



SEAKNOT

Severe Accident Infrastructure NETwork (SAINET)

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SEKNOT 1st Open Workshop

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Objectives

- To establish the current status of the available severe accident experimental EU capabilities able to answer to the roadmap under preparation thanks to a complete mapping of the experimental activity.
- To promote mutually beneficial collaborations between the experimental facilities itself and the various European partners (universities, regulatory bodies, industry, newcomers such as startups).
- To build **SAINET (Severe Accident Infrastructure NETWORK)**, an European infrastructure, able at time horizon of 2026-2030 to explore severe accident phenomena, mitigation actions, and accident-resistant instrumentation for all nuclear reactors including SMR issues.



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1st Step:

Mapping of Severe Accident Infrastructures

- Compiled under supervision of V.H. Sanchez Espinosa (KIT)
- Methodology:
 1. To build a questionnaire for the experimental mapping activity (See appendix 5.1).
 2. To identify institutions and contact persons to answer the questionnaire: four groups of institutions have been identified.
 3. To identify key-persons in all the four-target group to answer the questionnaire
 4. To evaluate the questionnaire regarding e.g.
 - Total number of test facilities.
 - Mapping of experimental facilities with SA research domain.
 - Identify experimental facilities under risky situation regarding funding, team, and perspectives.
 5. To draw analyses and assessment about the European severe accident experimental facilities capabilities.



Example of template

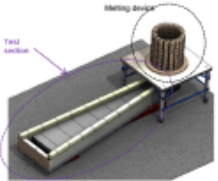
Contact details	
Organization-Country	CEA - France
Business	<input checked="" type="checkbox"/> Industry; <input type="checkbox"/> Authority; <input type="checkbox"/> University; <input checked="" type="checkbox"/> Research; <input checked="" type="checkbox"/>
Contact Person	Andrea BACHRATA Arthur DENOIX
Email	andrea.bachratakubic@cea.fr Arthur.denoix@cea.fr

1. Is your Institution operating an experimental facility in 2023 on the following severe accident areas?
- a) In-vessel
 - b) Ex-vessel
 - c) Source term
 - d) Containment
 - e) Other

2. Test facility description in 2023

(In case of several facilities, please provide below information separately for each facility)

Name of the facility	VULCANO
Starting year of operation	PLINIUS first experiment in 1997
Brief description	<ul style="list-style-type: none"> ▪ corium-concrete interaction configuration ▪ spreading configuration
Main Severe Accident research fields	Ex-vessel
Scale of the test facility	<p>MCCI configuration:</p> <ul style="list-style-type: none"> • Prototypic corium melting by induction or urano-thermite reaction • 400 kW 70-300 kHz induction generator to simulate decay heat • Heats mostly oxidic phase in case of oxide + steel mixture • ~140 thermocouples in the concrete crucible to monitor concrete ablation • Specially sheathed TC to monitor pool temperature <p>Spreading configuration:</p> <ul style="list-style-type: none"> • Spreading surface progression with calibrated optical image processing • Infrared surface temperature imaging • Bichromatic pyrometers • Thermocouples for substrate heating and front progression • Weighing scale for inlet flow rate • Posttest measurements for final shape • Sampling for Post-test analyses and property measurement

Figure of the test facility (if possible)	 <p>Figure 18: Scheme of VULCANO-spreading facility</p>
Design parameters	<ul style="list-style-type: none"> • 50-100 kg of corium • Melting temperature of corium mixture • Surface dimension for spreading depending on test • Concrete for MCCI depending on test • Atmospheric pressure
Materials:	Prototypic corium Oxide + steel
Current SA Program (2023)	International collaboration mainly with Japan.
Future SA Program (2024-2030)	OECD/NEA: COPS project. Corium Properties for reactor Simulation and uncertainties (2024)
Topics	Mitigation Instrumentation
Experimental team	Permanent: 4 for the experiment, 15 in the lab (5 technicians) Non-permanent: 2 technicians, 1 post-doc
Use of experimental data bases	MCCI data and spreading data measured on VULCANO = data for validation of SA codes Produced blocks of corium samples = for cutting experiments

