REDUCTION OF RADIOLOGICAL ACCIDENT CONSEQUENCES

Title	SASPAM-SA (**S**afety **A**nalyses of **S**MR with **P**assive **M**itigation strategies - **S**evere **A**ccident) Horizon Euratom Project
Speaker:	Fulvio Mascari
Affiliation:	ENEA
Event:	R2CA Summer School
When:	4-6 July 2023
Where:	ENEA Bologna

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No 847656.

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

SASPAM-SA (Safety Analyses of SMR with Passive Mitigation strategies - Severe Accident) Horizon Euratom Project

R2CA SUMMER SCHOOL , July 4-6, 2023, ENEA, Bologna, Italy

Fulvio Mascari

ENEA, via Martiri di Monte Sole, 4, 40129, Bologna, ITALY

R&D GAPS ALONG SASPAM-SA PREPARATION

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

- iPWRs SA investigation is very limited and iPWRs safety assessment, with best estimate methods, is still not addressed.
- Novel topics of current high interests for TSOs, regulators, research centres, universities, industries and operators, are:
  - Systematic analyses of the applicability and transfer of the current available SA experimental database (developed for current large-LWR) for iPWR safety assessment studies, and
  - Analyses of current codes capabilities to simulate SA phenomena.
- Current on-going activities on iPWR, the SA investigation is very limited but DiD levels 1,2,3 are investigated.
- Project can contribute, going beyond the state-of-art, to investigate the key elements to create an European independent point of view on the safety of iPWR with respect to DiD levels 4/5.

STATUS OF THE SMR EUROPEAN INTEREST ALONG SASPAM-SA PREPARATION

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

- In the European area there is a growing technological and economical interest for the near-term deployment SMR, and several related activities are in progress:
  - France: the review by the French Safety Authority of the safety options files of the iPWR developed by the NUWARD consortium is foreseen in early 2024. Whereas the IRSN will support the French Safety Authority (ASN) in this review, the IRSN follows the development of safety standards, options and demonstration of the other concepts of iPWR that may be licensed in Europe.
  - Finland: VTT is developing a SMR design for low temperature district heating and desalination.
  - Bulgaria, Czech Republic, Romania and Ukraine: signed a memorandum of understanding with NuScale Power.
  - Ukraine: partnership agreement between Energoatom, SSTC-NRS and Holtec to establish an international consortium.
  - Other European countries, calls for projects on iPWR have been launched.
  - In this framework, European Technical Safety Organizations (TSO) are going to support Safety Authorities in the safety review of European and non-European iPWR concepts that are ready to be licensed in Europe.

KEY OBJECTIVE AND KEY OUTCOME

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

- Key Objective of SASPAM-SA:

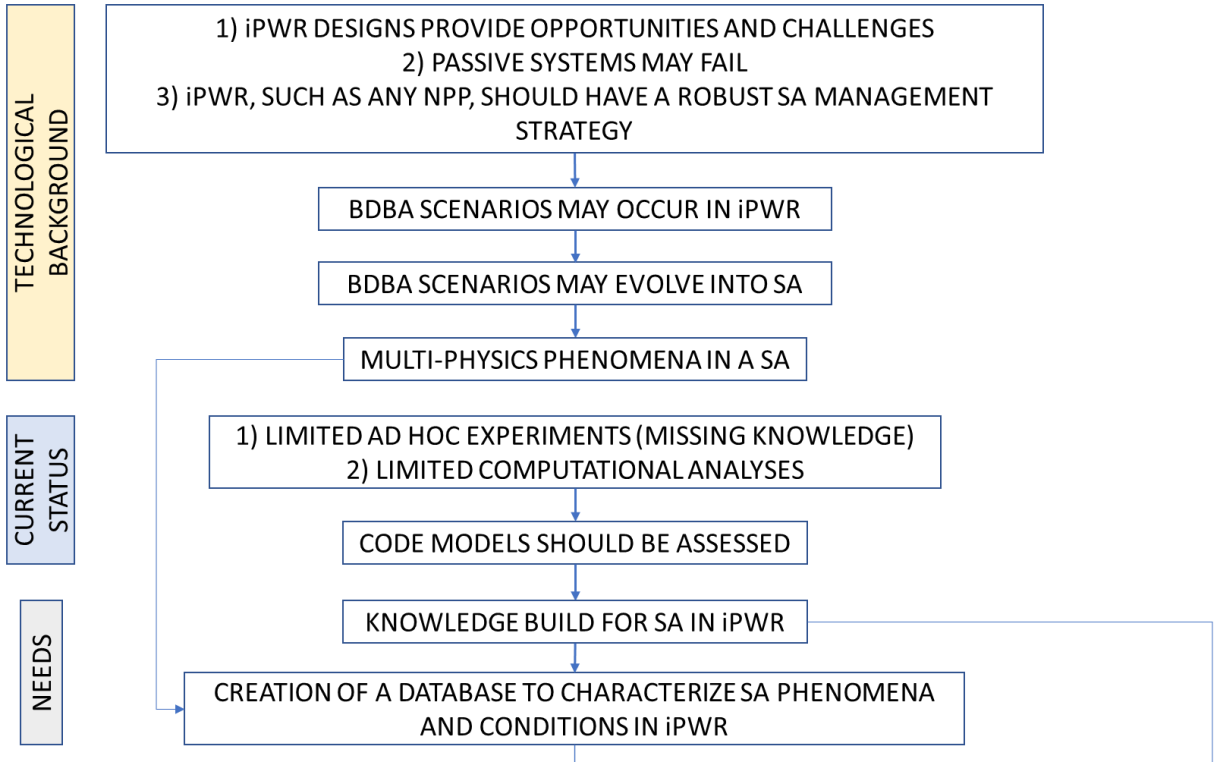
  investigate the applicability and transfer of the operating large-LWR reactor knowledge and know-how to the near-term deployment of integral PWR (iPWR), in the view of Severe Accident (SA) and Emergency Planning Zone (EPZ) European licensing analyses needs.

- Key Outcome of SASPAM-SA :
  - *To be supportive for the iPWR licensing process by bringing up key elements of the safety demonstration needed.*
  - *To speed up the licensing and siting process of iPWRs in Europe.*

- Dedicated actions on:
  - Accident Tolerant Fuels (ATF)
  - In-Vessel Melt Retention (IVMR).

