ASAMPSA_E
SEVENTH FRAMEWORK PROGRAMME

European ASAMPSA_E project

Advanced Safety Assessment : Extended PSA

The "Extended PSA" concept:
a current challenge for the PSA community ?
an opportunity for enhancing the NPPs safety ?

Focus on 10 lessons from the ASAMPSA_E project

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ASAMPSA_E OBJECTIVES

(the objectives are unchanged from the beginning of project)

7th FP - Ec call – November 2012

- The nuclear accident in Japan resulted from the combination of two correlated extreme external events (earthquake and tsunami). The consequences (flooding in particular) went beyond what was considered in the initial NPP design.

- Such situations can be identified using PSA methodology that complements the deterministic approach for beyond design accidents. 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 defence in depth of the plant.

- The present topic aims at providing best practice guidelines for the identification of such situations with the help of Level 1-Level 2 PSA and for the definition of appropriate criteria for decision making in the European context.

- Involvement of regulatory authorities in the foreseen action is strongly encouraged. Cooperation with Japan is welcome.

Project concept

- Main objective is to promote/identify appropriate methods/guidance applicable to examine, with PSAs, the NPPs safety (in their environment) after last reinforcements (e.g. post Fukushima Dai-Ichi accident).

- The scope of the project is large and covers internal and external hazards. Its framework leads specialists on hazards assessment (earthquake, flooding, ...) and PSA to work together …