References	<ul style="list-style-type: none"> ▪ Technical reports ▪ Open literature ▪ Journal ▪ Others
	<p>Laurent Brissonneau et al., Material characterization of the VULCANO corium concrete interaction test with concrete representative of Fukushima Daiichi Nuclear Plants, Journal of Nuclear Materials, Volume 528, 2020, 151860, ISSN 0022-3115, https://doi.org/10.1016/j.jnucmat.2019.151860.</p> <p>Christophe Journeau et al., Ex-vessel corium spreading: results from the VULCANO spreading tests, Nuclear Engineering and Design, Volume 223, Issue 1, 2003, Pages 75-102, ISSN 0029-5493, https://doi.org/10.1016/S0029-5493(02)00397-7.</p> <p>Christophe Journeau et al., The VULCANO VE-U7 Corium spreading benchmark, Progress in Nuclear Energy, Volume 48, Issue 3, 2006, Pages 215-234, ISSN 0149-1970, https://doi.org/10.1016/j.pnucene.2005.09.009.</p> <p>Proposed for ERMSAR 2024 : Denoix at al. Production of prototypic corium in the VULCANO facility using urano-thermite and induction heating</p>

Reached organizations

- 16 SEAKNOT partners
 - BT, CEA, CIEMAT, ENEA, FANP, FZJ, IJS, IRSN(now ASNR), KIT, KTH, PSI, Tractebel, UJV, Uni Pisa, UPM, VTT
- Other EU organizations
 - Energia MTA, FER, INRNE, LEI, NCBJ, NRG, NSC-NL, NUCLEAR, SSTC, TU Delft, TU Sofia, VUJE
- *Corresponding to 17 EU states + CH + UA*



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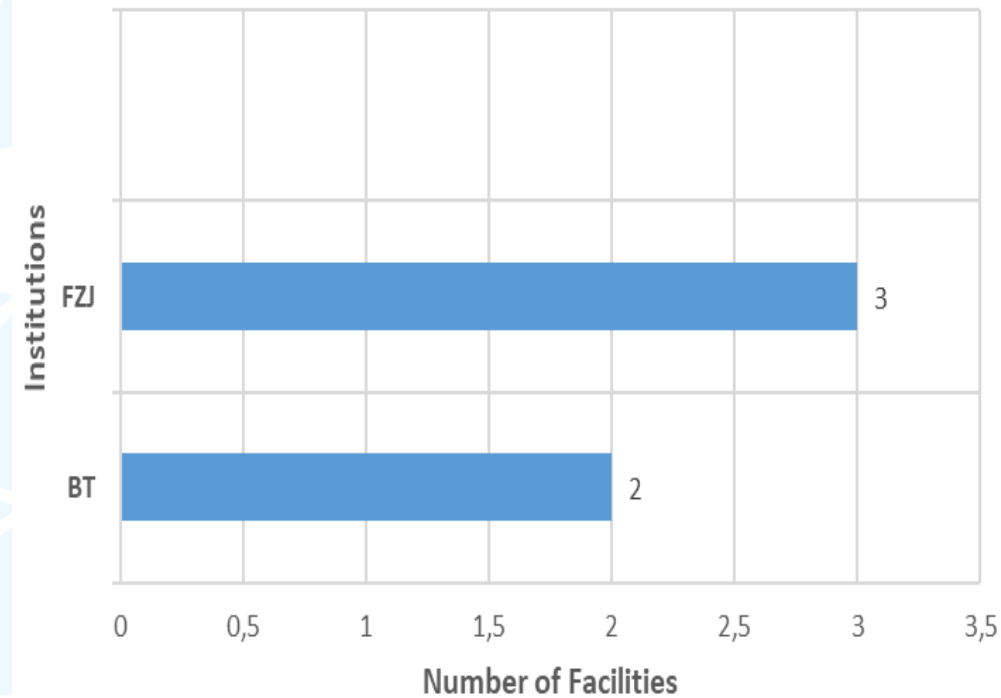
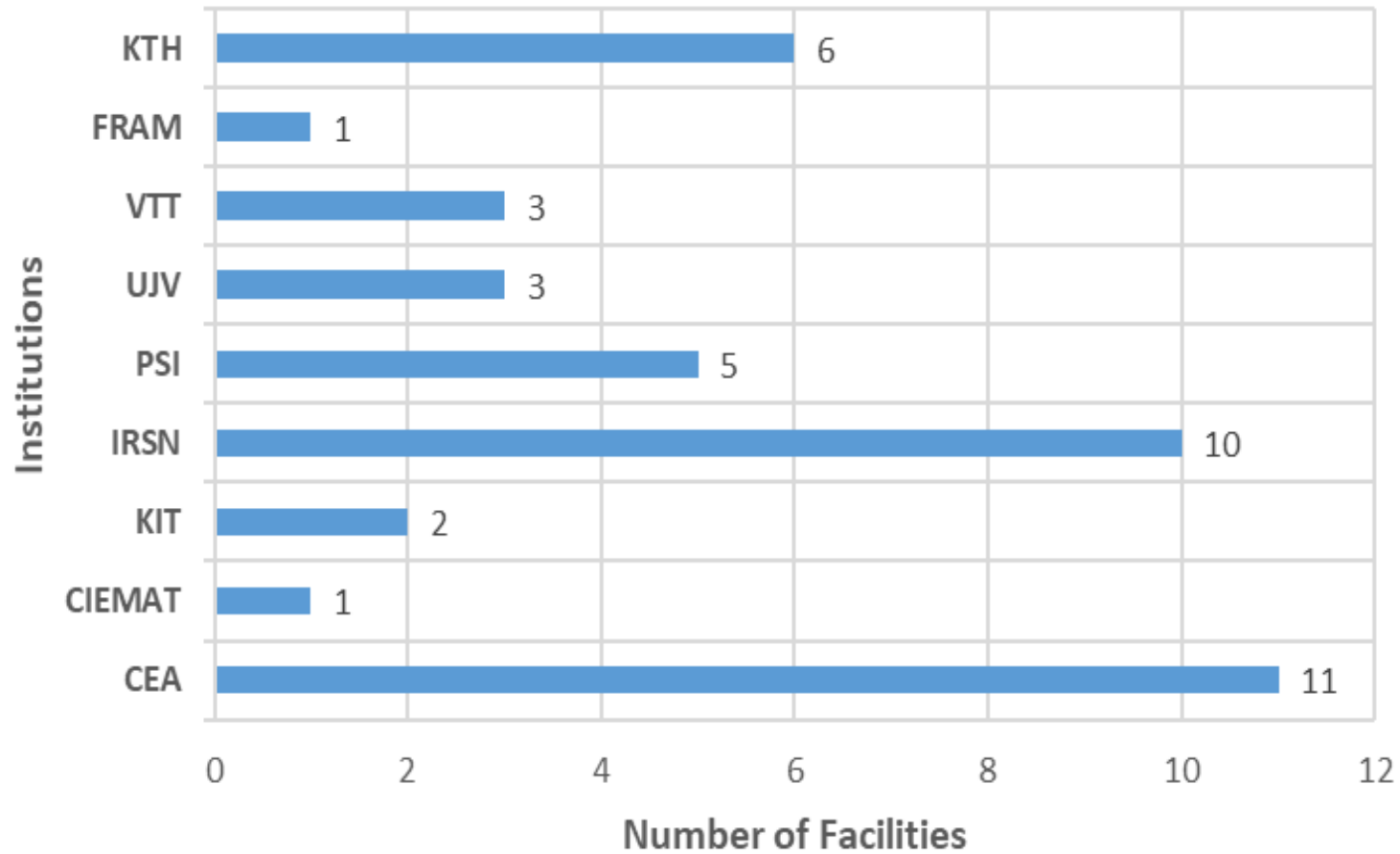
Identified facilities (operating in 2023)