GENERAL OVERVIEW OF THE PROJECT

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT



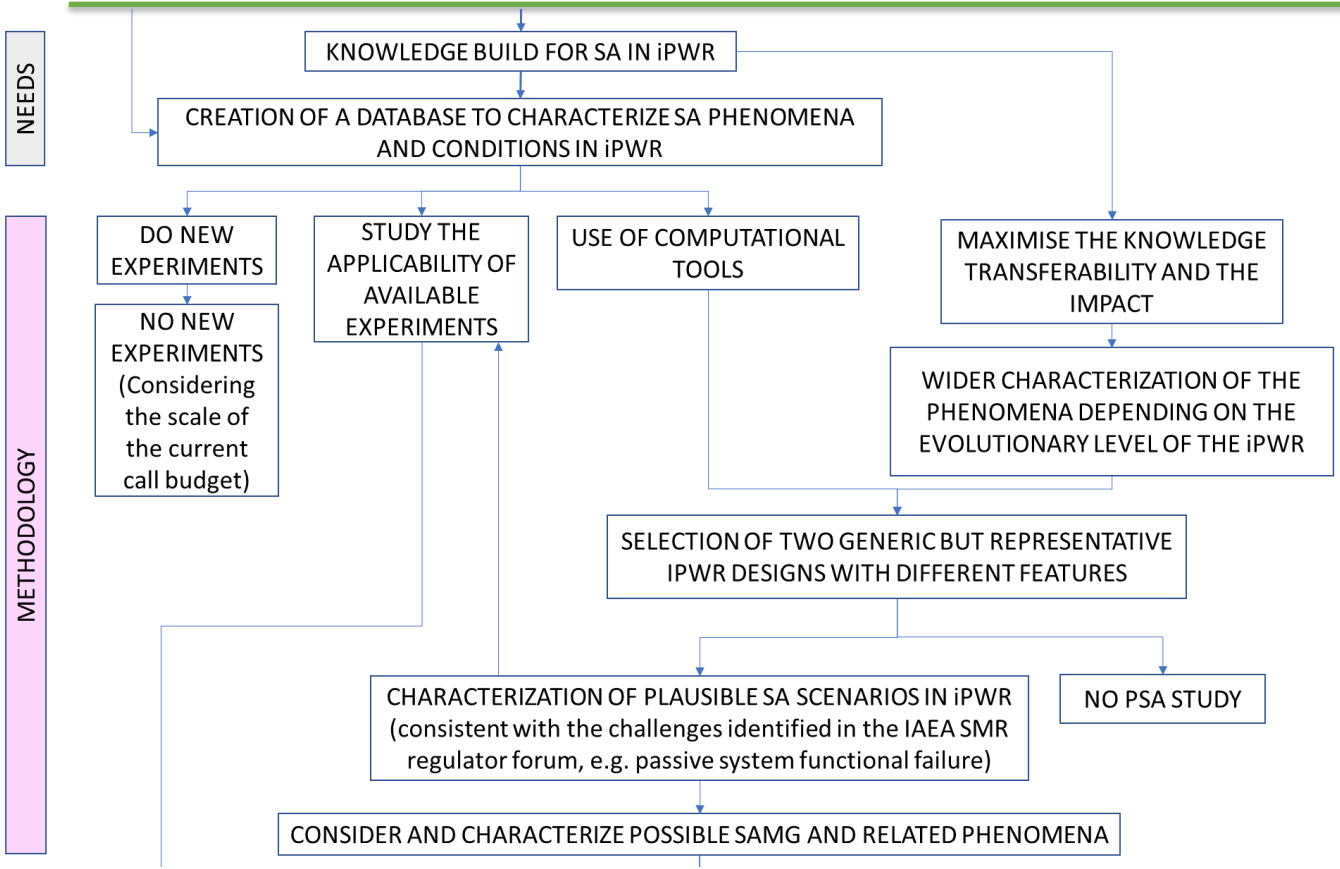
SPECIFIC NEEDS

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

- Identification of plausible SA scenarios for iPWR and address potential impact on the environment;
- Investigation of the applicability and transfer of the operating large-LWR reactor SA knowledge & know-how (codes, experiments, methodologies, etc.) to the near-term deployment iPWR;
- Identification of SA experimental and code development needs;
- Test the current best estimate safety analyses methodologies for iPWR SA analyses;
- Start to address challenges of SA mitigation measures in iPWR including EPZ assessment.

GENERAL OVERVIEW OF THE PROJECT

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT



GENERIC DESIGNS CONSIDERED

- To maximize the knowledge transferability and impacts of the project:
  - Two generic design-concepts will be considered;
  - Characterized by Different evolutionary innovations in comparison with larger operating reactor.

- Despite generic, they resemble currently discussed designs and take benefit from available data in the open literature:
  - Design 1: iPWR characterized by a submerged containment and electric power of about 60 MWe;
  - Design 2: iPWR characterized by the use of several passive systems, a dry containment and an electric power of about 300 MWe.