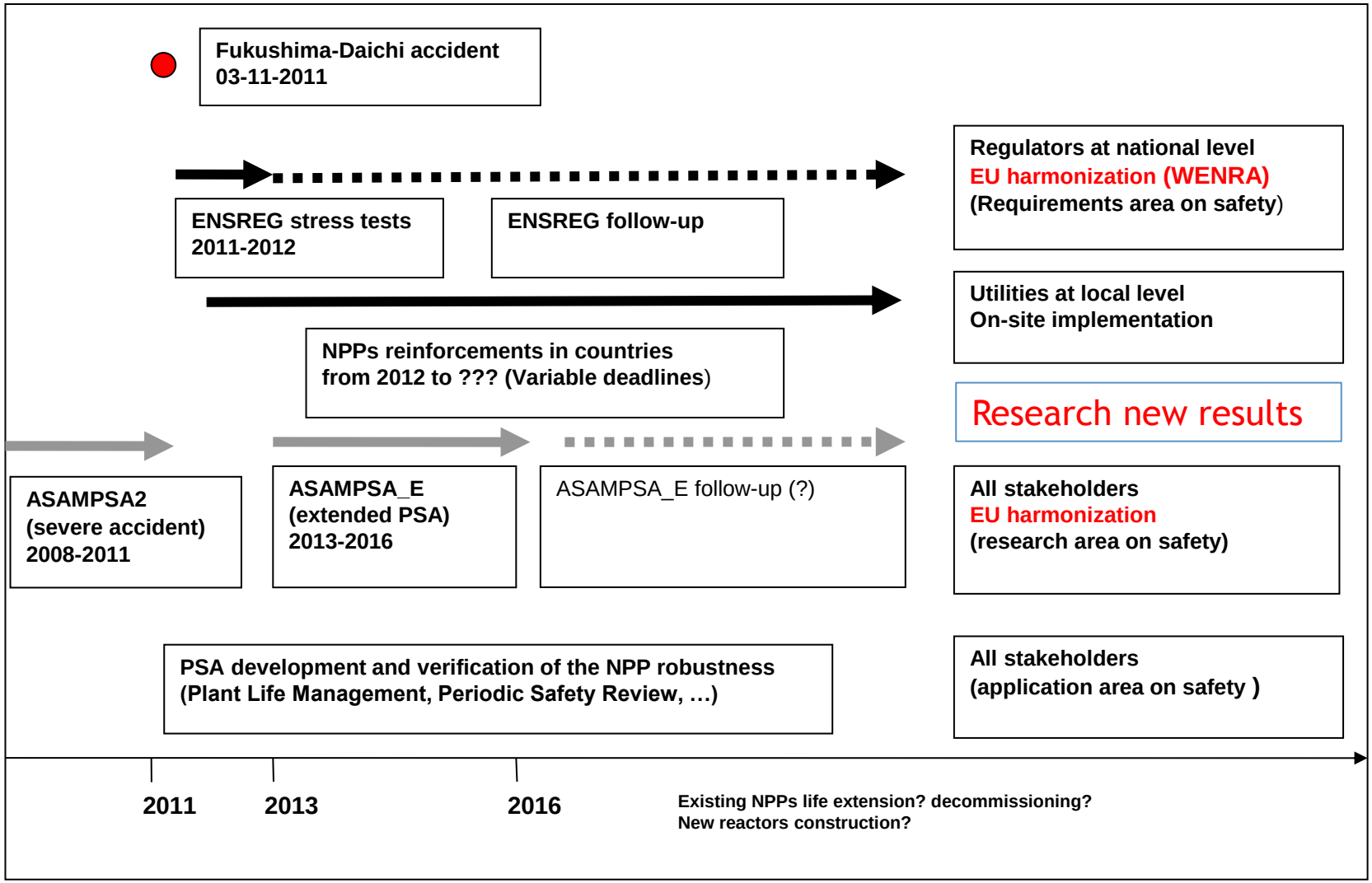
“Extended PSA” definition

- 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.

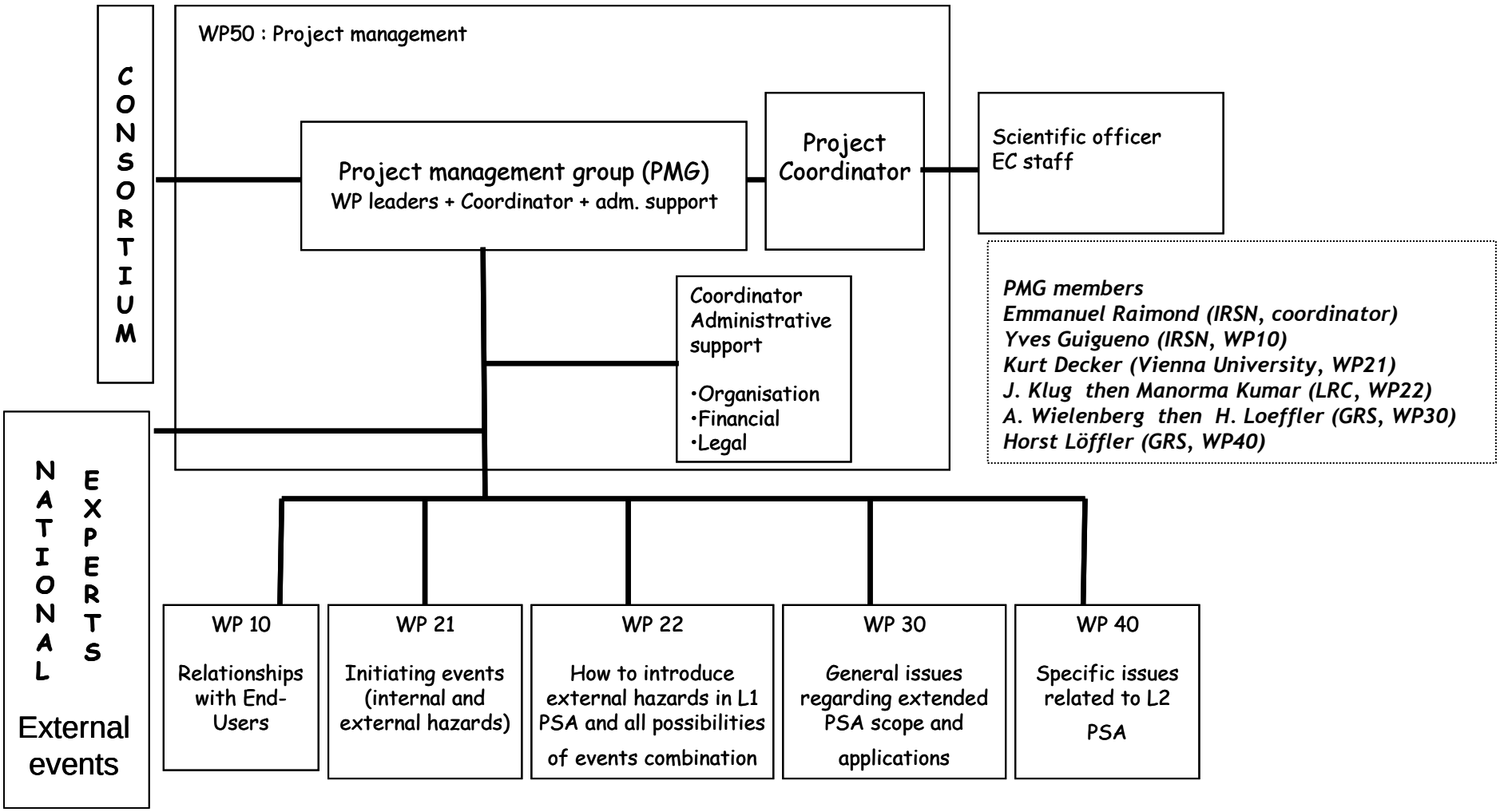
- The ASAMPSA_E project aims at helping European stakeholders to develop efficiently such *extended PSA* and verify that all *dominant risks* are identified and managed.