Category	Number of e-mails sent out	Number of answers /number of facilities
Test facilities in SEAKNOT-Partners involved in WP3	20	20 / 52
Test facilities in SEAKNOT-Partners not involved in WP3	9	9 / 5
Test facilities in institutions of EU-Countries partners of SEAKNOT but not beneficiaries of SEAKNOT	12	2 / 1
Test facilities in institutions of EU-Countries not partners of SEAKNOT	12	4 / 1

- Less than 1/3 of contacts out of SEAKNOT answered
- But main SA facility operators are within SEAKNOT consortium



Facilities by operators



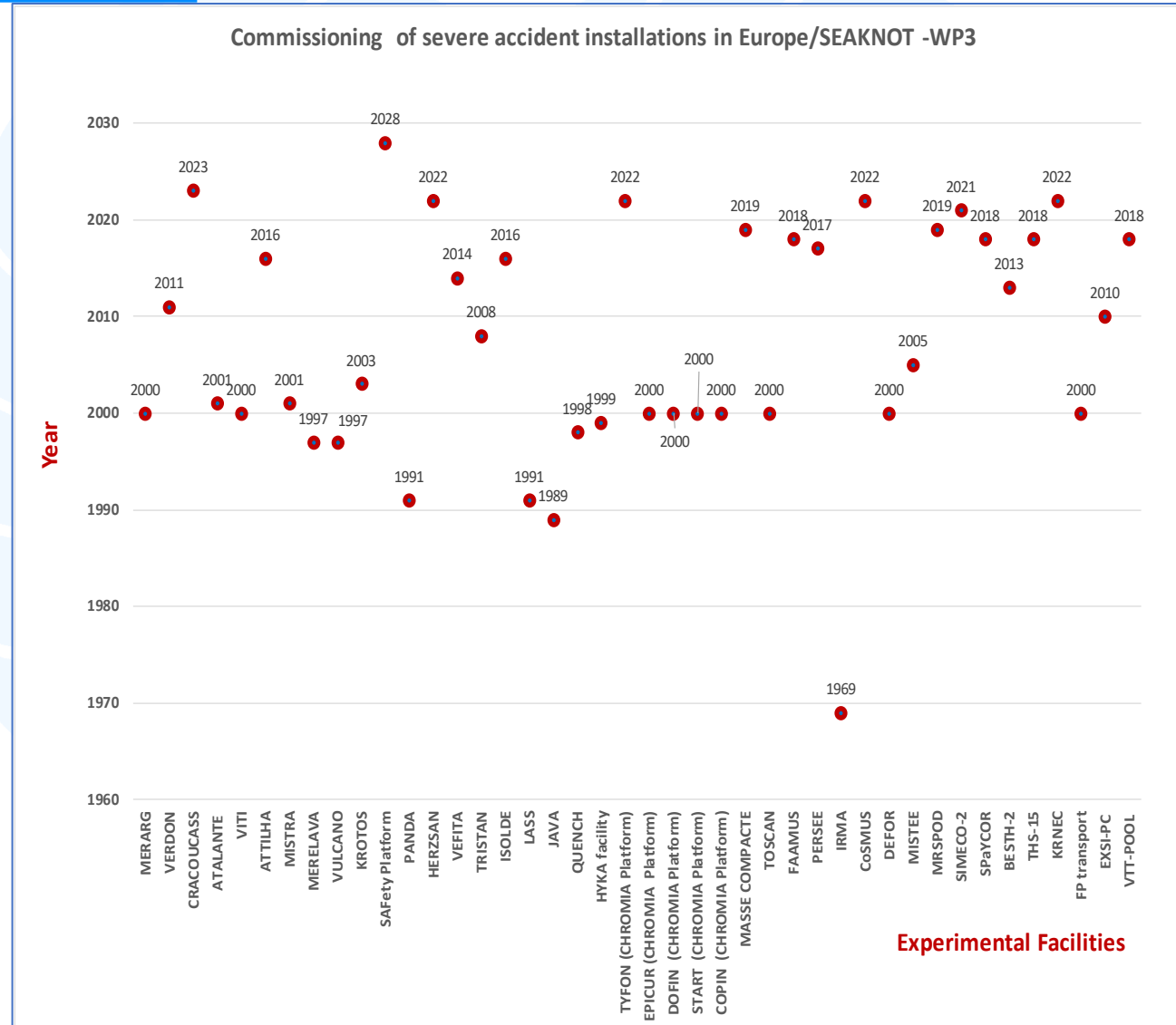
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Year of commissioning of operating SA facilities

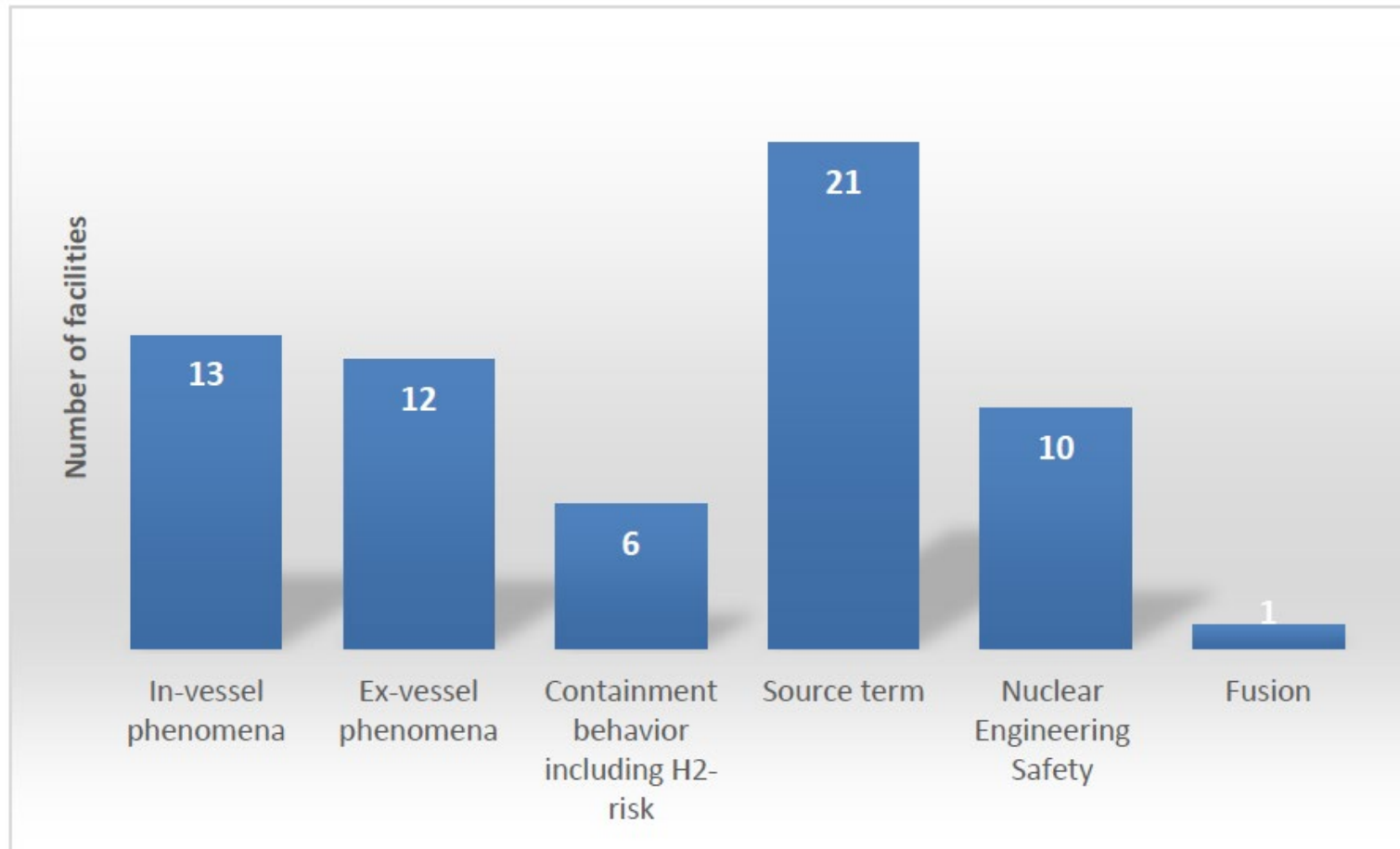
Average age
~30 years!



