

Ensuring safety of innovative solutions ELSMOR, PASTELS, and NUCOBAM projects

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Novel solutions, novel reactors

- In order to renew safe and sustainable nuclear energy production, new solutions must be innovated
 - Technologies are being developed that can be utilized in the nuclear field, such as advanced manufacturing technologies
 - Improved understanding of physical behaviour allows for robust safety functions such as those based on natural convection of water
 - Simpler systems enable even whole new breed of designs, such as small modular reactors
- Safety of new systems must be ensured when they're taken into use
 - NUCOBAM, investigating advanced manufacturing technologies
 - PASTELS, modelling and experiments on passive safety systems
 - ELSMOR, safety of light water small modular reactors



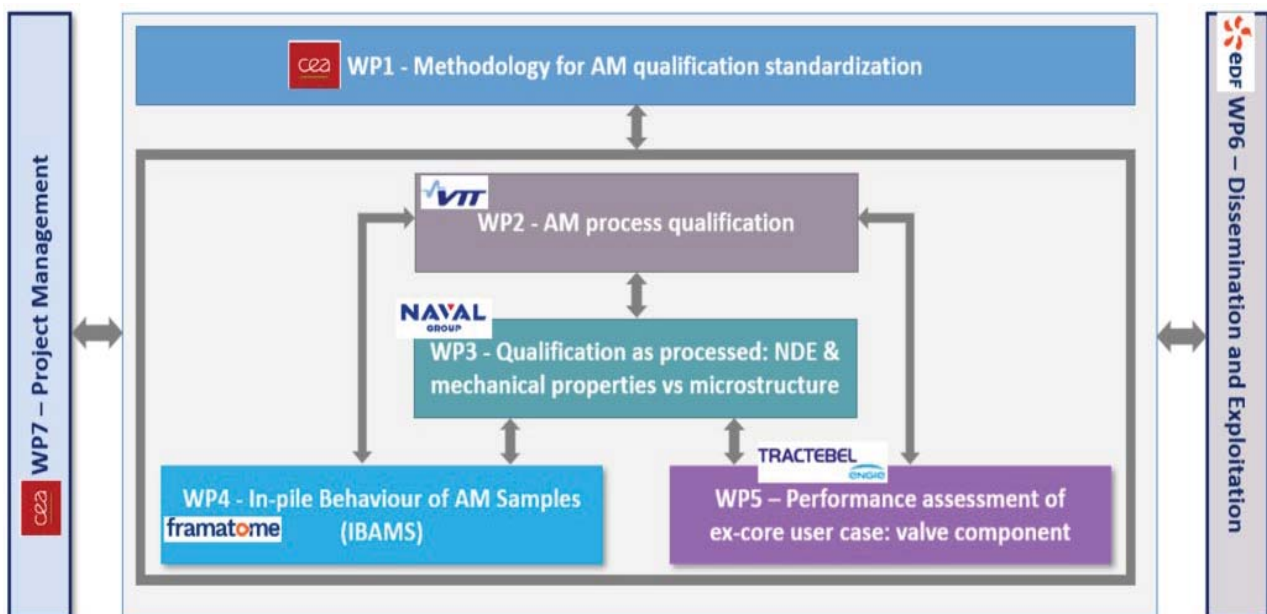
NUCOBAM

NUclear COmponents Based on Additive Manufacturing aims at:

- developing the qualification process
- provide the evaluation of the in-service behaviour allowing the use of additively manufactured components for nuclear installations
- Two types of demonstrators in 316L stainless steel will be manufactured:
 - debris filter
 - valve block body



NUCOBAM



NUCOBAM manufactured components

VALVE BODY



Assembled valve body with internals (Ramén Valves)

DEBRIS FILTER



Debris filter (Framatome)



NUCOBAM

Current status of NUCOBAM

- Draft methodology available and will be refined based on test results.
- First test coupons shipped to consortium members, test programme to start soon.
- Final methodology towards end of project (mid 2024).
- Mid-term workshop (end of September 2022), fab-lab event (March 2023) and final project workshop (September 2024) planned.