- For existing NPPs, there is a link to be done with the “design extension conditions” concept as defined by IAEA or WENRA

Context of ASAMPSA_E



Organization of ASAMPSA_E



Partners

Beneficiary Number *	Beneficiary name	Beneficiary short name	Country
1(coordinator)	Institute for Radiological Protection and Nuclear Safety	IRSN	France
2	Gesellschaft für Anlagen- und Reaktorsicherheit mbH	GRS	Germany
3	AMEC NNC Limited	AMEC NNC	United-Kingdom
4	Ricerca sul Sistema Energetico	RSE S.p.A.	Italy
5	Scandpower	SCANDPOWER	Sweden
6	Nuclear Research Institute Rez pl	UJV	Czech
7	Universität Wien	UNIVIE	Austria
8	Cazzoli Consulting	CCA	Switzerland
9	Italian National Agency for New Technologies, Energy and the Sustainable Economic Development	ENEA	Italy
10	Nuclear Research and consultancy Group	NRG	Nederland
11	IBERDROLA Ingeniería y Construcción S.A.U	IEC	Spain
12	Electricité de France	EDF	France
13	Lietuvos energetikos institutas (Lithuanian Energy Institute)	LEI	Lithuania
14	NUBIKI	NUBIKI	Hungary
15	Forsmark kraftgrupp AB	FKA	Sweden
16	AREVA NP SAS France	AREVA NP SAS	France
17	NCBJ Institute	NCBJ	Poland
18	State Scientific and Technical Center for Nuclear and Radiation Safety"	SSTC	Ukraine
19	VUJE	VUJE	Slovakia
20	NIER Ingegneria	NIER	Italy
21	VGB PowerTech e. V	VGB	Germany
22	TRACTEBEL ENGINEERING S.A.	TRACTEBEL	Belgium
23	BeL V	BeL V	Belgium
24	Institut Jozef Stefan	JSI	Slovenia
25	Institute of nuclear research and nuclear energy – Bulgarian Academia of science	INRNE	Bulgaria
26	Regia Autonoma Pentru Activatati Nucleare Droberta Tr. Severin RA Suc	INR	Roumania
27	Technical University of Sofia – Research and Development Sector	TUS	Bulgaria
28	AREXIS S.A.R.L.	AREXIS	France

External Expert Advisory Board (EEAB)

1	US-NRC	US
2	JANSI	Japan
3	TEPCO	Japan

ASAMPSA_E UPDATED DEADLINES

- JULY 1st 2013 : Kick-off meeting at IRSN, Fontenay-aux-Roses
- MAY 26-28th 2014 : First End-Users workshop hosted by FKA, Uppsala
- MAY 10th 2016 to JULY 20th : all ASAMPSA_E reports have been sent for external review (see list for reports just after)
- SEPTEMBER 12th-14th 2016 : second PSA End-Users workshop hosted by VIENNA university
- DECEMBER 31th 2016 : all ASAMPSA_E reports will be publically available. This will be the end of the project.

