How will the SAMOSAFER results be used in the new project proposal?

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SAMOSAFER Exploitation Meeting

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SAMOSAFER.. many gigantic results

WP1: Safety requirements and Risk identification

- Definition of severe plant conditions
- Defense in Depth approach
- List of PIEs for RIA and FTU + key phenomena for RIA & functional analysis for FTU + multiphysics analysis
- Preliminary PIRT on system TH

WP2: Fuel salt retention

- Novel data on Fuel Properties on fluorides and chlorides (phase diagrams), FP influence on Liquidus point
- New data for the JRCMSD + viscosity/density coupling
- Simulations tools as MD simulation on Chlorides properties, coupling of thermodynamics (ThermoChimica) and multiphysics and metallic FP transport (OpenFOAM)
- Data of irradiated fuel sample

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WP3: Source term distribution and mobility

- GFP and SFP removal rate assessment + computational tools (OpenFOAM)
- Fuel reprocessing scheme + fluorination tests + reductive extractions
- Radiotoxicity release during sever accident (cGEMS)
- Benchmark on burnup and source term distribution

WP4: Fuel salt confinement

- Simulation tools for for phase-change modeling including benchmark study + experimental validation
- Analysis of salt confinement (freeze plug ad emergency tank)
- Thermo-mechanical analysis

WP5: Heat removal and temperature control

- Extension & Validation of SIMMER
- DHR system modelling (multiphase + heat transfer)
- Radiative heat transfer experiments (SWATH) + modelling
- Natural circulation experiments (DYNASTY) + 2D cavity

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WP6: Reactor operation, Reactor control and Safety demonstration

- Drawings of MSFR
- Plant operational state definition and control strategy for MSFR
- Salt composition measurements + U(IV)/U(III) ratio determination
- UQ of safety calculations
- Analysis on scaling effect and chlorides options

WP7: Education & Training

- Online school
- Simulation tools for E&T

ENDURANCE – a project proposal on MSR

Eu kNowleDge hUb foR enAbling molteN salt reaCtor safety development and dEployment

Grand objective of the ENDURANCE: "to support the safe operation and the technological development of Molten Salt Reactor (MSR) technology in Europe, through the knowledge advancement in different fields of MSR research and safety assessment, connecting the needs of reactor designers and industry with the university and research centre capabilities and the regulator requirements."

Strength the European ENDURANCE on the MSR development

EU kNowleDge hUb = involvement of EU stakeholders & connections among research, lab & industry to maintain EU leadership in MSR technology

for enAbling MolteN Salt ReaCtor safety development and dEployment = bring the MSR technology safety development from research (TRL 1-3) to development (TRL 4-6) and deployment (TRL 7-9)

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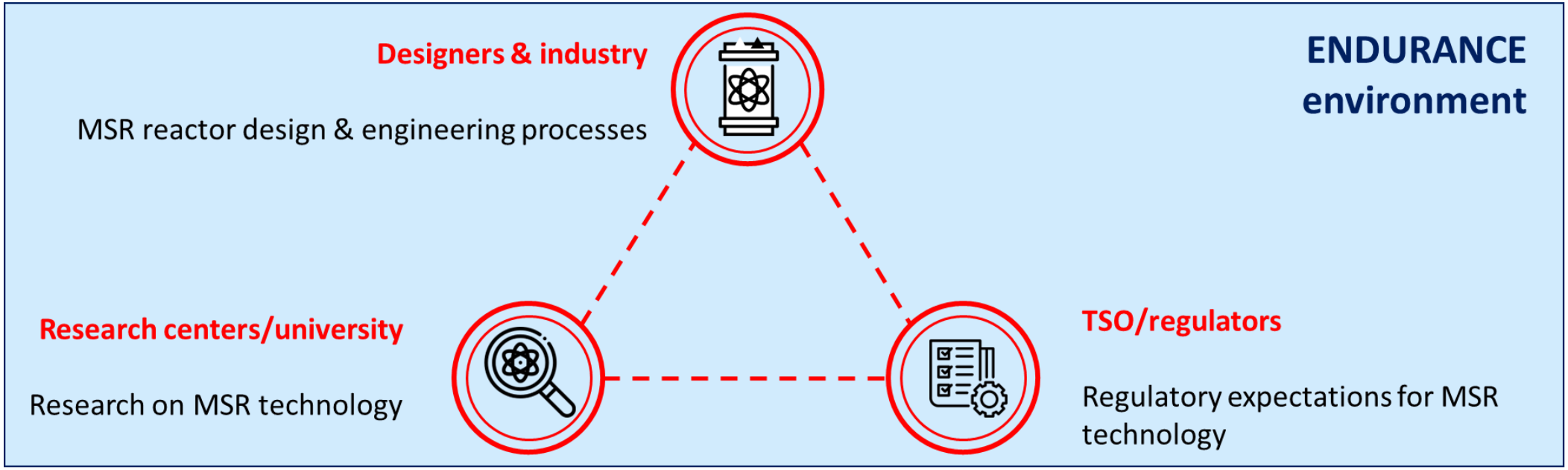
High-level objectives - HLO1

