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NUCLEAR AND RADIOLOGICAL EMERGENCY MANAGEMENT AND PREPAREDNESS

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Layout of presentation

- EP&R issues following Fukushima;
- EURATOM recent projects on EP&R;
- European context;
- ST issue;
- PREPARE project;
- FASTNET project;
- Future R&D needs and priorities.

Post-Fukushima EP&R Issues

The outcomes of the analysis of the European reaction to the Japanese accident showed several important and common issues:

- Missing early and rapid information on the potential Source Term (ST);
- Absence of a coordinated plan at European level to estimate the ST;
- Absence of an harmonized response to the safety of the European residents living in Japan;
- Partly chaotic communication with the public;
- Insufficient guidance on how to deal with incoming goods from Japan.

EURATOM recent Projects on EP&R

- **PREPARE** Collaborative Project (FP7)
  - 1 February 2013 - 31 January 2016;
  - Coordinator: KIT;
  - 45 partners;
  - 6.5 M€ project, with 4 M€ EU contribution.
- **FASTNET** Research and Innovation Action (H2020)
  - 1 October 2015 - 30 September 2019;
  - Coordinator: IRSN;
  - 20 partners;
  - 4.7 M€ project, with 2.8 M€ EU contribution.

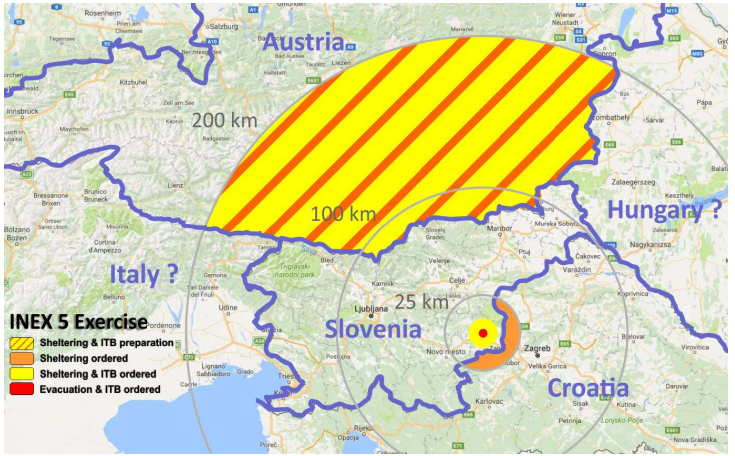
EURATOM efforts in EP&R: 6.8 M€ in 7 years, ≈ 1 M€/year.

European context

Strong need to enhance the coherence in EP&R, because Europe is:

- very dense in population;
- very dense in nuclear power installations;
- very diversified and heterogeneous as far as the nuclear technologies;
- very heterogeneous as far as the national legal frameworks;
- very complex as far as orography.

→ Transboundary cases



INEX-5 (OECD/NEA No. 7379, 2018)

