXTERNAL HAZARDS)

56-type A
ASAMPSA_E shall examine how to improve HRA modelling for external hazards conditions to tackle the following issues :

- the high stress of NPP staffs,
- the number of tasks to be done by the NPP staffs,
- the impossibility, for rare events, to generate experience or training for operators actions (no observation of success/failure probability, e.g. simulator),
- the possible lack of written operating procedures (or approximative procedures),
- the possible wrong information in the MCR or maybe the destruction of the MCR,
- the methodologies applicable to model mobile barrier installation (for slow developing event),
- the methodologies available to model use of mobile equipment (pumps, DGs) and conditional failure probability (human and equipment),
- the methodologies applicable to model equipment restoration (long term accident sequences, specific case of multi-units accidents, …).

Comment from FKA: OK for this project. Actions on this issue are better performed in other projects.

57-type A

Methodologies to develop modelling of “warning” for slowly developing external events.

Comment from FKA: Forsmark lack information on this issue in the ASAMPSA-E reports.

11 SPECIFIC ISSUES OF INTEREST FROM EXPERIENCE OF PAST REAL EVENTS

60 –type A
ASAMPSA_E guidance shall explain how to introduce in L1-L2PSA a more diverse modelling of internal and external electrical disturbances.
The Forsmark NPP experience presented during the ASAMPSA_E End-Users workshop in Uppsala shall be considered as a starting point (include in PSA voltage surge on plant grid (e.g. lightning))
Comment : examples of assessment may be more useful and feasible in the framework of ASAMPSA_E.

Comment from FKA: Forsmark lack action to this issue. It is not covered in any of the ASAMPSA-E reports not even in the report on Lightning.

61 –type A

ASAMPSA_E guidance shall identify methodologies available to quantify the frequency of loss of heat sink due to natural hazards (e.g. clogging effect). An additional question that can be addressed is criteria (from PSA perspective) from which a design change can be needed?
The Cruas NPP example provided by EDF (loss of heat sink) during the ASAMPSA_E End-Users workshop in Uppsala shall be considered as a starting point.
Comment : examples of assessment may be more useful and feasible in the framework

of ASAMPSA_E.

Comment from FKA: Forsmark is not sure that this action is performed.

62-type A

From Le Blayais NPP example, ASAMPSA_E shall explain for external flooding PSA that :
 Conditional CDF can be calculated depending on event flooding amplitude,
 Initiating flooding events (amplitude, frequency) can be modelled separately from PSA,
This can be a starting point for some ASAMPSA_E guidance on external flooding.

Comment from FKA: Forsmark is not sure that this action is performed.

64 type A
Past earthquakes in Romania (it affected a Bulgaria NPP) and Armenia could complete D10.3

Comment from FKA: Forsmark is not sure that this action is performed.