HLO1 “to create an environment for a constructive alignment aimed at the development of MSR among designers, university, research centers and TSO, maintaining the competence inside the Europe” - creating an agora among the different stakeholder to promote the cross-fertilizations of the ideas, the solution of the technological issues, the discussion about the regulation on MSR.



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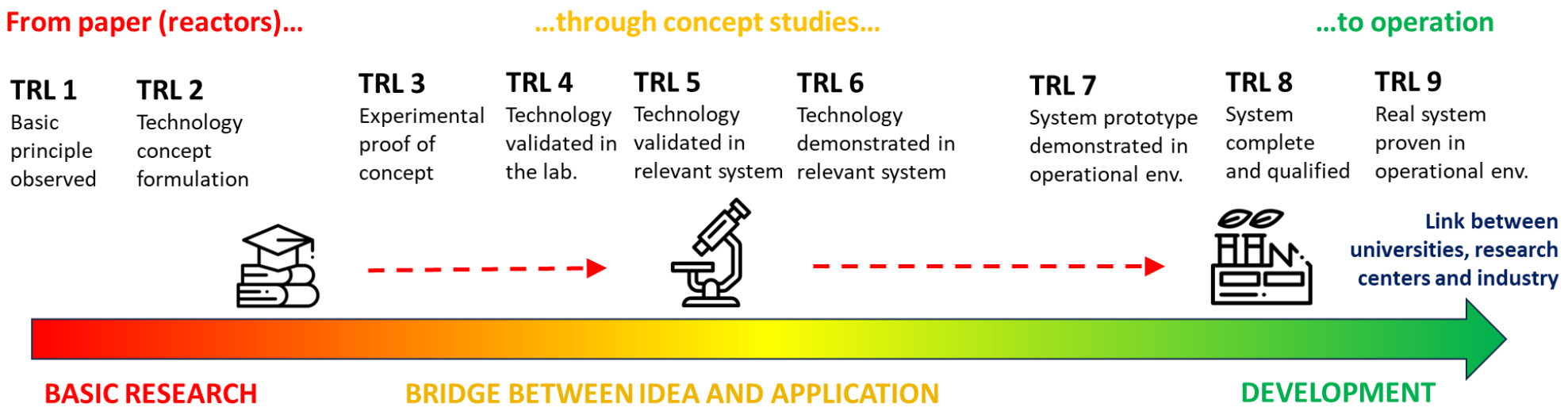
High-level objectives - HLO2

HLO2 “enable the MSR safe development and deployment increasing the SRL and the TRL on key enabling phenomena, technologies and methodologies (Critical Technology Elements) and filling R&D gaps”



The focus is not on (a specific) design but it is rather on the scientific and technological challenges!