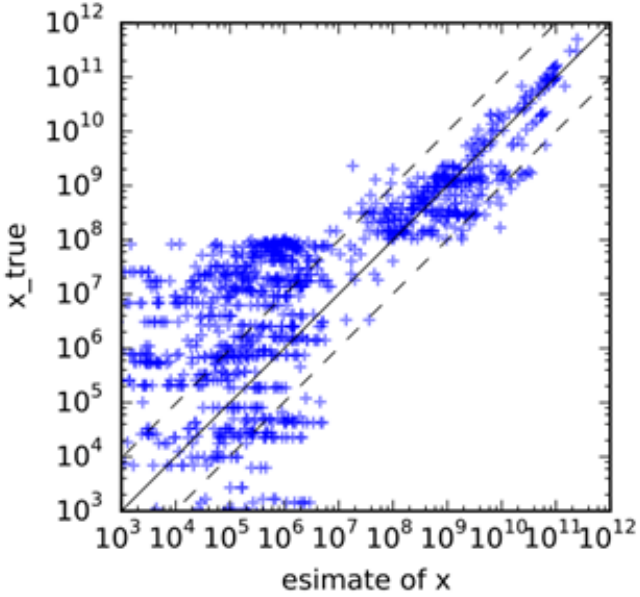
Source Term

- The fast and timely delivery of comprehensive information about an existing (**Diagnosis**) or developing future (**Prognosis**) situation is a key point for decision making in the early stage of an emergency. **Fast and reliable ST assessments**, not necessarily of a strongly conservative nature, are at the very heart of the problem.
- OECD/NEA WGAMA FASTRUN Project (2015) outcomes.

Source Term

- Complementarity of approaches:
  - Situations requiring an early prognosis of an emergency, in order to timely (a few hours before release) activate and trigger protective countermeasures;
  - Prognoses must be made prior to any release to the environment, and therefore before the availability of any measured data;
  - Prognoses are therefore enabled by fast-running tools;
  - Measured data can be used, later on, either to confirm or to improve the calculated prognosis;
  - Inversion algorithms need a first-guess ST; this can be provided by fast-running tools;
  - Techniques based on measured data and inversion algorithms still need further development and refinement (+uncertainties in ATM and weather data).

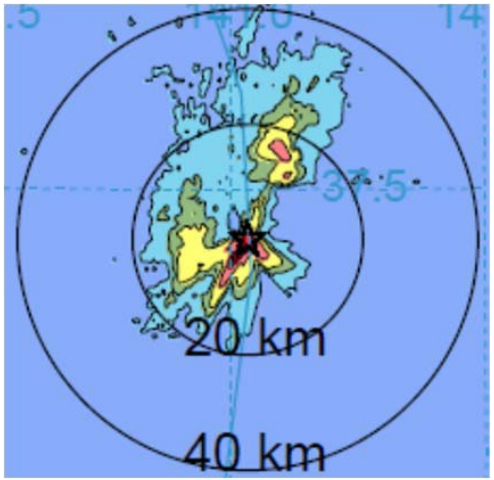
Source Terms from inversion algorithms



PREPARE: Comparison of “true” and “estimated” ETEX experiment source strength

Fukushima STs

Inversion alg. -> **ST**



N. Bixler, 31st Annual Regulatory Information Conference, USA 2019

PREPARE

- **Operational procedures for long lasting releases**: review and “stress-test” of existing EP&R procedures for long lasting releases by performing scenario calculations.

- **Platform for information collection and exchange**: so-called Analytical Platform. It allows discussion between institutional and non-institutional experts on an expert-level, and widespreads congruent information on the current situation to the public, including mass media.

- **Management of contaminated goods:** stakeholder panels have been prepared, with meetings in 10 European countries to review existing guidance.

PREPARE

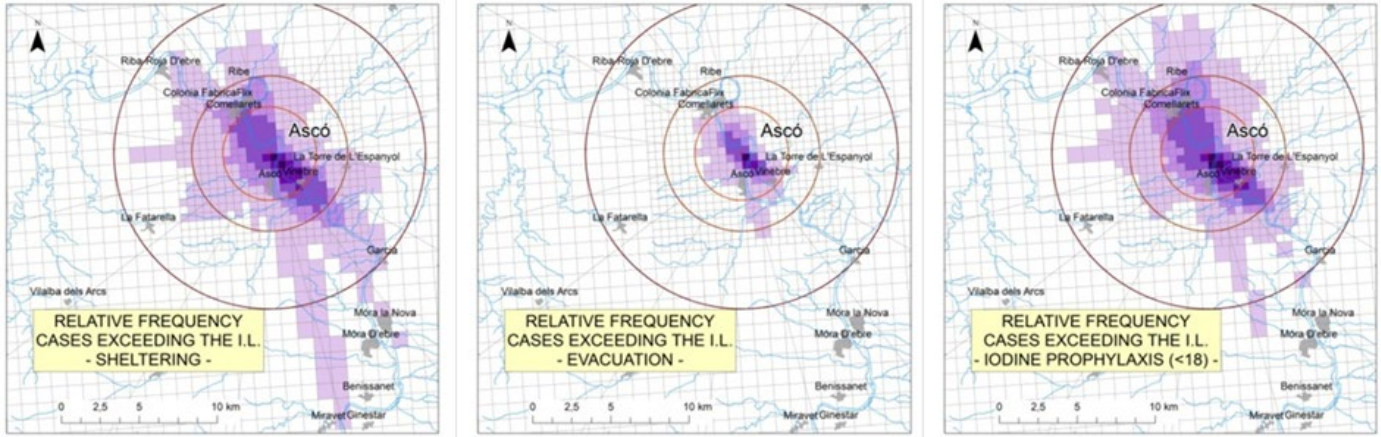
- **Improvement of decision support systems**: ARGOS and RODOS DSS continuous development.