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Facilities by Severe Accident domain

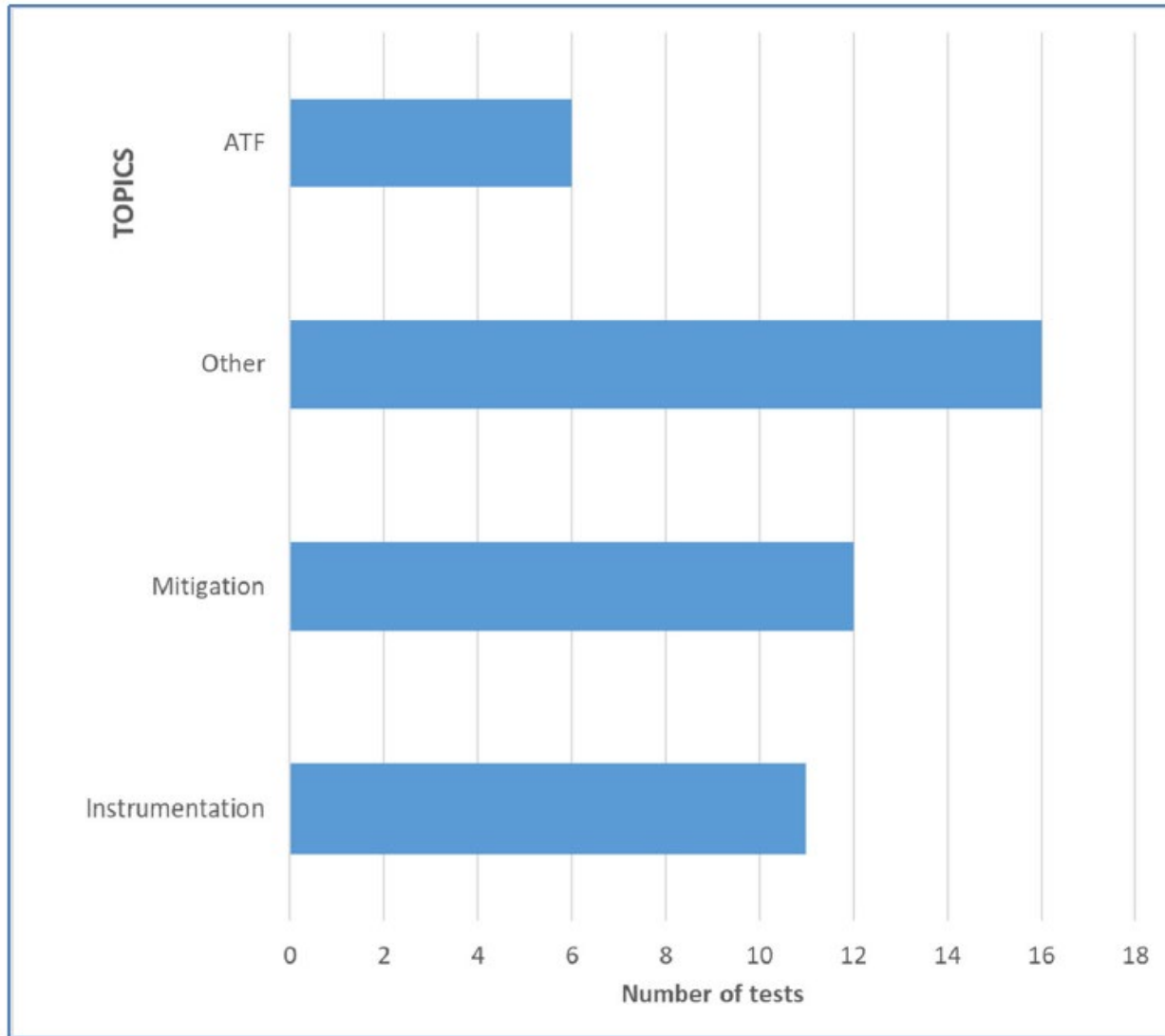


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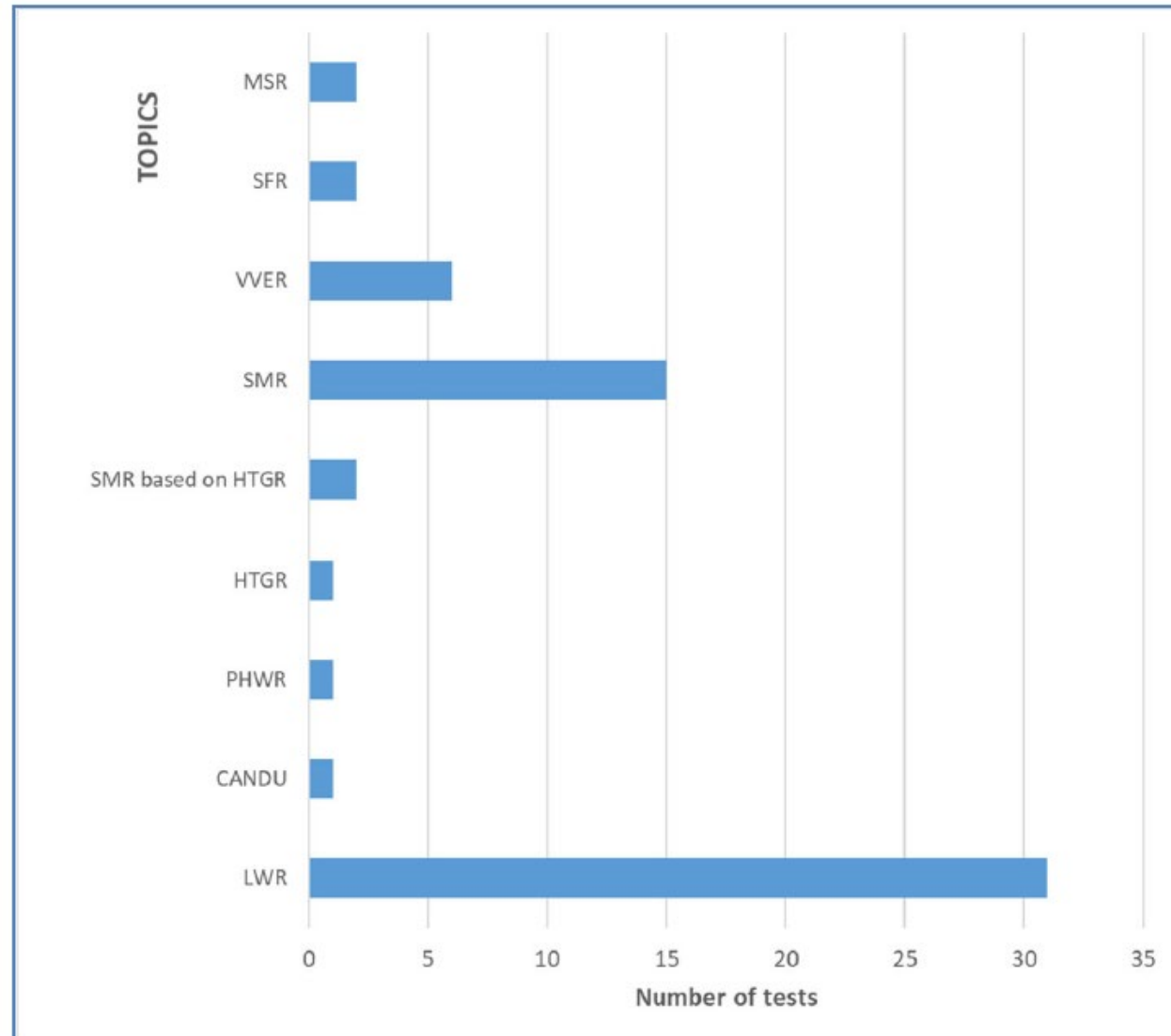
Experimental Topics and size