FIRST DRAFT OF AM QUALIFICATION PROCESS FOR NUCLEAR INDUSTRY

OUTLINE OF REPORT

General:

Terminology:

Documentation:

Powder Procurement

Qualification of the AM Process

Manufacturing of Component & Test Specimens

Heat Treatment

Inspections & Tests

Finishing of AM component

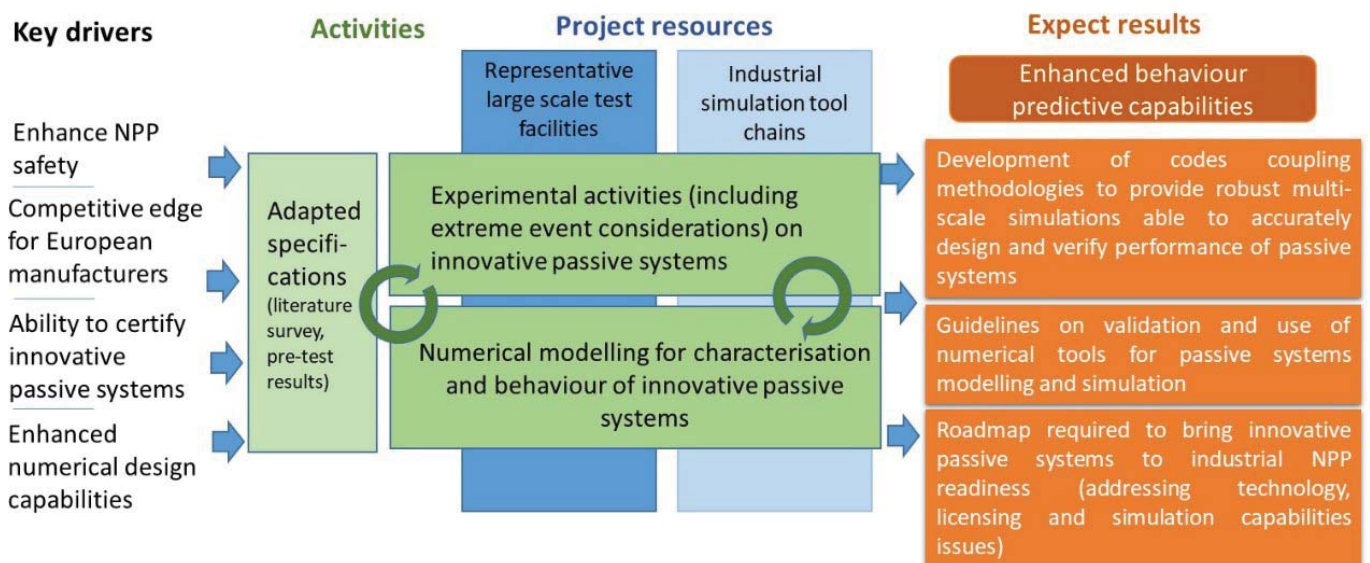
Examination



In order to ensure their safe and reliable functioning, the study of innovative passive systems encompasses several important aspects:

- The identification and understanding of the main physical phenomena governing the behaviour of these systems.
- The efficient numerical modelling of these physical phenomena, and their validated implementation in dedicated computational codes, to use these numerical tools for the system design and safety demonstration.
- The adaptation of the safety demonstration methodology in order to consider the specificity of passive systems (scaling, reliability, performance level, etc.).

PASTEELS

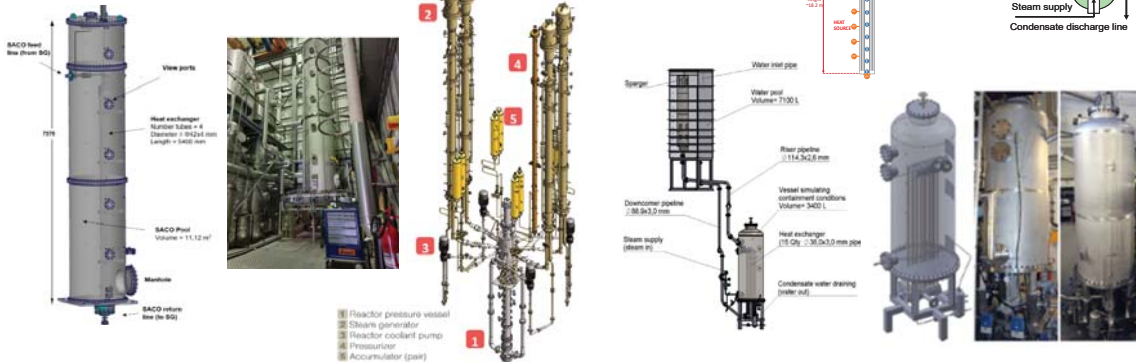


The PASTEELS project focuses on two specific passive safety system designs:
Safety CONdenser (SACO) and **Passive Containment Cooling System (PCCS)**