- **Communication with the public**: to investigate the conditions and means for relevant, reliable and trustworthy information to the public (both traditional and social media).

- **Training, exercises and dissemination**: training and exercising strongly incorporated within the project.

PREPARE – Long-lasting releases

- Conventional cases: from few hours to few days of release duration;
- Fukushima case: from several days to weeks;
- «Stress-tests» of national procedures for such long scenarios;
- Parametric study (ST strength, release duration, weather conditions) and analysis of cases for which national procedures are not adequate.



Frequency of scenarios exceeding Spanish intervention limits.

PREPARE – Long-lasting releases

- In the majority of release scenarios the areas calculated for protective actions do not exceed current planning zones. Were these ranges exceeded, the amount of affected population remained quite small.
- The current intervention criteria in all European countries guarantee that the residual dose in the first year (ICRP reference level) does not exceed 100 mSv.
- Some shortcomings were identified: a one-time intake of stable iodine is often not sufficient for protecting the population against large thyroid doses.
- Two questions still unanswered:
  - A long lasting, low release rate ST may require a very large capacity air-sampling for good measurements; have these special and non-standard monitoring devices ever been considered in the emergency plans?
  - Is the evacuation of the population during the passage of the plume nearby always preferable against sheltering?

PREPARE – Drinking water

- In case of a nuclear accident, surface water can be contaminated and may not be suitable for drinking water production.
- Advanced treatment processes as ion-exchange and reversed osmosis do remove radionuclides effectively, but these processes are not common.
- Soil passage (dune infiltration, river bank filtration, groundwater) is a safe barrier for I-131 and Cs-137.
- If surface water is the main direct source for drinking water production, emergency plans for drinkable water supply are needed.
- Drinking water utilities in European countries are required by the EU Drinking Water Directive to provide emergency drinking water in case of a major accident, including nuclear accidents.

PREPARE – RODOS & ARGOS

- Two algorithms for source term estimation based on measurements and atmospheric dispersion models (inversion methods) were developed and integrated into JRODOS.
- The atmospheric dispersion models of ARGOS and JRODOS were enhanced with particle size information and the European Model for Inhabited Areas (ERMIN) has been modified to deal with particles of different solubility.
- The Hydrological Dispersion Module (HDM) of JRODOS was improved (1-D hydraulic model RIVTOX, 3-D model THREETOX), the marine model POSEIDON was enhanced and the MOIRA decision support tool was integrated into JRODOS.

FASTNET

- The development of a **reference SA scenarios database**, inclusive of time-dependent, isotopic STs, created using best-estimate SA codes;

- The extension of existing **methods** (3D3P) **and fast-running codes** (PERSAN and RASTEP) to predict STs to all current nuclear power plant technologies deployed in Europe and their further development;

- The dissemination of **best-practices** on the use of the methods and tools developed within the project **to estimate STs in real-time and during conditions typical of real emergencies**;

- Two EP&R Exercises, one of which in **real-time**.