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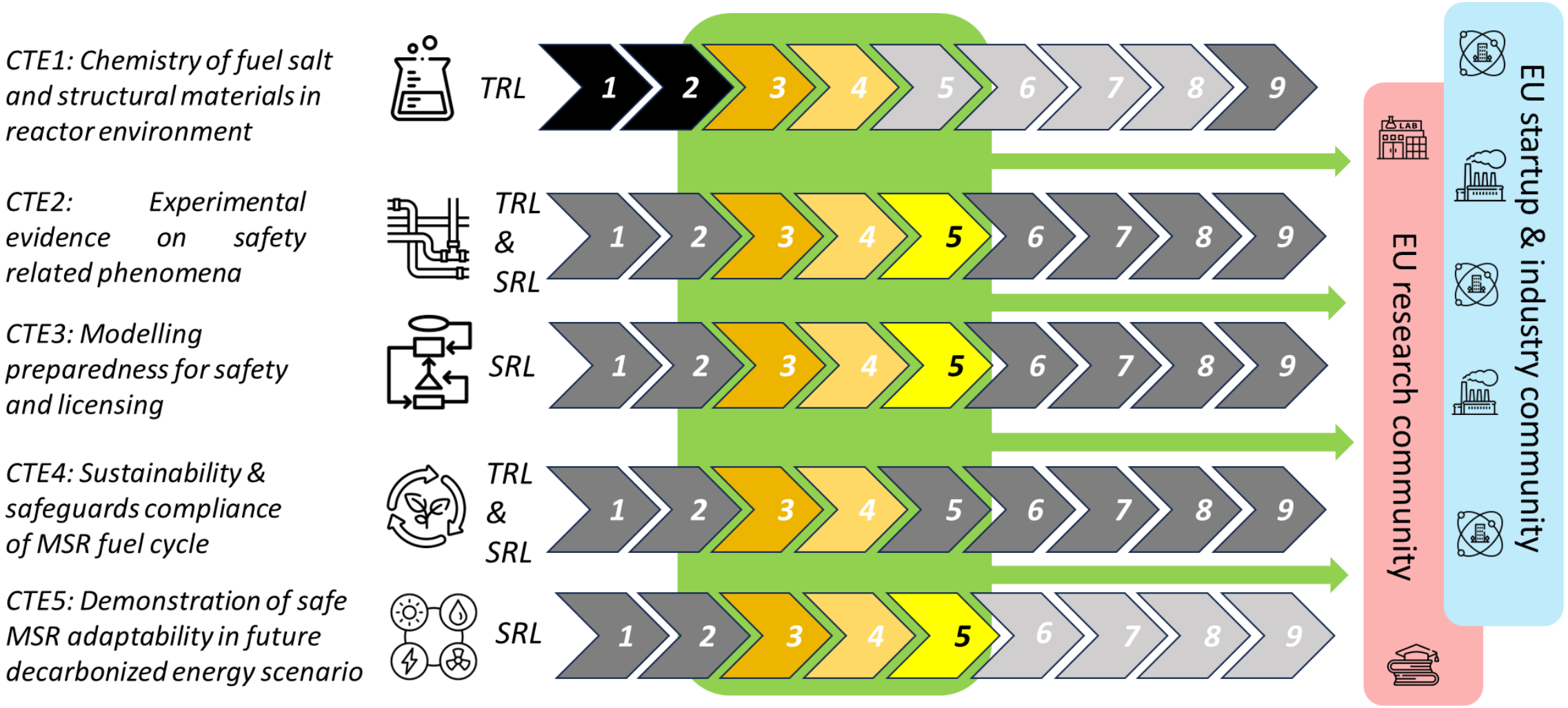
Critical Technology Elements



