Work shop on Evaluation of Uncertainties in relation to severe accidents and level 2 PSA

Severe Accident Research Network (SARNET)
Level 2 PSA work package: comparison of partners'methods for uncertainties assessment

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Summary

SARNET general presentation

General objectives of SARNET level 2 PSA WP

Status of work already performed

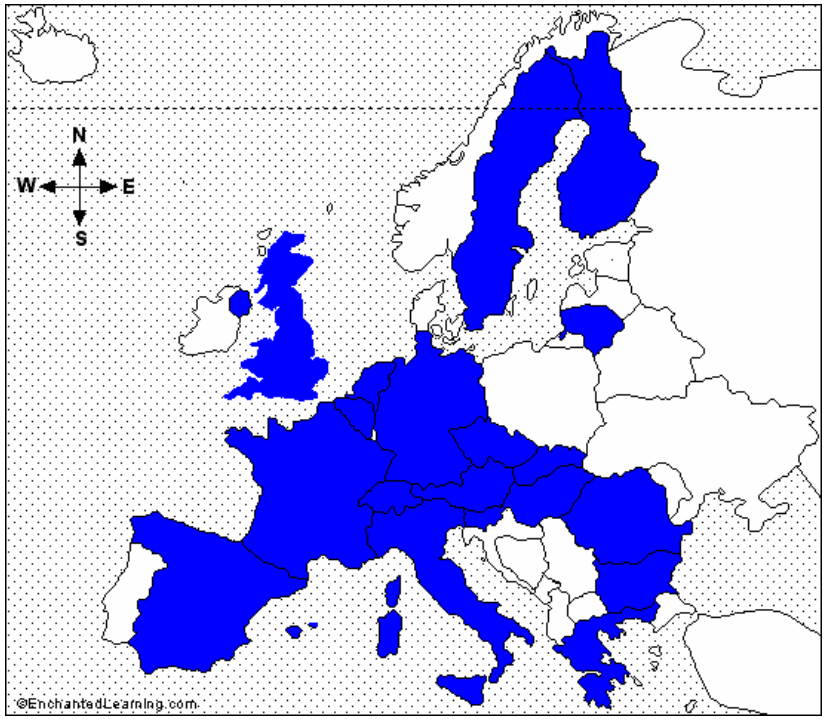
Global comparison of partners' approaches

Some results of the comparison

- **Level 1 PSA uncertainties propagation**
- **Uncertainties considered in the APET and for the releases assessment**

Conclusions & future work

Severe Accident Research NETwork of excellence



EURATOM 6th Framework Programme (FP-6) 2002-2006

18 Countries, 49 organizations

- **18 Research Organizations**
- **10 Universities**
- **11 Industry Organizations**
- **4 Utilities**
- **6 Safety Authorities or Technical Supports**

Programme started in April 2004

SARNET: themes of interest

Integrating Activities

WP 1 : ACT
Development on an Advanced Communication Tool

WP 6 : IED
Implementation of Experimental Database

WP 7 : SARP
Definition of Severe Accident Research Priorities

WP 8 : IA
Integration Assessment

WP 2 : USTIA
ASTEC Users Support and Training, Integration, and Adaptation

WP 3 : PHYMA
ASTEC PHYsical Model Assessment

WP 4 : RAB
ASTEC Reactor Application Benchmarking

WP 5 : PS2
Level 2 PSA methodology and advanced tools

Joint executed research activities

WP 9,10,11 : CORIUM
Early phase core degradation
Late phase core degradation
Ex-vessel corium recovery

WP 12, 13 : CONTAINMENT
Hydrogen behaviour
Fast Interaction in Containment

WP 14, 15,16 : SOURCE TERM
FP Release and Transport
Aerosol Behaviour impact on Source Term
Containment Chemistry impact on Source Term

Spreading of excellence activities

WP 17 : ET
Education and Training

WP 18 : BOOK
Book on severe accident phenomenology

WP 19 : MOB
Mobility programme

WP 20 : Management

SARNET PSA 2 WP content

Part of Joined Programme Activities / Integrating Activities

Organization in three main tasks

- **Task 5.1 : Comparison of level 2 PSA approaches and identification of improvement needs**
- **Task 5.2 : Comparison of methodologies for assessment of uncertainties and identification of improvement and harmonization needs**
- **Task 5.3 : Improvement of event tree methodology using dynamic reliability techniques**

Detailed specific programme defined for these tasks for the two first years (JPA1 and JPA2)

Participants

	WP 5.1 : methods	WP 5.2 : uncertainties	WP 5.3 : dynamic reliability
IRSN (France) Coordinator	X	X	X
AVN (Belgium)	X		
CEA (France)		X	X
CSN (Spain)	X	X	X
EDF (France)	X	X	X
FRAMATOME (Germany)	X	X	X
GRS (Germany)	X	X	X
INR (Romania)	X		X
JRC (Belgium)		X	
LEI (Lithuania)	X	X	X
NNC (United Kingdom)	X	X	
PSI (Switzerland)	X	X	X
SWP (Sweden)	X	X	
TUS (Bulgaria)	X	X	
ULB (Belgium)			X
UJV (Czech Republic)	X	X	
VEIKI (Hungary)	X	X	

WP5.2: status of work performed

Description, comparison of partners methods concerning uncertainties assessment

- **Propagation from level 1 PSA**
- **Uncertainties considered in the APET and associated methods**
- **Uncertainties for releases assessment and associated methods**
- **Sensitivity studies performed in the frame of the level 2 PSA**