FASTNET - Database

- Up to now, about 120 sequences are included;
- IAEA IRIX format for data exchange;
- To be transferred to **IAEA-IEC** at the end of the project.

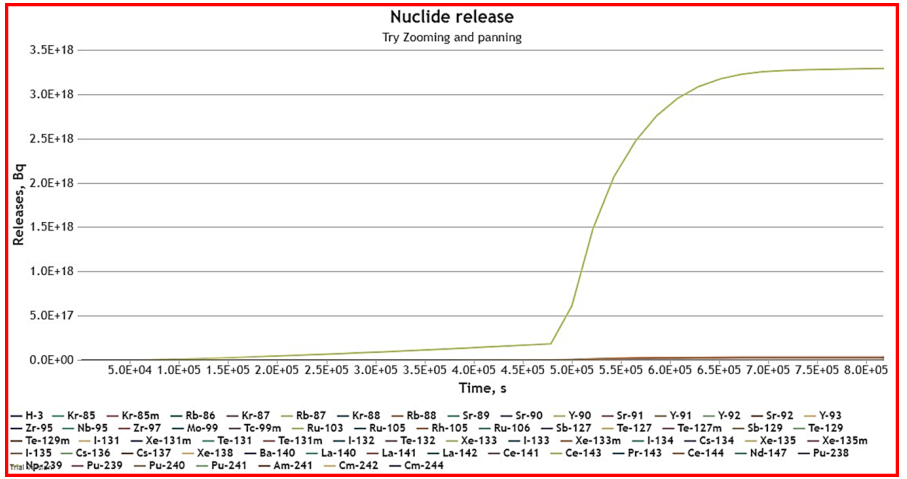
Matrix of Scenarios

GENERIC DESIGNS	ATW	LFWSG	LBLOCA	IBLOCA	SBLOCA	SBO	SGTR	SFP
BWR-MARK1				*		*		
BWR-ABB	*		*			*		
CANDU			*		*	*	*	
French PWR 1300		*	*	*	*			
French PWR-900						*		
PWR-1000			*	*	*	*		*
VVER-440			*			*	*	
VVER- 1000					*	*		

FASTNET - Database

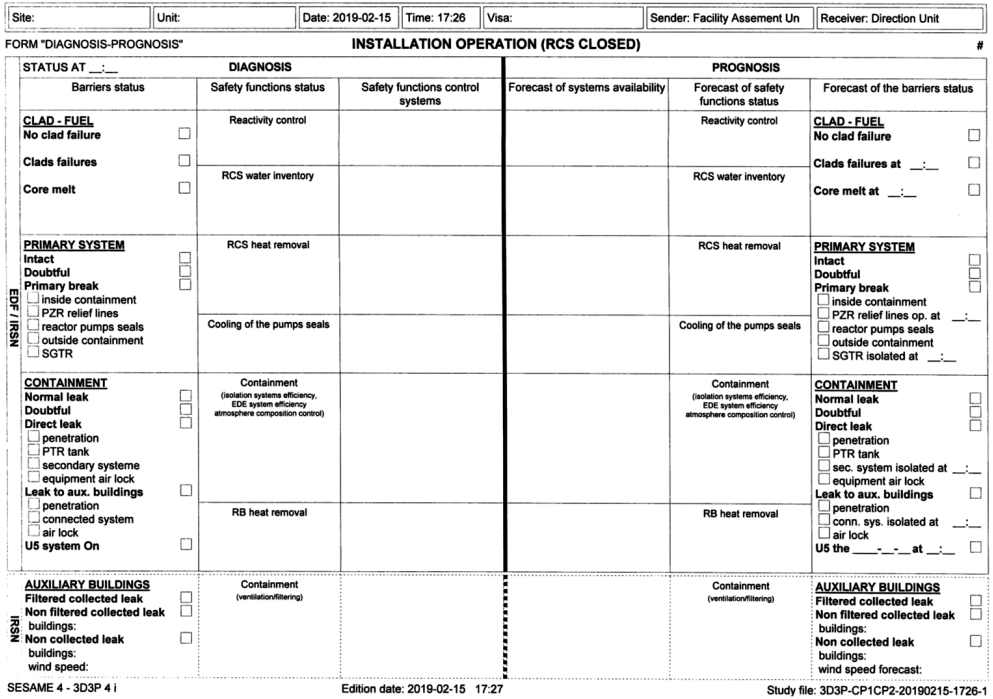
The data have been grouped as:

- Basic data regarding the plant;
- Initial Inventory;
- Scenarios description;
- Key events;
- Physical data regarding core behavior;
- Physical data regarding primary circuit behavior;
- Physical data regarding secondary circuit behavior;
- Physical data regarding containment behavior;
- Physical data regarding release;
- Released elements and isotopes;
- Other data requested.



FASTNET – 3D3P

- Triple Diagnosis / Triple Prognosis;
- Method to assess plant status (**Diagnosis**) and to make predictions on future development (**Prognosis**) of the **three barriers**: fuel, primary system, containment;
- Based on **plant data** (when available) and on **expert judgement**;
- It is a basis for the correct use of the PERSAN fast-running code;
- Already developed by IRSN for PWRs, and now extended to all reactor types in Europe.



Site:	Unit:	Date: 2019-02-15	Time: 17:26	Visa:	Sender: Facility Assement Un	Receiver: Direction Unit

FORM "DIAGNOSIS-PROGNOSIS" — **INSTALLATION OPERATION (RCS CLOSED)** — #

STATUS AT __:__	DIAGNOSIS		PROGNOSIS		
Barriers status	Safety functions status	Safety functions control systems	Forecast of systems availability	Forecast of safety functions status	Forecast of the barriers status
CLAD - FUEL ☐ **No clad failure** ☐ **Clads failures** ☐ **Core melt**	Reactivity control RCS water inventory			Reactivity control RCS water inventory	**CLAD - FUEL** ☐ **No clad failure** ☐ **Clads failures at** __:__ ☐ **Core melt at** __:__
PRIMARY SYSTEM ☐ **Intact** ☐ **Doubtful** ☐ **Primary break** ☐ inside containment ☐ PZR relief lines ☐ reactor pumps seals ☐ outside containment ☐ SGTR	RCS heat removal Cooling of the pumps seals			RCS heat removal Cooling of the pumps seals	**PRIMARY SYSTEM** ☐ **Intact** ☐ **Doubtful** ☐ **Primary break** ☐ inside containment ☐ PZR relief lines op. at __:__ ☐ reactor pumps seals ☐ outside containment ☐ SGTR isolated at __:__
CONTAINMENT ☐ **Normal leak** ☐ **Doubtful** ☐ **Direct leak** ☐ penetration ☐ PTR tank ☐ secondary systeme ☐ equipment air lock ☐ **Leak to aux. buildings** ☐ penetration ☐ connected system ☐ air lock ☐ **U5 system On**	Containment (isolation systems efficiency, EDE system efficiency atmosphere composition control) RB heat removal			Containment (isolation systems efficiency, EDE system efficiency atmosphere composition control) RB heat removal	**CONTAINMENT** ☐ **Normal leak** ☐ **Doubtful** ☐ **Direct leak** ☐ penetration ☐ PTR tank ☐ sec. system isolated at __:__ ☐ equipment air lock ☐ **Leak to aux. buildings** ☐ penetration ☐ conn. sys. isolated at __:__ ☐ air lock ☐ **U5 the ____-__-__ at __:__**
AUXILIARY BUILDINGS ☐ **Filtered collected leak** ☐ **Non filtered collected leak** buildings: ☐ **Non collected leak** buildings: wind speed:	Containment (ventilation/filtering)			Containment (ventilation/filtering)	**AUXILIARY BUILDINGS** ☐ **Filtered collected leak** ☐ **Non filtered collected leak** buildings: ☐ **Non collected leak** buildings: wind speed forecast:

EDF / IRSN — IRSN

SESAME 4 - 3D3P 4 i — Edition date: 2019-02-15 17:27 — Study file: 3D3P-CP1CP2-20190215-1726-1

FASTNET – Fast-running codes

PERSAN

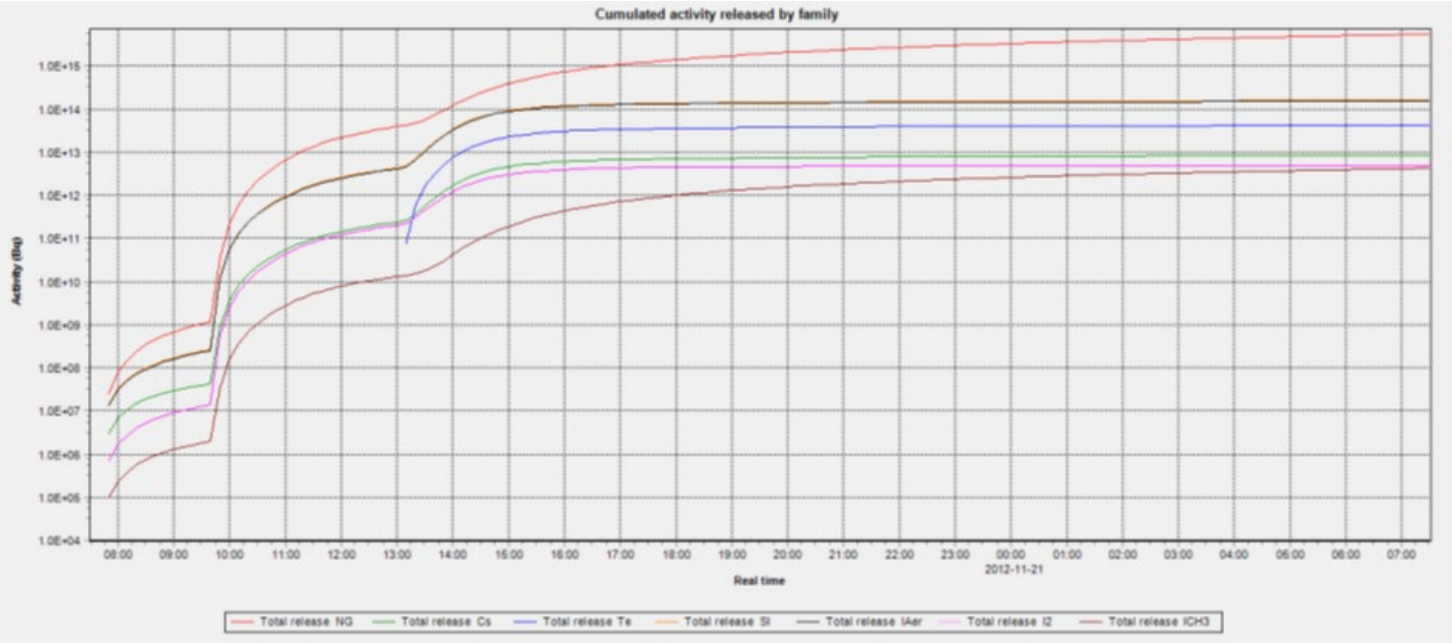
- Initially developed for PWRs by IRSN, now extended to all types of NPPs;
- **Deterministic** code to evaluate time-dependent STs in a time-frame of a few minutes;
- Some realistic assumptions, such as either the timing of core dewatering or the specific leak-rates to the environment, need to be specified as input;
- Solution of simple balance equations for isotopes.