AVAILABLE REPORTS : BIBLIOGRAPHY

Summary report of already published guidance on L2 PSA for external hazards, shutdown states, spent fuel storage
(report ASAMPSA_E / WP40 / D40.1 / 2013-3 - IRSN PSN-RES/SAG/2013-00413)

Bibliography – Existing Guidance for External Hazard Modelling
(report ASAMPSA_E / WP21 / D21.1 / 2015-09 - IRSN PSN-RES/SAG/2015-00082)

Summary report of already existing guidance on the implementation of External Hazards in extended Level 1 PSA
(report ASAMPSA_E / WP22 / D22.1 / 2014-09 - IRSN-PSN-RES-SAG-2015-00082)

Bibliography on regulatory requirements on the implementation of defense in depth for nuclear power plants
(report ASAMPSA_E / WP30 / D30.1 / 2016-29 IRSN-PSN-RES-SAG-2016-000247)

AVAILABLE REPORTS : GENERAL

Synthesis of the initial survey related to PSAs End-Users needs
(report ASAMPSA_E/WP10/D10.2/2014-05 -IRSN PSN-RES/SAG/2014-00193)

Lessons of the Fukushima Dai-ichi accident for PSA *
(report ASAMPSA_E / WP30 / D30.2 / 2015-08 - IRSN PSN-RES/SAG/2015-00025)

Summary report on the impact and experience feedback of the previous ASAMPSA2 project
(report ASAMPSA_E / WP40 / D40.1 / 2013-3 - IRSN PSN-RES/SAG/2013-00413)

External events with high amplitude that have concerned NPPs in operation (in Europe or other countries)
(ASAMPSA_E / WP10 / D10.3 / 2016-13 - IRSN PSN/RES/SAG/ 2016-0003)

List of external hazards to be considered in ASAMPSA_E*
(*report ASAMPSA_E / WP21/ D21.2/2015-10 - IRSN PSN-RES/SAG/2015-00085)*

** Reports have been submitted to a peer review during the summer 2016*
Update is on-going and will be achieved on Dec. 31, 2016

AVAILABLE REPORTS : PSA APPLICATIONS

Criteria to select initiating events to be considered in an extended PSA*
(report ASAMPSA_E/WP30/D30.3/2016-13 -IRSN PSN-RES/SAG/2016-00101)

Risk metric for extended PSA*
(report ASAMPSA_E/WP30/D30.5/2016-17- IRSN PSN-RES/SAG/2016-171)