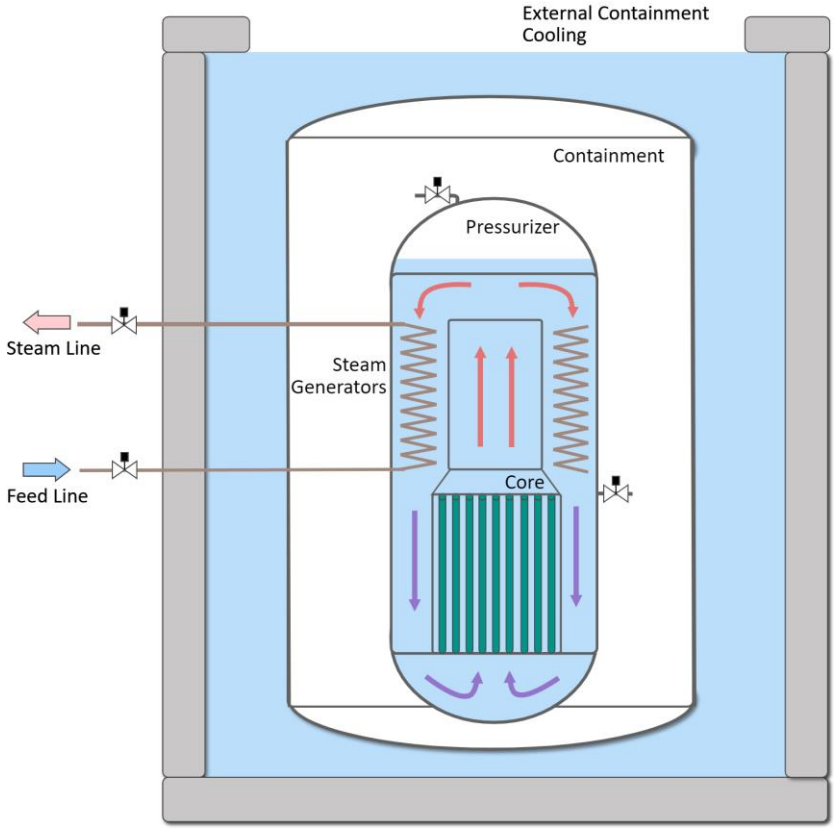
GENERIC DESIGNS CONSIDERED

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

- The two generic reactor concepts:
  - Include the main iPWR design features, considered in the most promising designs ready to go on the European market;
  - Allow to assess in a wider way the capability of codes (SA and CFD) to simulate the SA phenomena typical of iPWR.

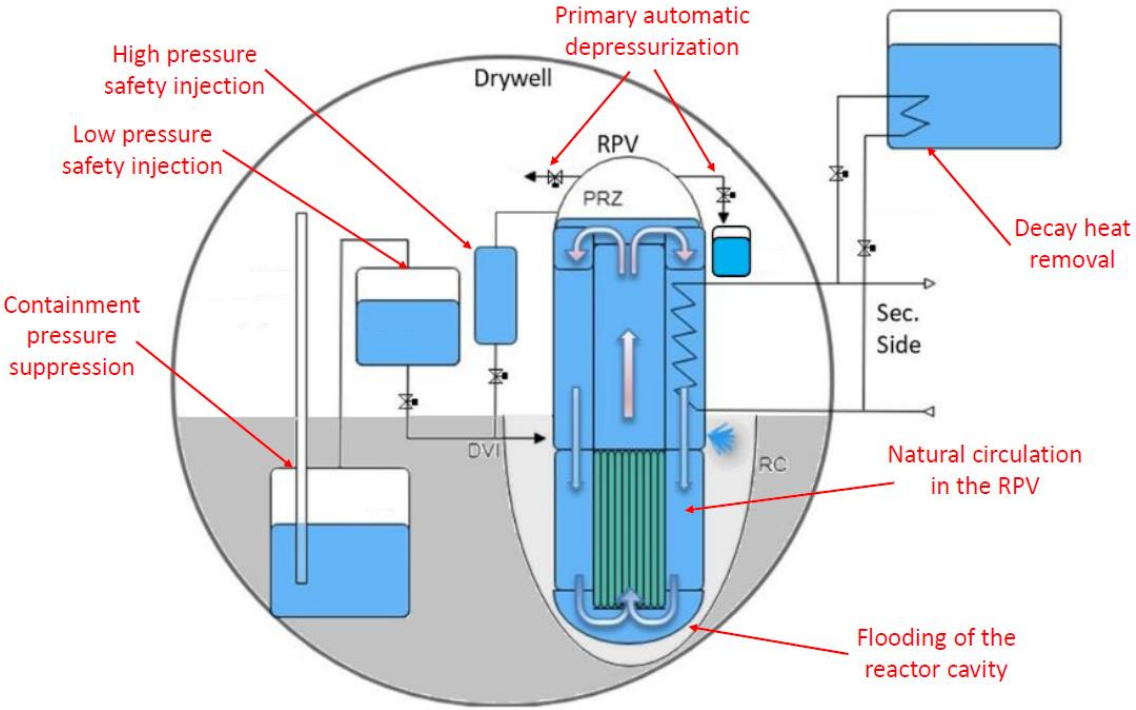
- This will allow to characterize:
  - Feasibility and efficiency of the different SA mitigation features of the non-European designs, ready to be installed in Europe in the very near term;
  - Feasibility and efficiency of the different SA mitigation features of new European iPWR concepts, already in advanced design status, when the final designs become available.

