



**REDUCTION OF  
RADIOLOGICAL  
ACCIDENT  
CONSEQUENCES**

## The EU H2020 R2CA project

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Event: WGFS 2020 Interim Meeting

When: March 4, 2020

Where: OECD Headquarters, Boulogne, France



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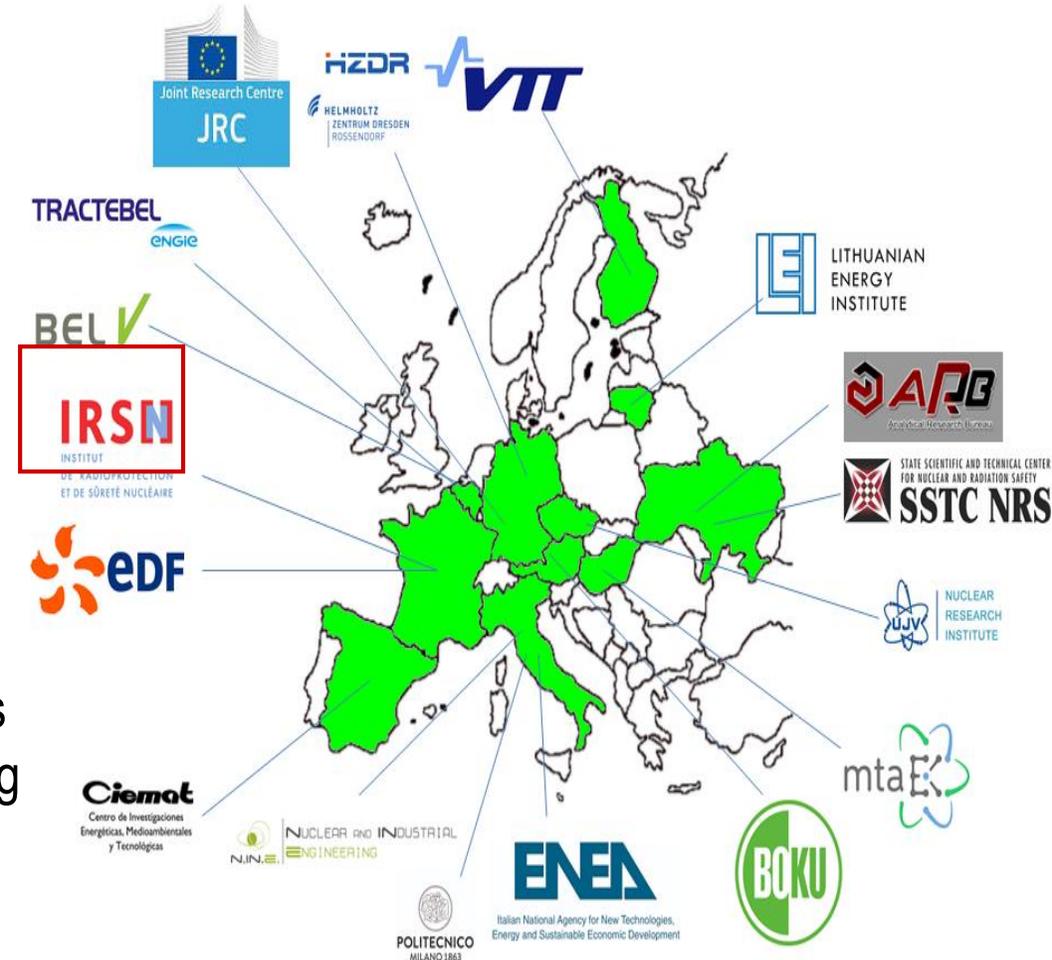