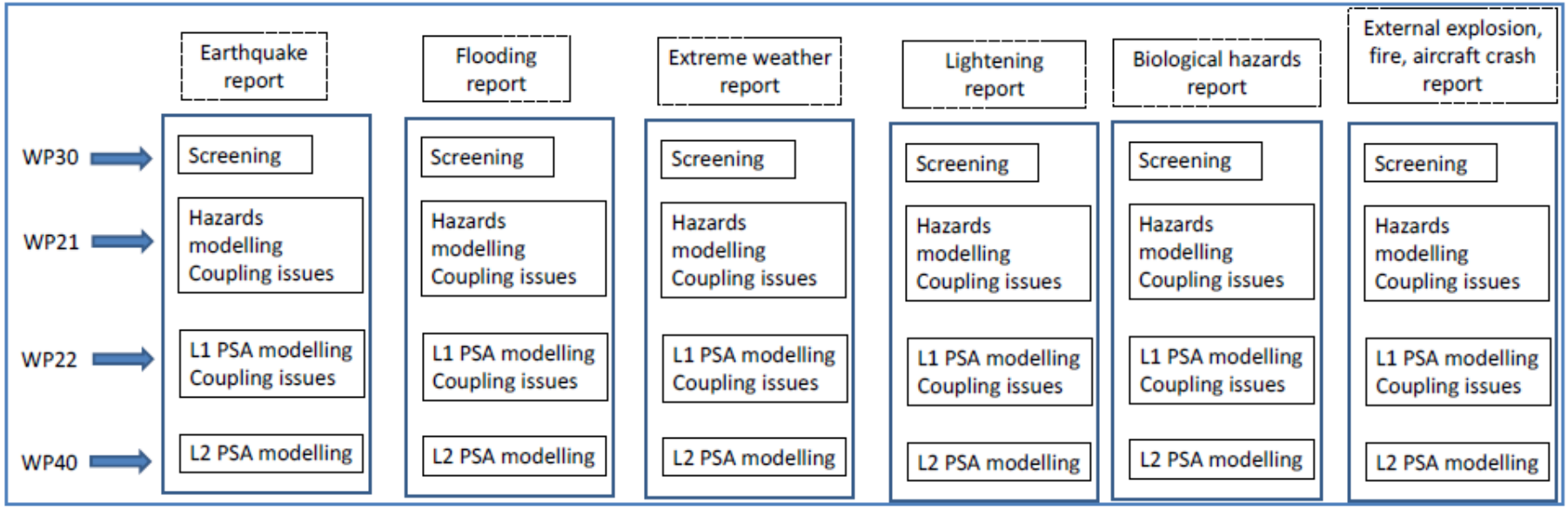
Link between extended PSA and defence-in-depth concept*
(report ASAMPSA_E/WP30/D30.4 /2016-26 - IRSN PSN-RES/SAG/2016-209)

Guidance for decision making based on extended PSA *(report
ASAMPSA_E/WP30/D30.6/2016-28 - IRSN PSN-RES/SAG/2016-00234)

** Reports have been submitted to a peer review during the summer 2016*
Update is on-going and will be achieved on Dec. 31, 2016

TOPICAL GUIDANCE REPORTS

Seven topical guidance reports to cover some external hazards recommended by the End-Users (from the first End-User Workshop in Uppsala 2014)



** Reports have been submitted to a peer review during the summer 2016*
Update is on-going and will be achieved on Dec. 31, 2016

L2 PSA – Severe accident management

Implementation of external events modeling in extended L2 PSA
(report ASAMPSA_E/WP40/D40.4/2016-14 IRSN PSN-RES/SAG/2016-00115)

Optimization of SAMG strategy by L2 PSA
(report ASAMPSA_E/WP40/D40.5/2016-16 IRSN PSN-RES/SAG/2016-00159)

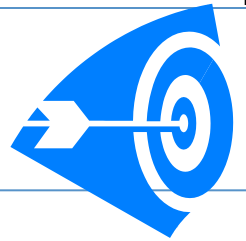
Complement of existing ASAMPSA2 guidance for shutdown states of reactors, SFP and recent R&D results
(report ASAMPSA_E/WP40/D40.6 /2016-25 IRSN PSN-RES/SAG/2016-00170)

** Reports have been submitted to a peer review during the summer 2016*
Update is on-going and will be achieved on Dec. 31, 2016

FOCUS ON 10 ASAMPSA_E LESSONS

- Preliminary views proposed for the PSAM13 conference –
- Consistent with the ASAMPSA_E final workshop (September 2016) -

LESSON 1



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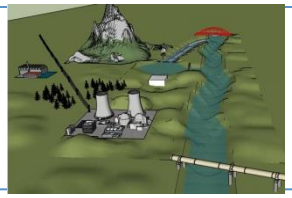
- **An extended PSA is still an objective to be reached by most (maybe all ?) PSA teams working on NPPs :**
  - **No NPP site has today a L1-L2 PSA that covers :**
    - **Full-power and all reactor shut down-state initial states,**
    - **All sources of radioactivity,**
    - **All relevant type of initiating events (internal and external)**
    - **Multi-units accident management**
- **An issue for both the regulators and the operators …**
- **But there is a large space for PSA developments …**

LESSON 2



- For external hazards, a PSA team shall consider a global picture :
  - The neighboring threats around the site (cliff-edge for flooding (sea, river, dam failure, rain impacts in surrounding area, combinations, other industrial facilities, transports …)
  - The site (case of multi-units)
- Simplified approach may be relevant to get first insights on this global pictures.
- Of course a single internal IE NPP L1-L2 PSA is needed first

LESSON 3

global risk = Σ F_ixConseq$_i$, {i} = all …

Shall "extended PSAs" calculate "global risk metrics" ?