GENERIC DESIGNS CONSIDERED: DESIGN 1



iPWR characterized by a submerged containment and electric power of about 60 Mwe

GENERIC DESIGNS CONSIDERED: DESIGN 2



iPWR characterized by the use of several passive systems, a dry containment and an electric power of about 300 MWe

GENERIC DESIGNS CONSIDERED

- It is not the project's objective to assess the generic reactor designs selected;
- Based on the project findings, the target of the project is to allow a more general statement on the code's applicability to currently favored designs under postulated SA condition;
- No PSA considerations will be done in the project due to the generic nature of the reactor concept considered:
  - Scenarios identified will be characterized in terms of severity but not in terms of probability.

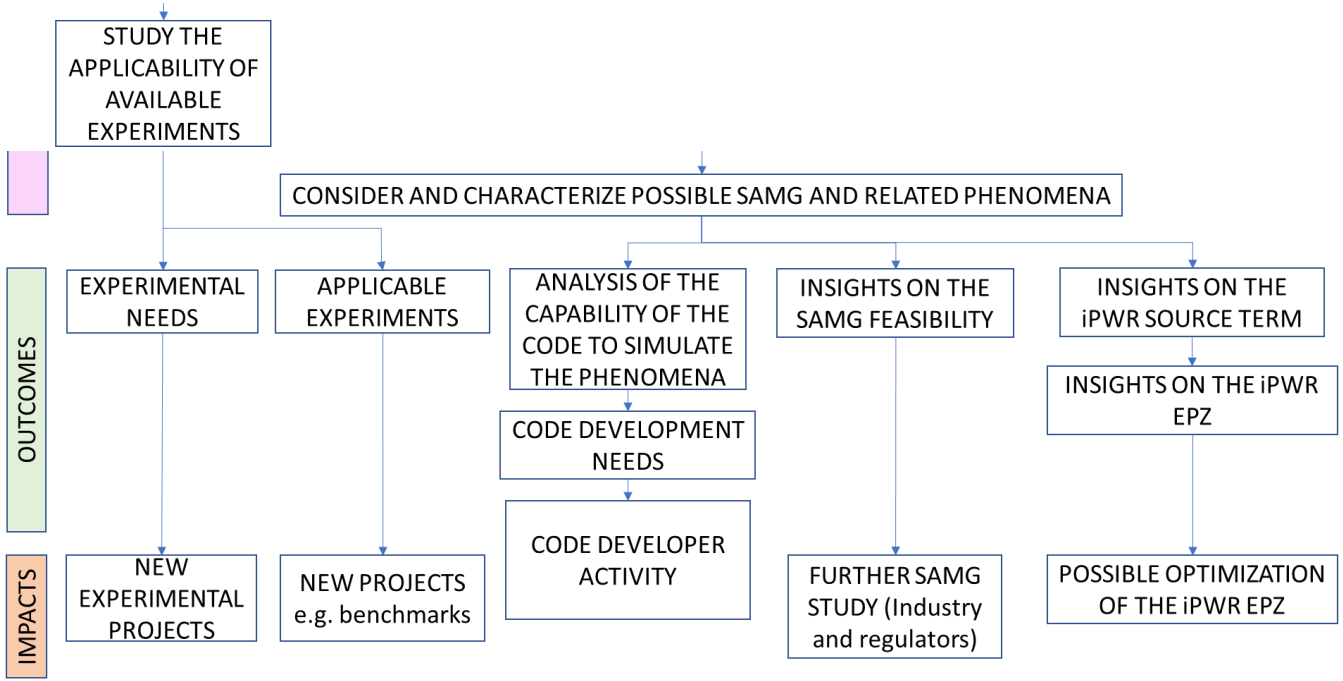
SPECIFIC OBJECTIVES

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

- Identification of plausible SA scenarios for iPWR designs;
- Identification of the conditions in the vessel and in the containment that characterize iPWR SA scenarios and differ significantly from those in large-LWRs;
- Study the applicability of the existing experimental database to iPWR and identify new experimental needs;
- Assess the capability of internationally recognized European and Non-European computational tools (largely used in Europe) to describe the behaviour of the most promising iPWR designs during SA scenarios and to predict the resulting radiological impact on- and off-site.

GENERAL OVERVIEW OF THE PROJECT

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT



SPECIFIC OUTCOMES

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

- Assessment and development of generic but representative iPWR SA codes input-decks:
  - Analyses of the iPWR behaviour under hypothetical postulated BDBA conditions;
  - Plausible SA scenarios in iPWR will be identified.
- Development of know-how in relation to the use of ATF in iPWR:
  - Enhances ATF application in iPWR;
  - Develop code capability to simulate it.
- Study the applicability of the existing experimental database to iPWR and identify new exp. needs.
- Study IVMR strategy in postulated SA scenarios in iPWR:
  - Assess the capability of the codes to simulate the main phenomena characterizing the IVMR in iPWR;
  - Characterize IVMR feasibility in iPWR.
- Study containment behaviour in postulated SA scenarios in iPWR:
  - Assess the capability of the codes to simulate the main phenomena characterizing the containment behaviour;
  - Characterize the efficiency of existing and innovative passive measures.
- Provide evaluations of size and extension of EPZ for postulated SA scenarios coupling the results of best estimate ST codes to radiological consequences tools.

SPECIFIC MAJOR IMPACTS

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

- Identification of plausible SA scenarios for iPWR to be used for further analyses:
  - In the envisaged European licensing processes (e.g. from TSO, Regulators) or
  - For the design of the European iPWRs (e.g. from industries).
- Assessment of the available experimental database to iPWR and identification of exp. needs;
- Build expertise of code users for SA in iPWR and training of new code users (e.g. youngest generations);
- Applicability of the built knowledge on ATF for iPWR and large-LWR;
- Applicability of assessed code guidelines and best practices for the simulation of iPWR;
- Applicability of the assessed state-of-art methodologies to carry out iPWR SA det. safety analysis;
- Build the know-how for the demonstration of the ultimate confinement function of the iPWR containment in SA conditions along an independent safety review process;
- Development of SAMG to prevent accidents or mitigate their consequences avoiding rad. releases;
- Applicability of tools and methods for EPZ iPWR analysis.

COMPUTATIONAL TOOLS USED IN THE PROJECT

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

- In SASPAM-SA several state-of-art computational tools will be adopted, both European and non-European largely used in Europe.

- For integral SA codes:
  - ASTEC (European code developed by IRSN);
  - AC2 (European code developed by GRS);
  - MAAP-EDF (non-European code developed by EPRI embedding EDF code changes);
  - MAAP (non-European code developedby EPRI);
  - MELCOR (non-European code developed by Sandia National Laboratories for the USNRC).

