



## Editorial

## ERMSAR 2024 conference “European Review Meeting on Severe Accident Research”



Despite the incorporation of the latest safety features and accident prevention measures in modern Nuclear Power Plants (NPP), there remains a very low probability that certain accidental sequences may evolve into a severe accident (SA). These events, also known as Design Extension Conditions type B (DEC-B) accidents, could result in the release of radioactive materials outside the plant, threatening public health and the environment.

The risks associated with such events can be substantially minimized through the deployment of state-of-the-art devices, designed to prevent and mitigate these scenarios. Insights gained from the Fukushima-Daiichi accident, alongside provisions from the European Nuclear Safety Regulators Group (ENSREG) stress tests and other national activities, underscore the importance of enhancing the safety protocols of NPPs. These developments collectively contribute to the continuous improvement of nuclear safety measures, providing a robust framework for accident management and public protection.

As part of the past EU's 6th and 7th Research and Development Framework Programmes (FP6 and FP7), the SARNET Network of Excellence (Severe Accident Research NETwork) was launched in 2004 to better coordinate national efforts in SA research across Europe, optimize the use of available expertise and experimental facilities, and address key issues for enhancing the safety of current and future European NPPs. Co-funded by EURATOM until mid-2013, this network significantly advanced the integration of European research capabilities in SA research, in collaboration with leading global organizations in the field of nuclear safety (Van Dorsseleare et al., 2015).

In mid-2013, SARNET was fully integrated into the Nuclear Generation II & III Alliance (NUGENIA), dedicated to the R&D of nuclear fission technologies with a focus on the safe and efficient operation of Generation II & III NPPs. From 2019, NUGENIA became one of the three pillars of the Sustainable Nuclear Energy Technology Platform (SNETP), which promotes the safe, reliable, and efficient operation of Generation II, III, and IV civil nuclear systems. The various activities related to SAs have continued within the NUGENIA Technical Area No. 2 (TA2) “Severe Accidents” (Van Dorsseleare et al., 2017). Initially coordinated by IRSN Cadarache, and since December 2018 by CIEMAT Madrid, NUGENIA TA2 has expanded the former SARNET activities to address new issues as “emergency and preparedness response” and the “SA impact on the environment.” This focus has led to a search for more efficient and innovative mitigation measures for SA sequences, a leading research area following the Fukushima Daiichi accident (Herranz et al., 2023a). The primary activities currently undertaken by the NUGENIA TA2 include:

- *Updating Research Priorities*; Revision of European research priorities in the SA area, building on the conclusions from the Severe Accident Research Priorities (SARP) workgroup within the SARNET network (Manara et al., 2019). At present, this activity has a renewed momentum in the frame of the EURATOM SEAKNOT (Severe Accident research and KNOWledge management) project (Herranz et al., 2024b). No less important, the basis for a European Severe Accident Experimental Infrastructure NETWORK (SAINET) are being also settled within the SEAKNOT project.
- *Developing New R&D Projects*; Proposals and developments of new research and development projects under various frameworks are being built, as detailed in the NUGENIA TA2 Project Portfolio. [http://snetp.eu/portfolio\\_category/nugeniata2/](http://snetp.eu/portfolio_category/nugeniata2/)
- *Education and Training*; Organization of education and training courses (Paci and Van Dorsseleare, 2012) on Severe Accident Phenomenology (SAP), with the latest edition held in June 2023, hosted by UPM Madrid, in the SEAKNOT project framework (Piluso et al., 2024). The next edition SAP 2025, always in the framework of SEAKNOT, will take place from 23 to 27 June 2025 at FZJ Jülich, followed by the first edition of the Severe Accident Summer Camp (SASCAMP 2025) from June 30 – July 4, 2025.
- *Organizing Conferences*: hosting periodic conferences, known as the European Review Meeting on Severe Accident Research (ERMSAR), since 2005 within SARNET and from 2017 under NUGENIA TA2 SARNET (Herranz et al., 2023b, 2020; Van Dorsseleare and Paci, 2018, 2016, 2014) and, for the 2024 and 2026 editions, in the SEAKNOT Project framework.

The last 11th edition of the ERMSAR 2024 Conference, whose most relevant papers selected by the conference Technical Committee are collected in this Special Issue, was successfully held from 13 to 16 May 2024, hosted and locally organized by KTH Royal Institute of Technology, in Stockholm, after 2 years from the previous 10th edition in Karlsruhe. For the first time it has been organized in the frame of the SEAKNOT project and the NUGENIA TA2, together with IAEA and NEA. ERMSAR 2024 gathered 157 participants from 77 organizations, settled in 26 countries worldwide. A total of 73 papers were orally presented, and 33 more were exhibited in the posters stand. These numbers highlight ERMSAR as the reference international conference on SAs. The conference was focused on the latest progress of knowledge on SAs and has been mainly an opportunity for researchers to discuss about the most recent achievements and future R&D priorities in this field.