The answer is YES in theory BUT …

- The data quality for the different parts of an "extended PSA" may be very heterogeneous … Typically the uncertainties on the IE frequencies are HUGE for rare natural events (high magnitude earthquake frequency, correlated extreme weather conditions …)

And maybe NO for practices (?) : it may be more relevant to separate clearly the PSA (internal events PSA, earthquake PSA, flooding PSA, fire PSA, extreme weather PSA, …) and to have a special treatment for highly uncertain zones (?)

Using "global risk" approach with "extended PSA" for decision-making is wished but is also questionable if the "quality" of the different parts of "extended PSAs" cannot be homogeneous

LESSON 4 (1/2)

Data quality

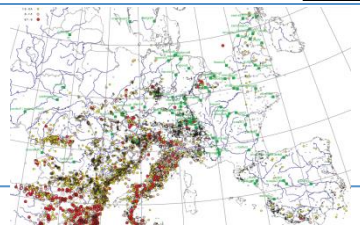
- Before developing an extended PSA, a first step is to determine the events that shall be considered (screened "in" or "out")
- Qualitative and quantitative criteria are applied in countries (which can be harmonized) and are mostly related to risk significance
- The following issue appeared during ASAMPSA_E (from utilities concern) :
  - how the data quality can be considered at this screening step ?
  - shall a PSA be developed when huge uncertainties come from the hazard modelling ?

LESSON 4 (2/2)

Data quality

- 2 objectives can be considered for screening:
  - to identify the most important hazards that contributes to the risks,
  - to identify the hazards for which it is useful to develop a PSA
- It can be concluded that a hazard is “risk significant” but that a PSA development is not relevant (see discussion on data quality). In that case, the utility may consider directly NPP reinforcement (?)
- This is an issue for the regulators and the utilities …

LESSON 5

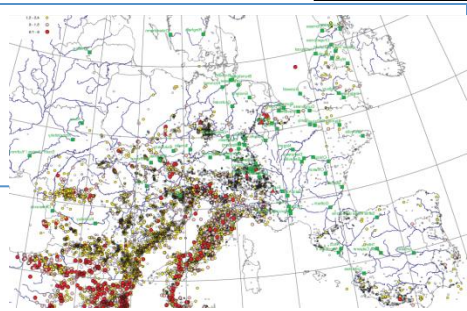


For natural hazards, the geosciences fail (?) to provide good solutions to calculate both frequencies and features of rare natural events for PSA, for example :

- **Earthquake predictions are mainly based on seismic historical data and on limited views on possible active faults displacement**

  Extreme weather conditions are identified (in ASAMPSA_E) as a significant contributor to the risk of accident but there are limited (or no ?) available methodologies to assess the frequencies of the worst cases (combined / correlated events)

LESSON 6



Geosciences capabilities for PSA analyst ...

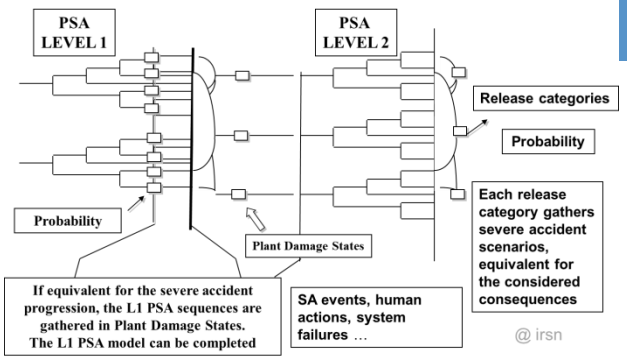
This is a societal concern, not only for nuclear industry … Progress in geosciences for rare extreme natural events modelling is highly desirable for "routine" application in PSAs :

- New tendency for seismology ? to apply physical modelling of fault rupture ; the simulation tools can be validated on real events and open an alternative to the statistical/historical data ; Can progress in faults identification and faults displacement improve the situation in the coming years for the prediction of extreme earthquake ???