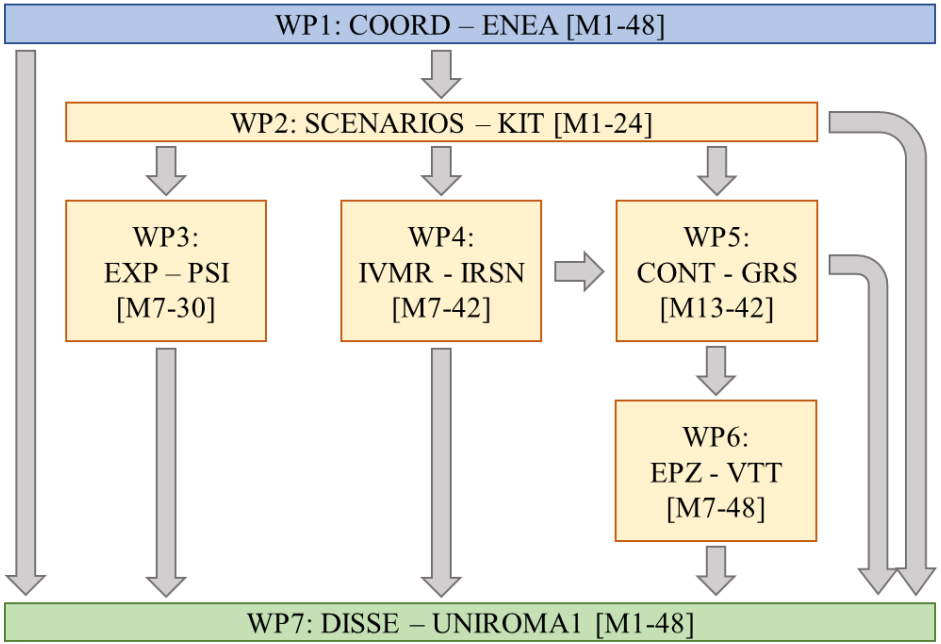
- For CFD codes:
  - ContainmentFOAM (European code developed by FZJ);
  - ANSYS CFX (non-European code developed by Ansys Inc.).

- For atmospheric dispersion codes:
  - ARANO (European code developed by VTT);
  - JRODOS (European code developed by KIT);
  - MACCS (non-European code developed by Sandia National Laboratories for the USNRC).

- For iodine chemistry:
  - IMPAIR (European code, developed as a European collaboration).

SASPAM-SA PROJECT STRUCTURE

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT



WP1 - Coordination

WP2 - Input deck development and hypothetical SA scenarios assessment (SCENARIOS)

WP3 - Applicability and Transfer of the Existing SA experimental database for iPWR Assessment (EXP)

WP4 - Assessment of code capabilities to simulate And evaluate corium retention in iPWRs (IVMR)

WP5 - Assessment of the code capabilities to simulate IPWR containment and characterize mitigation measures efficiency (CONT)

WP6 - Characterization of iPWR EPZ (EPZ)

WP7- Communication, dissemination and exploitation(DISSE)

SNETP LABEL

CERTIFICATE
SNETP LABEL

Date of certificate issuance: *27/08/2021*
Certificate number: *2021NUG0085*

The SNETP Scientific Committee during its meeting held on *27 August 2021* awarded the SNETP Label to the project idea identified as **Safety Analysis of SMR with Passive Mitigation Strategy (SASPAM)- Severe Accident (SA)** with the technical content reviewed and published through SOIP on 19/07/2021.

Signed for and on behalf of the SNETP Scientific Committee.