PASTELS experimental devices and numerical tools

Experimental means at different scales

- Separated effect tests for studying of closed two-phase flow thermosiphon loop
→ existing data from **HERO-2** test facility (SIET, Piacenza, Italy)
- Combined effect tests for studying of passive heat exchanger system in-pool
→ existing data from **PERSEO** test facility (SIET, Piacenza, Italy)
- Integral tests for studying of an open two-phase flow thermosiphon loop design of **PCCS**
→ new data from **PASI** test facility (LUT University, Lappeenranta, Finland)
- Integral tests for studying of an innovative design of **SACO**
→ new data from **PKL** test facility (Framatome GmbH, Erlangen, Germany)



Benchmarking of various numerical tools acting at different scales

- ❖ **system codes:** AC², CATHARE, RELAP5, TRACE
- ❖ **CFD codes:** CFX, Fluent, neptune_cfd
- ❖ **severe accident codes:** ASTEC, MELCOR



PASTELS

- PASTELS project will contribute to increase the reliability of safety demonstration for nuclear power plants and to enhance industrial design capabilities of European actors.
- Thanks to improved simulation tools and experimental support, the technologies relying on passive cooling will be better understood to help their qualification for future implementation in NPPs.
 - The PASTELS project will also increase academic and scientific knowledge in Europe concerning the understanding of passive systems.
- A synthesis of achievements and deficiencies of code capabilities for simulating passive systems will be established with suggestion for future work, new developments and additional experimental support.
- The expected outcome of numerical activities is to ensure that thermal-hydraulic numerical simulation tools capture the key physical phenomena observed during the experiments.
 - These activities will also contribute identifying the optimal range of conditions within which the passive cooling systems can operate.



PASTEELS

Current status of PASTEELS

- 6 technical reports submitted to date, learn more on:

→ PASTEELS official website: <https://www.pastels-h2020.eu>

→  <https://www.linkedin.com/company/pastels-h2020>

PASTEELS technical deliverables (May 22)	Statut
D2.1 Bibliographic research on the phenomena related to the natural circulation in closed loop	Public
D2.2 Description of HERO-2 facility and simulations	Public
D3.1 Technical description and design review of the PKL facility and the SACO component	Public
D4.1 PASI test specification	Public
D4.2 PASI facility description for PASTEELS	Public
D4.3 PASI pre-test analysis results	Public



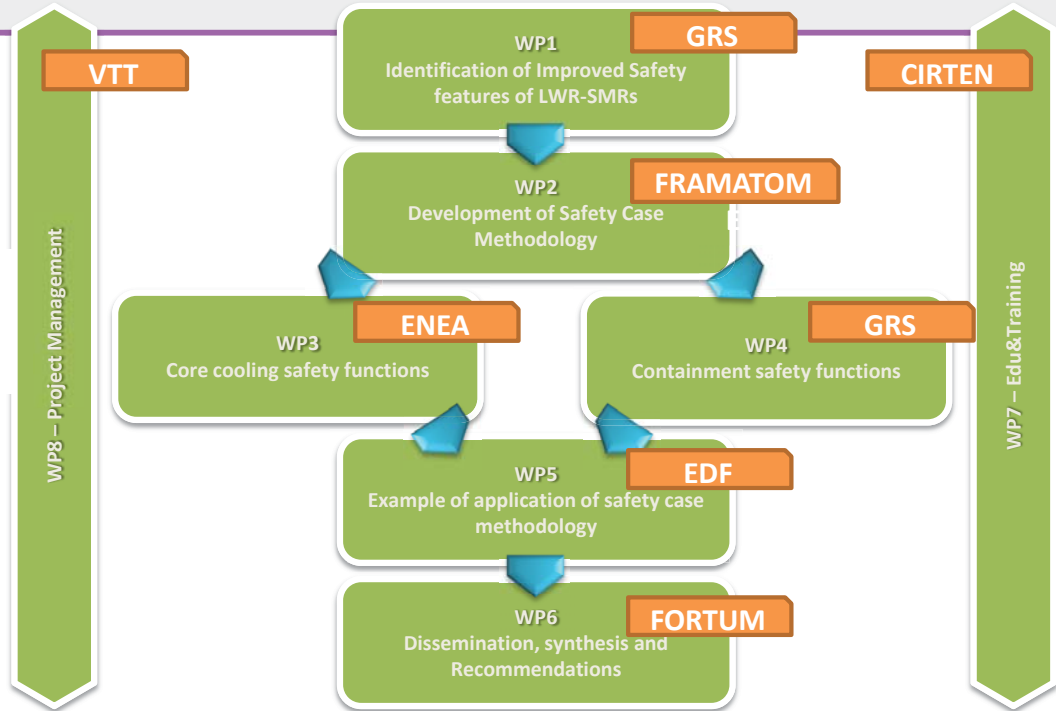
- Bibliographic studies on the phenomena related to the natural circulation in closed loop performed at the beginning of the project
- PKL/SACO test programme started in January 2022 – phase P1 dedicated to sensitivity analysis on boundary conditions is completed
- PASI/CWC test programme underway - initial testing started in spring 2022
- Hero-2 simulation activities terminated in early 2022
- Pre and post-tests calculations on PASI/CWC and PKL/SACO have begun