- Self classification by facility operators
- 21 large-scale
- 18 mid-scale
- 3 small-scale



Reactor types addressed by facilities



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Future perspectives of these facilities

- For 22 facilities, there were (as of 2023) no concrete plans for the coming years 2024-2030.
 - In 5 of them there were nevertheless good prospects.
- 8 facilities indicated *critical conditions* regarding manpower and/or knowledge loss.
 - Many experts are expected to retire in the coming 5 years, so knowledge may be lost if there is no knowledge management actions.



WP3-2 Objectives

WP 3.2: Severe Accident Infrastructure NETWORK (SAINET)

CEA-

Christophe Journeau-Pascal Piluso

Introduction - Context:

- One of the expected outcomes of the SEAKNOT (Severe Accident Research and Knowledge management for LWRs) project is to create the first step for **an integrated experimental European Severe Accident Infrastructure of laboratories** able to answer at horizon 2026-2028 to current and future needs for water-cooled reactors severe accident research, Small Modular Reactors (SMRs) and Advanced Technology Fuels (ATFs) included.
- After having carried out a **mapping of European Severe Accident experimental facilities**, discussions have progressed within SEAKNOT on the outline of a future Severe Accident Infrastructure Network (SAINET) and its expected benefits.



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Outline of the future SAINET

The aim of this future network will be to cover **all the aspects of experimental Severe Accident R&D:**

- **in-vessel corium,**
- **ex-vessel corium,**
- **source term,**
- **containment issues,**

including experiments related to **severe accident mitigation** processes/systems and to **post-accident D&D.**



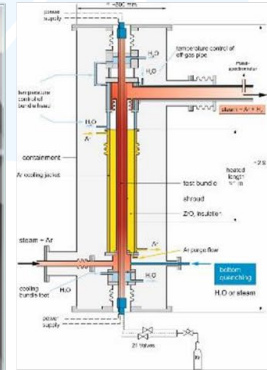
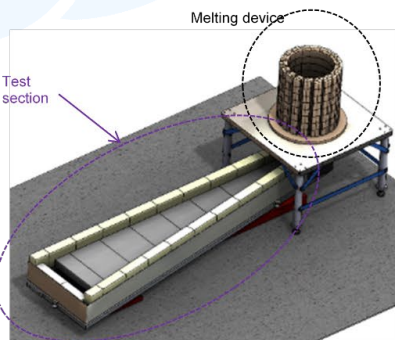
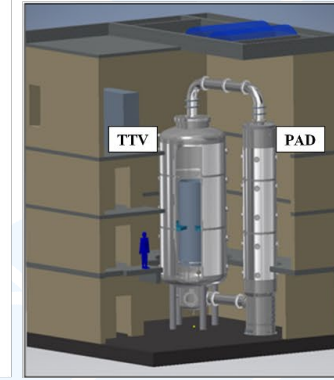
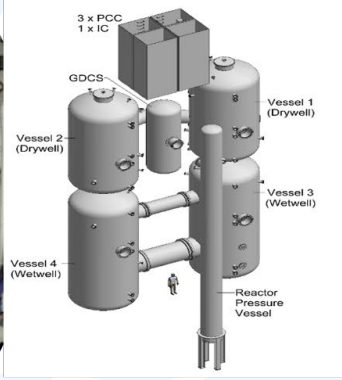
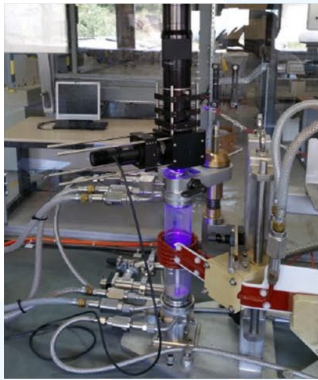
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European experimental facilities of interest

European experimental facilities of interest :

- with irradiated or prototypic materials
- with justified simulants.



Expected benefits

- Capability to provide an **integrated experimental offer** for any Water-Cooled-Reactor (PWR, BWR) severe accident issue
 - both to **classical stakeholders** (TSOs, Research Centres, Regulators, vendors, utilities)
 - and newcomers such as SMR **start-ups**.
- Providing **exchanges** for the **technical staff** and **young scientists** working on these facilities and developing/applying up to date experimental techniques (e.g. instrumentation, high temperature heating, refractory material issues...).
- Also possibility to provide **expertise** to users of SA experimental facilities.
- Be a forum of exchange in view of **future investments** in new **research infrastructures** and facilitate **cross funding** between different partners of future facilities. It should indeed help **adjust the capabilities** of a future facility with the expected needs of the **European severe accident Research Area**, optimizing both resources and data quality.