SNETP LABEL

SNETP AISBL
Avenue des Arts, 53
1000 Brussels – Belgium
VAT N° : BE 0843 497 746
Company Registration: 0843 497 746
secretariat@snetp.eu

SNETP
Sustainable Nuclear Energy Technology Platform

- SASPAM-SA ideas born in the framework of the NUGENIA TA2, Severe Accident.
- SNETP Scientific Committee awarded the SNETP Label to the project idea

SASPAM-SA GENERAL DATA

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

- Project name: Safety Analysis of SMR with PAssive Mitigation strategies - Severe Accident
- Project number: 101059853
- Project acronym: SASPAM-SA
- Call: HORIZON-EURATOM-2021-NRT-01: Nuclear Research and Training
- Topic: HORIZON-EURATOM-2021-NRT-01-01: Safety of operating nuclear power plants and research reactors
- Type of action: EURATOM Research and Innovation Actions
- Project starting date: 1 October 2022
- Project end date: 30 September 2026
- Project duration: 48 months

SASPAM-SA GENERAL DATA

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

- Project Officer: Angelgiorgio Iorizzo (EC)
- Technical project leader: Fulvio Mascari (ENEA)
- BUDGET:
  - Overall Budget: € 4 276 038.85
  - EU Contribution: € 2 991 694.00 (about 70%)
- KICK-OFF MEETING: 12-13th October, 2022, in Bologna, Italy

SASPAM-SA PARTNERS

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

BELGIUM: EC-JRC, TRACTEBEL-ENGIE
BULGARIA: INRNE, TUS
CZECH REPUBLIC: SURO
FINLAND: VTT
FRANCE: CNRS, EDF, IRSN
GERMANY: KIT, FZJ, GRS, RUB
ITALY: ENEA, UNIROMA1, POLIMI, SINTEC
LITHUANIA: LEI
ROMANIA: RATEN
SWEDEN: KTH
SWIZERLAND: PSI
SPAIN: CIEMAT
UKRAINE: SSTC-NRS

23 PARTNERS FROM 13 EUROPEAN COUNTRIES, COMPOSED OF: UNIVERSITIES, RESEARCH INSTITUTES, TSO, INDUSTRIAL AND ENGINEERING ORGANIZATIONS

PARTNERS LOGOS

SAPAM-SA

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

SASPAM-SA-KOM- PICTURE

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

ACTIVITY IN PROGRESS AND FIRST RESULTS

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

- WP2 started and the KOM was the 12 December 2022
  - Analysis of hypothetical postulated SA-sequences for iPWR-designs with different SA-codes:
    - First SA scenarios have been identified under hypothetical postulated BDBA conditions;
    - Code capability are under investigation and first interactions with code developer;
    - Code Input-decks available have been shared to optimize the schedule;
    - Code input-decks missing are under developments and first results has been presented.
  - Two different groups has been formed to consolidate the design 1 and 2 database.
    - CFD user and system code users collaborate in order to have consistent input-deck;
    - A first version of the two generic reactor database has been consolidated;
  - Estimation of the Nuclide inventory for realistic radiological source term prediction for design 1 and 2
    - First version for comments has been release;
    - Revised version has been already released.
    - Deliverable “iPWR Inventory” under internal review

- WP3 started and the KOM was 13 March 2023
  - Review of the experimental data is in progress (Interaction WP2-WP3)

- WP6 started and the KOM was 30 March 2023
  - Critical review of the existing methodology for EPZ determination is in progress (interaction WP2-WP6)

- WP4 started and the KOM was the 26 of May 2023
  - Preliminary conservative analyses (interaction WP2-WP4)

GRAZIE PER LA VOSTRA ATTENZIONE

Acknowledgement/Disclaimer

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

Funded by the European Union

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Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

SAFETY ANALYSIS OF SMR WITH PASSIVE MITIGATION STRATEGIES - SEVERE ACCIDENT

TO HAVE MORE INFORMATION:

[Safety Analysis of SMR with PAssive Mitigation strategies - Severe Accident (SASPAM-SA) Horizon Euratom Project | etson.eu]

[https://www.linkedin.com/company/saspam-sa-horizon-euratom-project/]

[SASPAM-SA Horizon EURATOM – YouTube]

[Saspam-sa] **(under construction)**

Fulvio Mascari,
PhD Nuclear Engineer, Researcher
ENEA Research Center,
Via Martiri di Monte Sole n. 4,
40129, Bologna (BO), Italy
Tel: +39 0516098674
Mobile Phone: +39 3881135591
Email: fulvio.mascari@enea.it