Review of complementary possible methods

- **To propagate uncertainties**
- **To perform sensitivity studies**
- **To assess that a probability exceeds a thresold**
- **Surrogated methods (including surface response methods)**

Identification of some improvement needs

WP5.2 : method used

First general questionnaire including some questions about the general approach for uncertainty assessment

- **Different sources of uncertainties considered**
- **Methods used to assess them (qualitative description expected)**

Second specific questionnaire on uncertainties (quantitative data expected)

- **Uncertainties treatment for the different steps of the level 2 PSA**

Answers to the questionnaires provided by the partners, compiled and then compared for the different subjects of interest

WP5.2: Some elements of the global comparison

Criteria defined for global methods comparison

Criteria for « quantification » methods

1. None or very coarse
2. Mathematical – assignement of arbitrary distributions
3. Physical-mathematical – process/phenomenon oriented

Criteria for « propagation » methods

1. Not addressed
2. Uncertainties discussed but not quantified or dismissed as of little consequence or interest
3. Treatment implicit, i.e. uncertainties discussed but not quantified, but rather addressed with sensitivity studies
4. Explicit, quantification performed for PDS frequency
5. Explicit, quantification performed for PDS frequency and magnitude of source terms

WP5.2: Some elements of the comparison

Partner	« Quantification » method	« Propagation » method
AVN	1	1
EDF	2	2
FRAMATOME	3	5
GRS	2	4
IRSN	3	2 & 5
LEI	1	1
NNC	3	2
SWP	1	2 & 3
TUS	1	2 & 3
UJV	1	2
VEIKI	2	4
INR	To be defined	2
PSI	3	5

Some conclusions of the global comparison

Diversity of partners' approaches

- **No requirement, in most of the countries, for uncertainties assessment in level 2 PSAs**
- **Partners' approaches depend on level 2 PSA objectives and also on available ressources**
- **Apparent contradiction of partners' practices with existing AIEA guidelines stressing the importance of uncertainty assessment in level 2 PSA**
- **Clearer evidence of the benefit of an uncertainty assessment in a level 2 PSA probably to be provided**

Propagation of uncertainties from level 1 PSA to level 2 PSA

- Uncertainties generally assessed in the partners' level 1 PSA
  - **Uncertainties on input data (initiating events frequency, systems or components reliability, sometimes human actions)**
  - **Uncertainties on physical phenomena not considered**
- Agreement on a propagation method based on distribution functions of Plant Damage State (PDS) frequency
- Uncertainties generally not propagated to level 2 PSA
- Binning uncertainty not assessed (relevant choice of PDS attributes considered as a way to limit the corresponding uncertainties)
  - **Nevertheless great variations in the number of interface variables, in the choice of these variables, in the number and meaning of variables modalities**

Accident Progression Event Tree (APET) uncertainties

Some physical phenomena omitted or neglected but associated uncertainties not assessed

- **Lists of corresponding phenomena may vary between the different partners**
- **Different consequences of the same physical phenomenon may be investigated**

Some physical phenomena considered sometimes as aleatory (and sometimes as deterministic)

- **Triggering of steam explosion**
- **Hydrogen ignition of a flammable mixture**

No assessment of the uncertainties resulting from the « coarse » structure of the APET

- **Decisions necessary on the level of APET complexity according to limited time and knowledge available**
- **May be assessed using dynamic reliability methods (WP5.3 task)**

Accident Progression Event Tree (APET) uncertainties

Partners' interest on the uncertainties related to physical phenomena

- **But no estimation of the relative importance of uncertainties on human actions, systems reliability and physical phenomena**

Uncertainties related to cut-off frequency during APET quantification estimated – and sometimes demonstrated - to be negligible

Uncertainties propagated during the APET quantification using the Monte Carlo method

Feasibility of a rather systematic assessment of uncertainties for recently developed level 2 PSA using

- **Systematic severe accident code calculations**
- **Some complementary expert judgement interpretation**

Uncertainties on releases assessment

Few partners assess the uncertainties on releases

As for the APET, some physical phenomena omitted or neglected but associated uncertainties not assessed

- **Lists of corresponding phenomena may vary between the different partners**

Quite different number of releases categories (from 8 to 1000)

- **Binning uncertainty not assessed separately (excepted partly in one case) but probably dependant on the number of RCs**

Both uncertainties due to binning process or to source term assessment estimated very high (at least more than one order of magnitude)

Lack of knowledge on gaseous iodine behaviour estimated to be the most important contributor to the source term uncertainty (estimated unquantifiable for some partners)

Conclusions / future work

Very high difficulty to correctly address all sources of uncertainties notably due to

- **The lack of completeness of the study**
- **The lack on knowledge on some subjects**
- **The limitations of classical methodologies**

Feasibility of a rather systematic assessment of uncertainties on physical phenomena on the basis mainly of severe accident codes calculations

Probable difficulty to achieve globally a certain level of harmonization due to the complexity of the subject and to the diversity of initial partners' approaches

Future work concentrated on recommendations of best estimate method(s) to assess in a level 2 PSA the uncertainties on some physical phenomena (tasks now on going) :

- **Hydrogen distribution and combustion**
- **Melt corium and concrete interaction**
- **Iodine releases**