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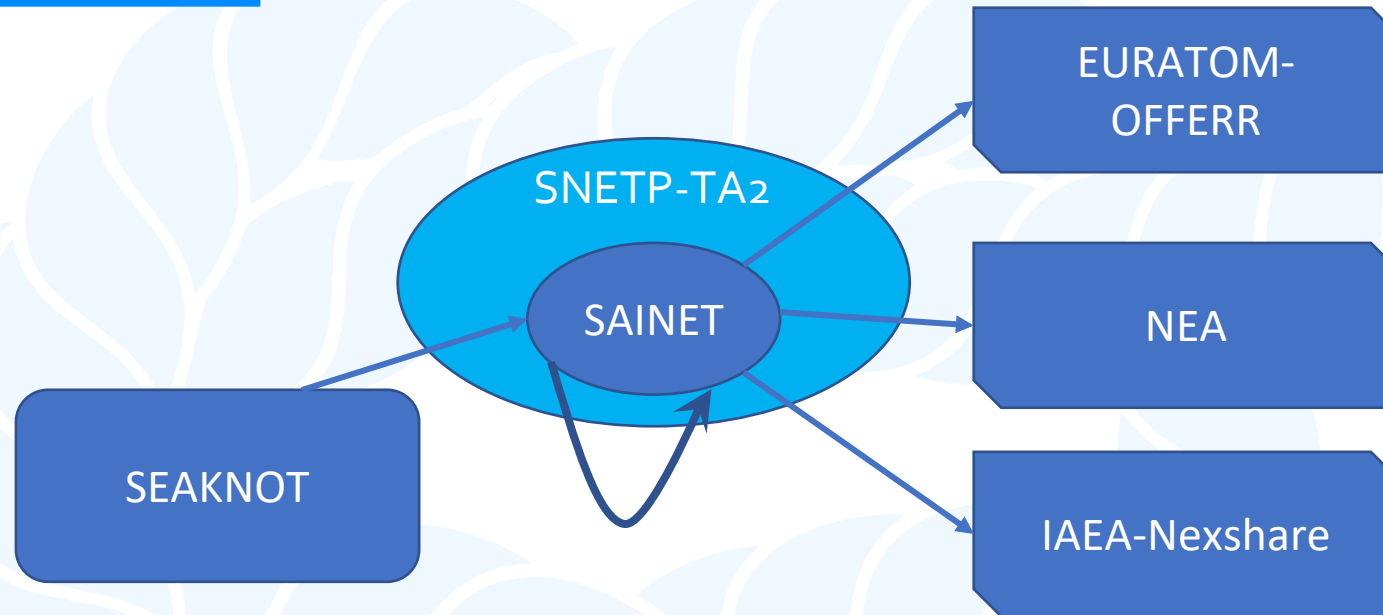


Positioning SAINET in its environment

- IAEA Nexshare
 - Forum to match experiment operators and end-users (focus SMR-newcomers).
- OECD/NEA: ATHENA
 - Overall program for ThermalHydraulics
 - Would be extended (around 2030?) towards Severe Accident issues
- SILENCE (and FONESYS) groups
 - Expert group for TH experiment experts (and code experts)
- OFFERR
 - EURATOM Partnership within SNETP
 - Supports transnational access to 220 Nuclear Engineering facilities in EU



Options for SAINET club



- Another option (more complex) is to make a dedicated legal structure (~non-for-profit association)



Next steps

- ***Internal discussions within SEAKNOT on what we would like to build (before taking into account legal department and general management recommendations)***
 - ***Which type of activities do we wish to put in SAINET?***
 - ***Do we want to join as a legal entity some existing structures such as NEXShare and/or ATHENA?***
 - ***Shall we lobby for an European partnership on Severe Accidents in // to OFFERR ?***
 - ***Shall we extend from EU geographical extend and how/when?***
 - ***To which level could SAINET request membership fees ?***



Timeline for future activities

- October: internal discussions within the partner organizations on proposed solutions and questions.
- November : Discussion webmeeting
- December-January : draft of D3.3 on SAINET infrastructure including solution decided in November
- February-March: Discussions on draft (1 webmeeting)
- April- May: revised D3.3
 - If necessary, final in person discussions aside ERMSAR26
- June-July: D3.3 published



THANK YOU!

Get in touch for more information



All of the reports of the project will be available for download on the SEAKNOT website: www.seaknot-project.eu



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