

Research Activities in NUGENIA-TA2: Severe Accidents

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NUGENIA is mandated by SNETP to coordinate
nuclear Generation II & III R&D

OUTLINE

- Context.
- Background
- Framework
- Present NUGENIA-TA2.
- Final Remarks.

Context

3

Context

- The SARNET network (Severe Accident NETWORK of excellence) was co-funded by EC from 2004 to 2013 in FP6-FP7 and then integrated in NUGENIA.
- The main network activities are continuing in the NUGENIA Technical Area N°2.
- As of Dec. 2018, TA2 coordination by CIEMAT was approved by NUGENIA Excom.
- This presentation is aimed at giving an update of TA2, with particular emphasis on recent actions and plans.

4

Background

SARNET in Euratom (1/2)

- **Coordinated by IRSN, gathered ≈50 partners (> 20 countries, EU and non-EU).**
 - 250 researchers and 30 PhD students = work equivalent to 40 full-time persons per year.
- **FP7 project divided into the following WPs:**
 - ASTEC IRSN-GRS code development and assessment
 - Corium and debris coolability
 - Molten corium concrete interaction
 - Containment
 - Source term
- **Main end-products:**
 - Huge database and improved knowledge on phenomena
 - Knowledge capitalization in the ASTEC code and in an experimental database based on JRC STRESA tool

SARNET in Euratom (2/2)

■ Dissemination of knowledge

- 6 **ERMSAR** periodic conferences (100 to 150 participants)
- 6 **Education & Training one-week courses** (40 to 100 participants)
- Publication in 2011 of a 750-pages **textbook on severe accident phenomenology**
- During the FP6-7 projects, publication of \approx 200 papers in peer-review journals and presentation of \approx 400 lectures in international conferences
- Mobility programme for young researchers and students (52 delegations with average duration of 3 months)

■ Ranking of research priorities

- Periodic update to account for the results of recent research and, after 2011, for the impact of Fukushima Dai-ichi accidents
- This process led to define 20 issues of medium to high priority

7

Framework

8

NUGENIA Association



- **International non-profit association for collaborative R&D on Gen. II-III nuclear systems (2011)**
 - More than 100 members from many countries (including out of Europe Korea, Japan, USA and Canada) from industry, research, TSOs and academia.
 - 8 technical areas (TA): plant safety and risk assessment, integrity of structures, fuel development.... and "Severe accidents" TA2
- **New NUGENIA R&D roadmap to be published in 2019**
 - Update of SARNET ranking (2013) - ERMSAR 2019 paper based
 - Main priority of R&D efforts to focus on improvement of prevention of SA and **on mitigation of their consequences**, as underlined by the Fukushima Dai-ichi accidents
- **Towards a single nuclear platform (SNETP)**
 - NUGENIA keeps its "technical identity" and project management

9



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SARNET in NUGENIA



- **Overall objectives remain:**
 - Integration of efforts of European R&D organisations in definition of research priorities and of common research programmes,
 - Capitalizing the knowledge (SOAR, simulation codes, databases),
 - Bringing together top scientists in SA research to constitute a world leadership position,
 - Disseminating knowledge through E&T programmes and papers, to students and young researchers, and to new nuclear countries.
- **But extension to emergency preparedness and response and SA impact on environment**
- **The main network activities are continuing:**
 - Technical workshops, ERMSAR, Education & Training courses
 - Elaboration of new R&D projects (H2020 & in-kind types)

10



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TA2 Current Status

Context

- **TA2 coordinator (JPvD, IRSN) retired Fall.**
- **An election set in Summer 2018.**
 - Three candidates (CIEMAT, IRSN, TRACTEBEL)
 - 45 organizations voted
 - CIEMAT option was the most voted on.
 - Deputy coordination set on IRSN.
 - NUGENIA ExCom approval on Dec. 10th.
- **First coordination meeting held on Jan. 17th.**

Introduction

- **Coordination:** CIEMAT (IRSN, Deputy)
- **Sub-TA and leaders:**
 - 2.1 In-vessel corium/debris coolability (KIT)
 - 2.2 Ex-vessel corium interactions-coolability (CEA)
 - 2.3 Containment behaviour, incl. H₂ risk (JSI)
 - 2.4 Source term to the environment (CIEMAT)
 - 2.5 Environmental Impact & emergency management (IRSN)
 - 2.6 Severe accident scenarios (ENEA)
- **Coordination of dissemination of knowledge:** UNIPI