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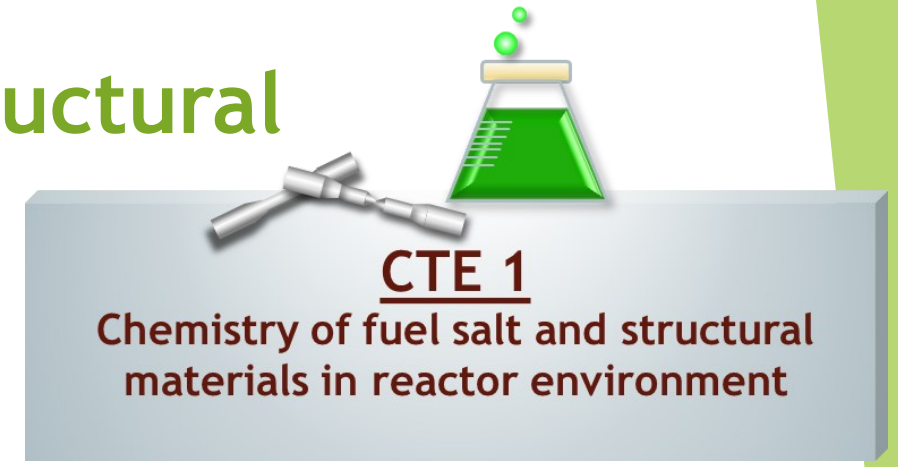
WP2 “Chemistry of fuel salt and structural materials in reactor environment”



Models and simulation codes of the chemistry of irradiated fuel salt and of corrosion mechanisms of structural materials are essential for the safety assessment of the MSR and its licensing process

WP2 is aimed at providing **experimental data and models on density, viscosity, and thermal conductivity of fission products systems**, i.e., systems representative of irradiated fuel salt. Regarding the corrosion phenomena of the reactor core structural material, the WP will address **the combined effects of salt corrosion with respect to mechanical stress and irradiation.**

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WP2 “Chemistry of fuel salt and structural materials in reactor environment”

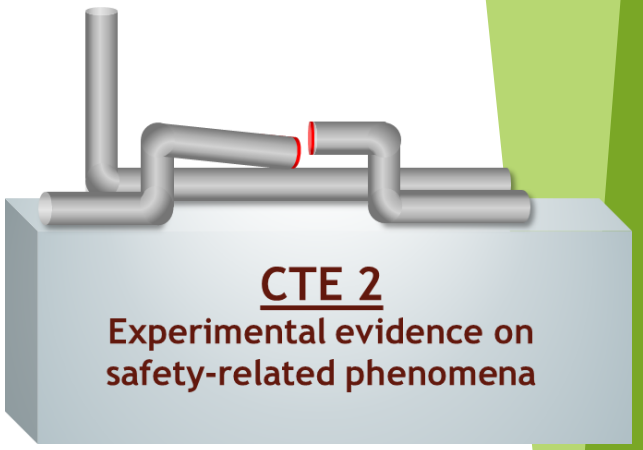
WP2 Activities:

- Organize a round robin campaign on thermo-physical property measurements of salts;
- Define best practices for accurate measurements of thermochemical and thermophysical properties;
- Develop a density and viscosity database coupled to the JRCMSD;
- Provide information in actual fission product behaviour (volatilization, deposition) under MSR-representative conditions.
- Gain insight into the combined effects of structural material corrosion and mechanical stresses

SAMOSAFER results:

- Round robin campaign based on the experience of SAMOSAFER partners on measurement of thermo-physical properties.
- FP influence results (and salt synthesis)
- JRCMSD database development
- Data of irradiated fuel sample
- Thermo-mechanical analysis of salt containment (Hastelloy N)

WP3 “Experiments on phenomena relevant for safety”



All the EU MSR designs have to fulfil the safety functions with a high degree of reliability. This may involve the use of passive features and considering the peculiar features of the use of liquid fuel.

WP3 is aimed at increasing the knowledge of the **phenomena that are relevant for safety-related components** (e.g., passive safety systems, safety functions, …).