The Conference was conducted through the following technical tracks:

<https://doi.org/10.1016/j.anucene.2024.111016>

Available online 28 October 2024

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1. In-vessel corium and debris coolability
2. Ex-vessel corium interactions and coolability
3. Containment behaviour including Explosion risk
4. Source term
5. Analysis, Management, and Consequences of SAs for Gen I-III reactors
6. SAs in innovative reactors such as Gen IV and Small Modular Reactors (SMR)
7. Other applications (fusion reactors, interim spent nuclear fuel storage, Accident Tolerant Fuels, etc.)

In addition, the technical programme included three plenary sessions:

- I. Singular careers in the SA research, which brought prestigious senior researchers on stage to share its insights into their main expertise domain.
- II. Regulatory perspective and approaches for SAs in SMRs, which collected positions adopted in different countries concerning SMR licencing
- III. Looking ahead in SA research, which discussed the strategic moves made by international agencies when preparing new platforms for future SA research.

As top-level conclusions from ERMSAR 2024, one may highlight:

- A good part of R&D is and will continue investigating feasibility/development of “new” mitigation measures.
- An emerging substantial amount of work is being devoted to very near-term deployment systems, like WC-SMRs (Water-Cooled Small Modular Reactor), with a major take on “safety demonstration”. At the same time, current analytical tools are being adapted to better suit innovative systems, such as non-water-cooled systems and Generation IV technologies. This involves incorporating new phenomena and/or extending the ranges of known phenomena to address current limitations in modelling these advanced systems. Furthermore, identifying experimental data needs is crucial for studying non-LWR designs and, in the long term, for the Verification and Validation (V&V) of codes essential for licensing these new systems.
- An important shift has been observed in SA safety analyses towards including uncertainty quantification (BEPU) and sensitivity analysis. However, a systematic application of a BEPU approach to SA requires further research to consolidate a soundly supported methodology.

It is worth to highlight that some new R&D needs brought up during the ERMSAR 2024 presentations, are currently being addressed by three EURATOM – Horizon Europe supported Projects, born inside NUGENIA TA2:

- ASSAS, for the Artificial Intelligence (AI) application in SA simulations, developing a proof-of-concept SA simulator. <https://assas-horizon-euratom.eu/>
- SASPAM-SA, for the application of current SA grounds to near-term SMRs, mainly integral Pressurized Water Reactor (IPWR), in the view of the European licensing analyses needs for SAs and Emergency Planning Zone. <https://www.saspam-sa.eu/>
- SEAKNOT, for SA knowledge management, its preservation and transfer to young generation of researchers, mainly to efficiently orient the forthcoming European research on SAs in the next decade. <https://seaknot-project.eu/>

Of course, additional experimental and theoretical investigations presented at ERMSAR 2024 were performed during previous EURATOM projects, supported in Horizon-2020: AMHYCO (Jiménez et al., 2021), MUSA (Herranz et al., 2021) and R2CA (Girault et al., 2022). Both

ERMSAR-2024 and all these research projects demonstrate how active and productive SA research is, particularly in Europe.

To encapsulate and preserve all this expertise, an open-access book containing the ERMSAR 2024 Proceedings has been published in KIT library (Herranz et al., 2024a). This comprehensive volume includes all the presented papers, presentations, and posters. The book is available for free download from the KITopen Repository. <https://publikationen.bibliothek.kit.edu/https://doi.org/1000174165/v2>.

The next edition of the ERMSAR conference, ERMSAR 2026, will once again be organized within the framework of the SEAKNOT project. CIEMAT will host the event in Madrid during the week of 18 to 22 May 2026.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Acknowledgements

All the actors of ERMSAR-2024 must be acknowledged, in particular Sean Roshan and the KTH support team, the Swedish Radiation Safety Authority SSM and the Technical Committee: besides the guest editors below, Ahmed Bentaib from IRSN (France), Sevostian Bechta from KTH (Sweden), Sanjeev Gupta from BT (Germany), Pascal Piluso from CEA (France), Federico Rocchi from ENEA (Italy), Ivo Kljenak from JSI (Slovenia), Alexei Miassoedov from IAEA (Austria) and Martina Adorni from NEA (France). Finally, this special issue would not have been possible without the assistance of the Elsevier staff.



Funded by the European Union ERMSAR 2024 was orga-

nized under the frame of the SEAKNOT project. This project has received funding from the Euratom Research and Training Programme 2021-2023 under grant agreement No 101060327.

The content of the papers reflects only the authors' views and do not necessarily reflect those of the European Union or EURATOM. Neither the European Union nor EURATOM can be held responsible for them.

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