ELSMOR

- ELSMOR aims investigate selected safety features of LW-SMRs
 - Prevention of early release
 - Core cooling functions
 - Containment
- Research on methods for robust safety assessments
 - Several prior proposals / methodologies developed for both currently operating plants as well as non-conventional, e.g. for GenIV, fusion...
- Demonstration of the applicability of developed tools and methods
 - Test case "E-SMR" ("European SMR")
- Dissemination to stakeholders



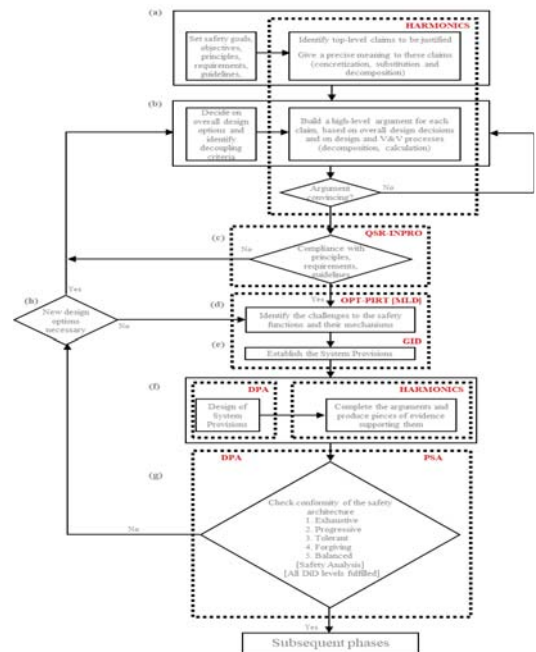


Safety Methodology for innovative reactor design – Main results

Proposed ELSMOR safety methodology for innovative reactors:

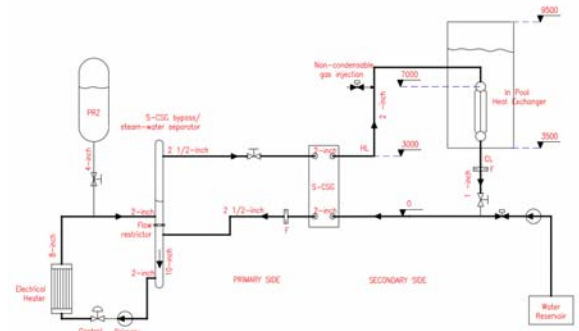
- mainly derived from the insights provided by the SARGEN_IV project that, in turn, is based on the GIF ISAM and IAEA INPRO methodologies.
- complemented with the HARMONICS method to develop high-level safety goals into more concrete requirements in a systematic and hierarchical manner

→ provide a framework for defining requirements of different level of detail and for documenting the results of different types of safety assessments.



Other ELSMOR work

- Investigation of passive core cooling
 - Phenomena identification and ranking, code benchmarks, experimental work at SIET
- Work on assessing containment
 - Metallic containment in pool, phenomena and code benchmarks
- "E-SMR" dataset
 - Creation of "E-SMR" dataset describing an SMR sharing similar safety functions as Nuward but based on publicly available data and expert judgement – aim to provide a common benchmark case that can be used afterwards too



Thank you



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<https://www.pastels-h2020.eu/>

www.elsmor.eu