WP3 “Experiments on phenomena relevant for safety”

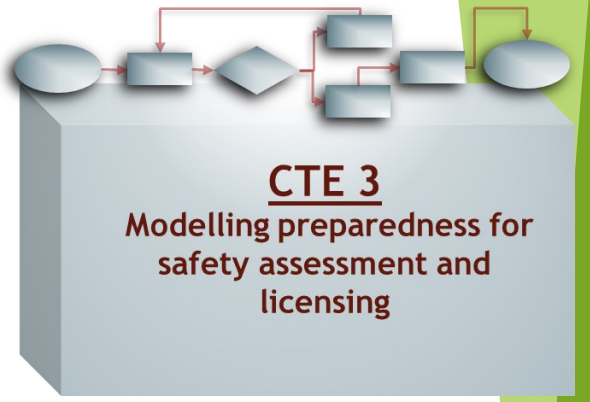
WP3 Activities:

- Validate numerical models for the transport of the solid fission products, deposition on the structural components and interaction with bubbling system
- Assess the stability of natural convection in 3D geometry with molten salts;
- Define specification requirements for large experimental facilities for MSRs .

SAMOSAFER results:

- Modelling tools for transport of SFP
- Natural circulation experiments (DYNASTY, SWATH, …), modelling on natural circulation and heat transfer
- Experience on the experimental facilities

WP4 “Modelling and simulations to enable safety assessment and licensing”



Molten salt designs are required to comply with the current and future safety regulatory environment, which includes recognized and shared practices and high-level standards. In this view, the evaluation and the enhancement of the predictive capabilities of modelling tools is a fundamental aspect.

WP4 helps to enable the **compatibility of design studies and problem-oriented R&D with the European regulatory environment**. It considers the involvement of comprehensive simulations directly in the safety assessment process, if practical experience feedback might be considered as poor or limited.

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WP4 “Modelling and simulations to enable safety assessment and licensing”

WP4 Activities:

- PIRT study to enhance the understanding of safety-related processes and factors that should be simulated. + Target Accuracy Requirements
- develop computational chains combing well-elaborated system codes and high-fidelity to estimate uncertainties of such modeling;
- develop and perform relevant numerical and experiment-based benchmarks
- demonstrate the maturity of the predictive capabilities of the modelling and simulation tools experience with modelling and simulation and the feasibility to compensate the lack of practical a graded approach to the safety assessment;

SAMOSAFER results:

- Preliminary PIRT on system TH
- Multiphysics and system code modelling development
- Benchmark developed for multiphysics and burnup problems
- Experimental dataset

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WP5 “MSR sustainability”

CTE 4
Sustainability and safeguards compliance of MSR fuel cycle

Sustainability is a key feature for the advanced systems and even more for MSRs due to their flexibility in the fuel cycle and the liquid nature. For the same reasons, safeguards compliance of MSR systems should be evaluated to ensure the deployment of these systems

The WP5 is aimed at contributing to the evaluation of the sustainability, proliferation resistance and safeguardability of the fuel cycle options and reprocessing schemes for MSR

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WP5 “MSR sustainability”

WP5 Activities:

- providing standardized methods to preliminary assess sustainability of fuel cycle performance of MSR concept
- simulating the detailed nuclides flow inside the MSR system
- analysis of possible salt clean-up and reprocessing techniques to assess their efficiency, pace and proliferation resistance;
- assessing alternative passive method for salt clean-up;
- simulating the radionuclide releases from fuel salt during nominal condition and at elevated salt temperature
- evaluating the proliferation resistance and safeguardability of different reprocessing schemes and fuel cycle options;

SAMOSAFER results:

- CFD tools and simulation for GFP and SFP removal to be employed for the analysis of the passive off-gas system
- Application of benchmark methodology for analysing the other MSR systems and the safeguaradability of reprocessing scheme and waste treatment
- cGEMS for radionuclides release

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WP6 “Safety aspects of MSR flexibility”

New challenges and opportunity are brought by the decarbonization challenges in the energy field for which advanced systems need to be ready.