# Project in a nutshell

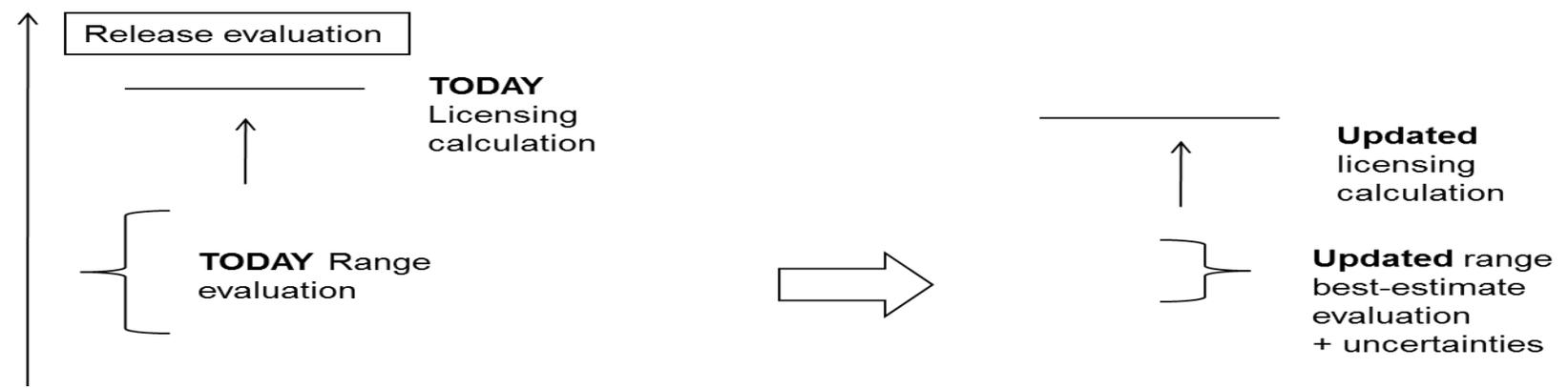
REDUCTION OF RADIOLOGICAL CONSEQUENCES OF DESIGN BASIS & DESIGN EXTENSION ACCIDENTS

- Acronym: R2CA: **R**eduction of **R**adiological **C**onsequences of design basis & design extension **A**ccidents
- Ressources 17 organisations - 522 pm - 4,2 M€ (~3/4 funded by Europe)
- Time frame 01.09.2019 – 31.08.2023
- Scope
  - ✓ DBA & DEC-A conditions (1 aggravating factor/others initiating events-multiple failure)
  - ✓ LOCA & SGTR
  - ✓ PWR, EPR, VVER & BWR avoiding decoupling factors)
- Main goal
 

Reduce the degree of conservatism in safety evaluations of selected bounding scenarios. BEPU calculations of releases and estimation of RC (more realistic safety margins, avoiding decoupling factors)



- Origin & context : issued from 4<sup>th</sup> periodic safety review of French 900 MWe PWR
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    - ❖ Increased safety required for NPPs in terms of RC reduction in addition to safety criteria in safety accident analyses
      - ⇒ *for DBA : tend to reduce the RC down to levels where no more population protection measures*
  - Worldwide, increased safety also required for NPPs
    - ❖ After FKS R&D efforts mostly focused on RC reduction of SA and less efforts paid on **DBA and DEC-A**
  - DBA evaluation usually done with very conservative deterministic assumptions of barrier loss of integrity + decoupled approaches (fewer efforts paid to best estimate evaluation of safety margins in terms of RC)
    - ⇒ Optimisation of EP&R actions + quantification of gains (in terms of RC) of additional measures/devices impossible