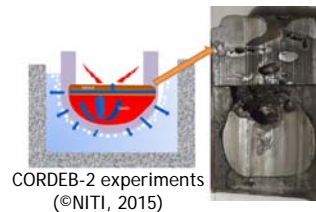
TA2.1 & TA2.2: Corium/debris coolability

Four subtopics

- Reflooding and coolability of a degraded core (REFCOOL)
- Remelting of debris, melt pool formation and coolability (MPF)
- Bringing research results into reactor application (COOL-RA)
- Spent fuel pool analysis (SFP)

TA2.1 linked R&D projects

- SAFEST, ALISA, IVMR, FASTNET, CORE-SOAR, QUESA



CORDEB-2 experiments
(©NITI, 2015)

Yearly review meetings since 2014

TA 2.1-TA2.2 Group Meetings:



- Yearly meetings : 2*2 days, about 70 participants



- Preservation of Network of excellence
 - Technical and scientific presentations with in-depth discussion
 - Common preparation of future R&D SA projects (H2020, CoreSoar, ...)
- Strong manifestation of interest
 - Next meeting TA 2.1 and TA 2.2: to be planned end of 2019 or 2020

15



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TA2.1 & TA2.2: Corium/debris coolability



- **Ended FP7 projects:**

- **SAFEST** (*Severe Accident Facilities for European Safety Targets*), led by KIT (2014-2018): pan-European platform on corium experimental facilities

Final meeting December 2018 CEA-Cadarache (France).
16 tests performed.

Road Map for corium experimental research (TA 2.1 & and TA2.2)

- **ALISA** (*Access to Large Infrastructures for Severe Accidents*), led by KIT (2014-2018): Europa-China platform for SA experiments.

Final meeting March 2018 (Spain).

13 tests performed (7 European & 6 Chinese)

16



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TA2.1 & TA2.2: Corium/debris coolability

- **Ended in-kind NUGENIA projects:**

- CORE-SOAR (*Core degradation State-of-the Art Report*), led by IRSN (2016-2018): update of SOAR 1995.
- QUESA (*QUench experiment with Steam and Air*), led by EDF (2016-2018): complements of SAFEST by pre- and post-calculations of experiments done in the latter.

TA2.1 & TA2.2: Corium/debris coolability

- **Euratom current projects (FP7 or H2020):**

- **SAFEST-Gen 4** (Maintain the European network of excellence for experimental laboratories-Expertise/Gen4): **rejected**
- **EVEREST** (Ex Vessel Retention European Simulation Tools): **rejected**
- **SARICOB** (Maintain the European-Chinese network of excellence for experimental laboratories Expertise): **rejected**

- **OECD future projects**

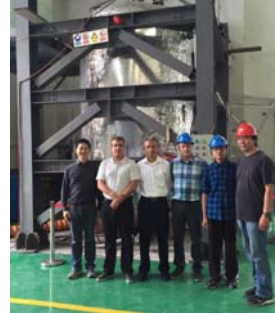
- OECD/ROSAU

TA2.3: Containment behavior

- FP7 projects:

- Link to ALISA project (*Access to Large Infrastructures for Severe Accidents - Coordinated by KIT*):

Experiments on H₂ combustion in Shanghai (2016) and H₂ mixing in Chengdu (2018).



- NUGENIA projects:

- SAMHYCO-NET (Towards an improvement of Safety Management procedures for severe accident late phase including Hydrogen and Carbon monoxide mitigation and explosion risk assessment models), led by IRSN (2017-2020)



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International workshop on Hydrogen Safety for Nuclear Power Plants

MITHYGENE

SAMHYCO-NET



11 April 2019 - Fontenay-aux-Roses, France

Hosted by Institut de Radioprotection et de Sûreté Nucléaire (IRSN)

TA2.4: Source Term

- **H2020 projects:**
 - FASTNET (*FAST Nuclear Emergency Tools*), led by IRSN (2015-2019): fast-running tools for evaluation of source term in emergency situations,
 - MUSA (*Management and Uncertainties in Severe Accidents*), led by CIEMAT. (2019-2023).
- **NUGENIA projects:**
 - IPRESCA (*Integration of Pool scrubbing Research to Enhance Source-term Calculations*), led by Becker Techn. (2017-2020).