RASTEP

- Initially developed for BWRs by LR and in use to SSM, now extended to all types of NPPs;
- Based on **Bayesian Belief Network** to select the most probable ST among a set of pre-calculated (PSA-2) sequences;
- Results in a few minutes;
- Solution up to now in terms of a few relevant isotopes.

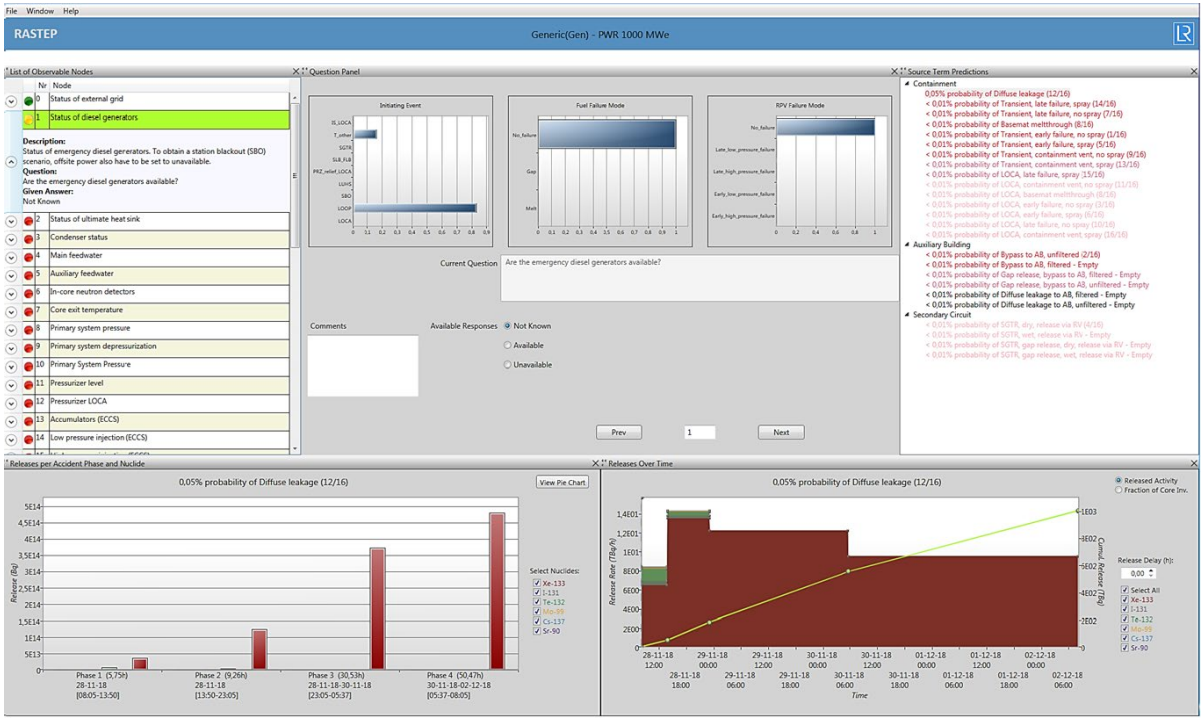
Both codes can export ST data in IAEA IRIX format.

FASTNET – PERSAN



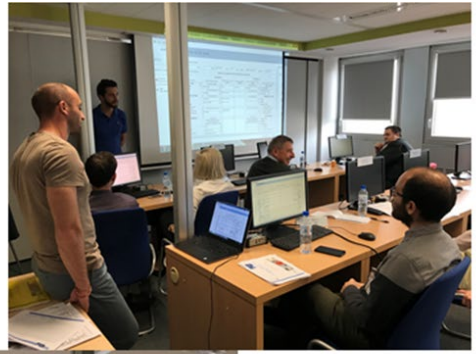
Example of ST calculated with PERSAN.

FASTNET – RASTEP



RASTEP Graphical User Interface.