The WP6 is aimed at analysing the safety aspects of the MSR flexibility in terms of operation and cogeneration requirements to safely adopt the MSR in an energy mix with intermittent energy sources.

WP6 “Safety aspects of MSR flexibility”

WP6 Activities:

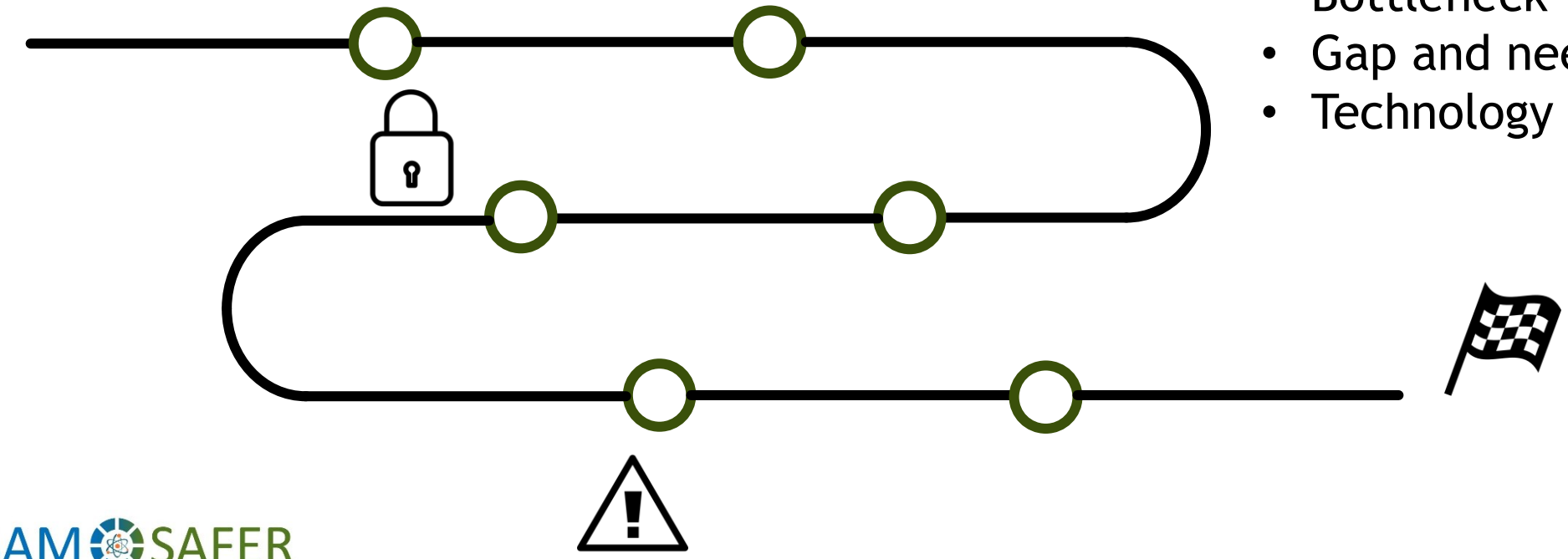
- highlight the operation strategy, potential limitations and opportunities for flexible use of MSRs
- select cogeneration options for MSR systems and define energy conversion system configurations to cope with non-electrical end-usages;
- enhance and extend the numerical simulation tools to analyse the whole plant configuration arrangement and take into account the operating conditions and the plant dynamics situations to consider;
- identify specific safety issues coming from flexibility performance from a functional safety analysis perspective.

SAMOSAFER results:

- Analysis on the plant operation states and control strategy
- Power plant simulation tools + Multiphysics tools
- Safety assessment approach

High-level objectives – HLO3

HLO3 “Identify the future R&D needs required to enable the safe development of MSR in Europe and define the technology roadmap development to preserve research and industry leadership in Europe on MSR technology”



- Bottleneck identification
- Gap and needs analysis
- Technology development

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ENDURANCE is standing on the shoulders of the gigantic SAMOFAR & SAMOSAFER results!

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