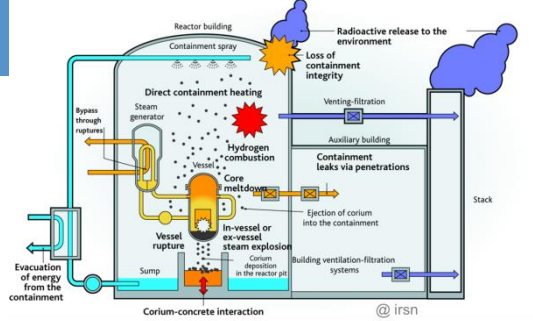
- Extreme weather prediction for PSA : which progress can be expected, especially for correlated events ? (not clear after ASAMPSA_E)

LESSON 7

- LIGHTNING impacts are in general not considered in PSA, except as a contributor to the external grid failure
- Shall PSA be developed, for example to examine possibilities of defaults propagation on electrical components …
- and how ?
- In ASAMPSA_E, this an open issue.



LESSON 8



ASAMPSA_E
SEVENTH FRAMEWORK PROGRAMME

- The Level 2 PSA methodologies are now quite well described with different options (integrated or not with Level 1 PSA, detailed or simplified …).
- The introduction of external hazards in single unit Level 2 PSA is possible with the existing methodologies (of course supporting studies shall include hazards impact assessment on SSCs modelled in Level 2 PSA for severe accident management)
- But no significant experience is available on multi-unit Level 2 PSA and the ASAMPSA_E reports recommend to start first with simple approach.

LESSON 9

Levels of defence in depth	Objective	Essential means	Radiological consequences	Associated plant condition categories
Level 1	Prevention of abnormal operation and failures	Conservative design and high quality in construction and operation, control of main plant parameters inside defined limits	No off-site radiological impact (bounded by regulatory operating limits for discharge)	Normal operation
Level 2	Control of abnormal operation and failures	Control and limiting systems and other surveillance features		Anticipated operational occurrences
Level 3 (1) 3.a	Control of accident to limit radiological releases and prevent escalation to core melt conditions (2)	Reactor protection system, safety systems, accident procedures	No off-site radiological impact or only minor radiological impact (4)	Postulated single initiating events
3.b		Additional safety features(3), accident procedures		Postulated multiple failure events
Level 4	Control of accidents with core melt to limit off-site releases	Complementary safety features(3) to mitigate core melt, Management of accidents with core melt (severe accidents)	Off-site radiological impact may imply limited protective measures in area and time	Postulated core melt accidents (short and long term)
Level 5	Mitigation of radiological consequences of significant releases of radioactive material	Off-site emergency response Intervention levels	Off site radiological impact necessitating protective measures(5)	-

DiD levels from WENRA

- PSA is recognized to be able to examine if defense-in-depth (DiD) concept has been correctly implemented in the plant design and operation
- The ASAMPSA_ E project has led to debate on the structure of PSAs : shall it be modified with the levels of DiDs (level 3 accident prevention, level 4 accident mitigation, …).
- A majority of partners consider that PSAs shall be developed independently of the DiD application for the NPP design.
- It remains an important application of PSA (backup for design)

LESSON 10

RIDM

- Extended PSA shall be associated to a “Risk Informed Decision Making” process.

- The ASAMPSA_E partners will propose some recommendations considering :

  - PSA list of application,
  - risk metrics,
  - screening approach,
  - multi-units issues (which criteria for PSA ?),
  - data uncertainties

- But the topics will clearly need additional exchanges at national and international levels

CONCLUSION

- All ASAMPSA_E reports will be available at the end of 2016
- As explained, most PSA teams have a lot to do to extend the scope of existing PSA
- Criteria to decide what is useful or not, are crucial
- In addition, a list of possible follow up actions will be proposed by the ASAMPSA_E partners for further considerations in new collaborative projects.


Thank you!


QUESTIONS ?