FASTNET - Training



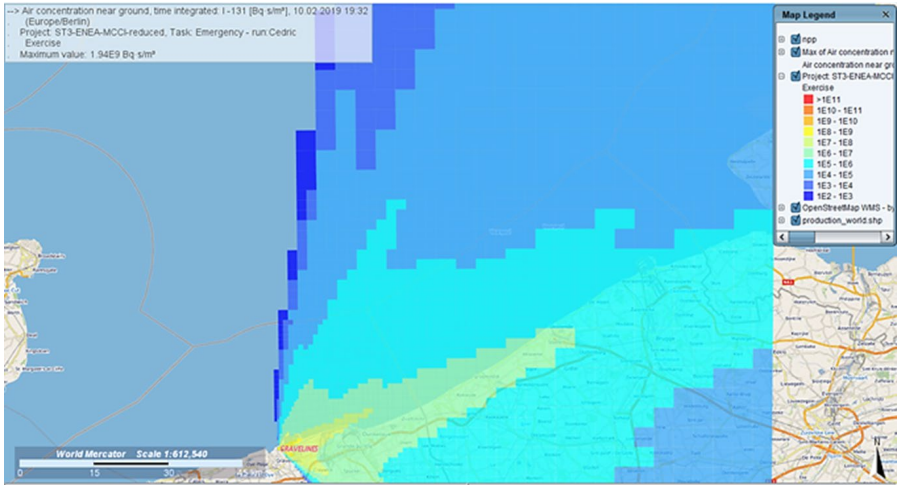
Training week on 3D3P, PERSAN and RASTEP.

Exercise 2 in Vienna.

Debriefing after Exercise 2.

FASTNET - Training

- Exercise 2: simulated accident at Gravelines NPP.
- Exercise prepared and conducted by IRSN.
- Real-time exercise.
- Use of PERSAN and/or RASTEP, and real weather data.



131I Time-integrated air concentration.

Thyroid dose after 10 days to children.

Dissemination and Education and Training

PREPARE

- Dissemination workshop in Bratislava;
- NERIS Workshop in Milan;
- Two basic courses on emergency management and rehabilitation;
- Training course on the Analytical Platform;

FASTNET

- Two international Workshops (Bologna and Paris);
- A one week-long training open also to End-User Group on methods and tools (Paris);
- A one week-long School on EP&R, open to all interested stakeholders (Bologna);
- Presentation at 2017 ECURIE Competent Authorities Meeting;
- Joint F-S-I side-event at next IAEA GC.

Future R&D needs and priorities

- One major challenge, anticipated and experienced in FASTNET, is related to the **dialogue** between the **severe accident management scientific community** and the **emergency management one**. They have the same aim of protecting people; they however speak different languages and are used to tackle similar problems but with different perspectives. FASTNET was the first European project on EP&R in which these communities were asked to cooperate; this first dialogue attempt was certainly **fruitful, but not complete**.

- In the future it is highly recommended, that opportunity is given to strengthen the links between these two communities, for example by organizing:

  1. several **operational trainings**, based on the feedback from the exercises organized within FASTNET;
  2. a new **series of exercises**, targeting the protection of population and having a higher level of reality (f.i. full-scale formats, scenarios based on every technology, etc.).

Future R&D needs and priorities

- Much more **training** is needed **on the fast-running tools**, especially in their use in emergency centres. As evidenced also in the PREPARE project, **training in EP&R is really an absolute need for Europe**. The development of fast-running codes is per se not enough if emergency responders are not properly trained in dealing with such tools and the phenomena they describe.

- The complementarity between the results of PREPARE and FASTNET should be taken to the level of productive interaction, for example by **using STs derived from fast-running tools for inverse methods**. This kind of interaction is also suggested by the NERIS Platform Gap Analysis (Area 1, Key Topic 3): “Link of inverse with in-plant (e.g. FASTNET project) ST estimation methodologies”.

- Development of **uncertainty propagation**, using STs evaluated in real-time by fast-running tools and ensemble data from numerical weather predictions.

Thank you for your attention!

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