TA 2.5: Impact of severe accident on environment an EMgmt

- **Signature of a MoU between NUGENIA and Radiation Protection platforms (MELODI, EURADOS, NERIS, ALLIANCE = MENA) in October 2017**



Memorandum of Understanding
initiate stakeholder dialogue and interactions between
the
European Radiation Protection Research Platforms
MELODI, EURADOS, NERIS, ALLIANCE
and
NUGENIA

TA 2.5: Impact of severe accident on environment and EMgmt

- Preparation of a 1st transverse workshop on projects of interest (end 2019)
- Preliminary list of transverse scientific issues (IRSN and SCK-CEN):
 - Liquid releases and the K_D issue (uncertainties !)
 - PSA level 2-3 and assessment of the radiological consequences of accidents, including inverse methods
 - On- and out-site interface to NERIS; a possible workshop on uncertainties of the assessment and mgmt of a severe accident (TERROTORIES and CONFIDENCE ongoing projects under MENA).
 - Instrumentation for severe accidents (OECD) - Environment

TA 2.6: SA Scenarios

- Activities recently carried out or ongoing
 - SA Database within FASTNET (about 120 scenarios, so far)

GENERIC DESIGNS	ATW	LFWSG	LB_LOCA	IB_LOCA	SB_LOCA	SBO	SGTR	SFP
BWR-MARK1				*		*		
BWR-ABB	*		*			*		
CANDU			*		*	*	*	
French PWR 1300		*	*	*	*	*		
French PWR 900						*		
PWR 1000			*	*	*	*		*
VVER 440			*			*	*	*
VVER 1000					*	*		

- ASCOM Nugenia Project
- Activities within OECD/NEA WGAMA.



TA 2.6: SA Scenarios

- **UASA (BEPU methods) major focus in future**

- IAEA CRP on "Advancing the State-of-Practice in Uncertainty and Sensitivity Methodologies for Severe Accident Analysis in Water Cooled Reactors"
- EC MUSA Project

Education and training (SAP)

- **8 editions of SAP Course (2005)**

(France, Hungary, Italy, Germany, UK, Sweden and Slovenia)

- Open to university students with discount fees and contributed for 3 Credits (ECTS). Strong link with ENEN Association.
- Last one hosted by JSI in Oct. 2017 at Ljubljana: 65 trainees from 22 countries (and 18 lecturers)
- SAP-course in China- October 2018 in collaboration with Chinese organizations (link with the FP7 Euro-Chinese ALISA project)-
- **Next SAP : planned in France CEA/ INSTN-Cadarache : 9-14 September 2019**

- **Scope:**

- SA phenomenology, progression and mitigation in current Light Water-cooled Gen.II and III Nuclear Power Plants (NPP), but also different design solutions in Gen.III NPPs. **This edition will include HWRs.**
- Special session on Fukushima-Daiichi NPP 2011 accidents.

Perspectives

15 years after its start, SARNET networking continues efficiently in NUGENIA frame

- **Technical workshops** : essential “brick” for share of R&D progress and brain-storming for new R&D projects...
- **Next events:**
 - 9th ERMSAR-2017 hosted by UJV in Prague (Czech Rep.) in March 2019 (<https://www.ermsar2019.com/>)
 - Next education/training course to be held in Sept. 2019
- **SARP (SA Research Priorities):** ERMSAR Conf. Update
- **Main challenges to face:**
 - Keeping active the Community (workshops, new projects, publications), despite possible ↘ of R&D funding
 - Identify opportunities in new NPP types, such as SMR

Perspectives on Coordination

- **Coordination meetings (4/year).** Next on April 30th.
- **New sub-leaders of TA2.1 & TA2.4.**
Procedure to be discussed in next TA2 Coordination meeting.
- **Strengthen links with OECD, CSNI/WGAMA & IAEA.**
 - Severe accident courses (IAEA).
 - Similarly-targeted project (IAEA; MUSA vs CRP).
 - OECD projects (TCOFF; ROSAU; THAI ...).
 - WGAMA activities (ST workshop; ST instrumentation; ...)
- **“Renew” TA2 portfolio & TA2 EC projects initiatives (NOIP, a useful tool)**