# Main objectives & overall approach



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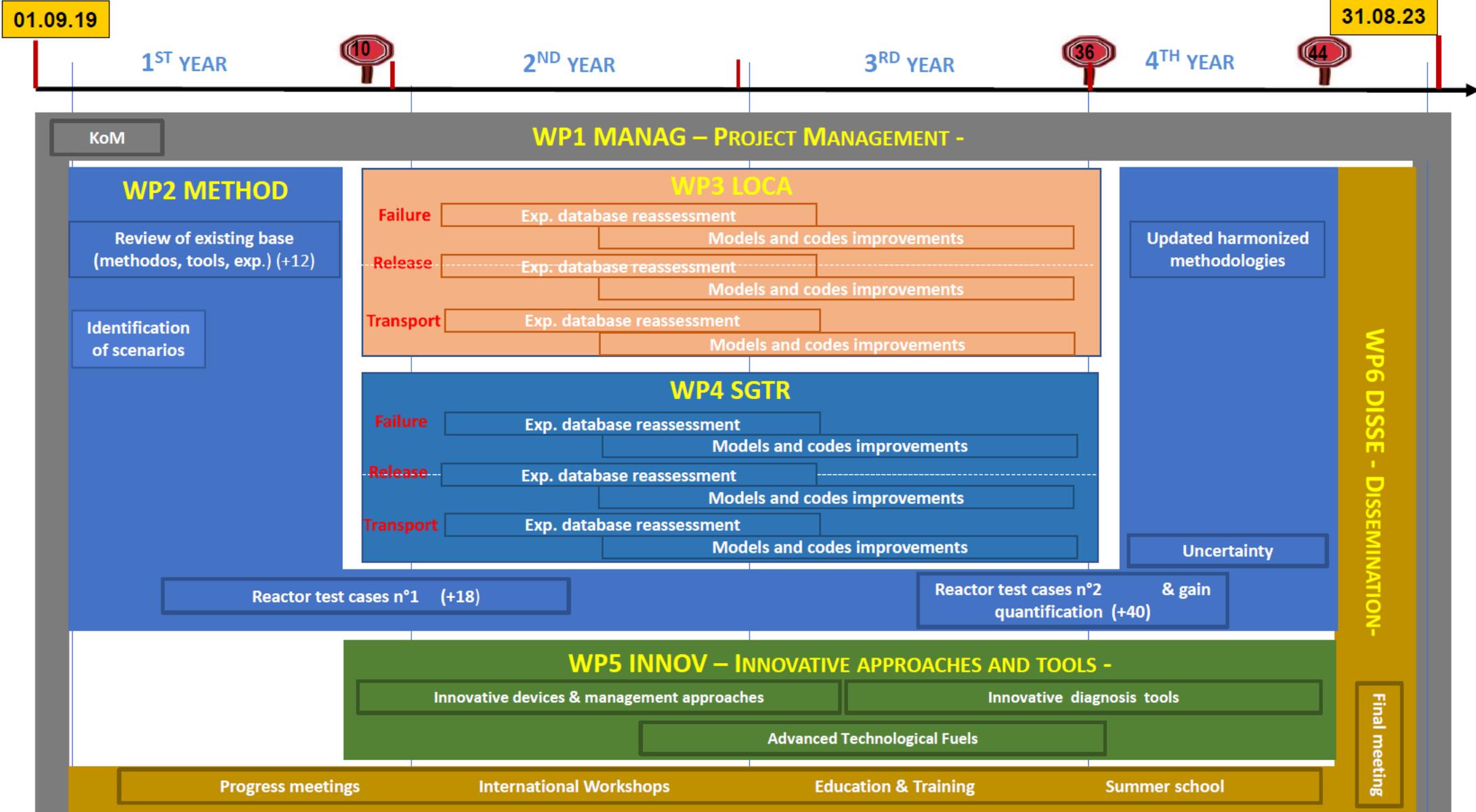
- Specific objectives of R2CA for a best estimation of releases for LOCA & SGTR
  - Upgrade simulation tools & calculation schemes
  - Elaborate updated and harmonized methodologies: *derivation of some principles for EP&R action optimization*
  - Develop innovative systems (ATF, safety devices...) and management approaches
  - Improvement of resilience & anticipation of the accident diagnosis
- Methodology
  - Review of existing base (methodologies, simulation schemes, calculation tools, experimental data)
  - Identification of reactor cases covering all aspects (conditions, accidents, reactors) & simulation schemes
  - Upgrade of simulation schemes through the re-assessment experimental data and code improvement
  - Identification of gains & proposal for development of harmonized evaluation methodologies & innovative AMP





# Project structure & organisation

REDUCTION OF RADIOLOGICAL CONSEQUENCES  
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# External links

- With End-Users that could be interested to get information on R2CA progress
  - Set-up of an End-Users Group (EUG) = researchers from institutions not participating to the project, stakeholders
  - Invitation to the international workshops
- With European & International organisations (OECD, IAEA, ETSO, NUGENIA...)
  - Organisation & implementation of communication activities disseminating the project results
  - Final project database gathering the reference reactor case simulations to be shared with IAEA
  - After the project, edition of a SOAR with OECD or of a part of “Safety guides” with IAEA for the methodologies of best estimate evaluation of RC in DBA and DEC-A conditions
- With other projects/programs/groups
  - McSAFE (overall integration of the research & technological development activities of EC), II TROVATORE (investigation of fundamentals properties relevant for safety analyses), MUSA? ...
  - Legacy: ESSANUF, FASTNET, OECD programs....
  - Users Groups of computer codes involved in the project (i.e. ASTEC, TRANSURANUS, FRAPCON...)





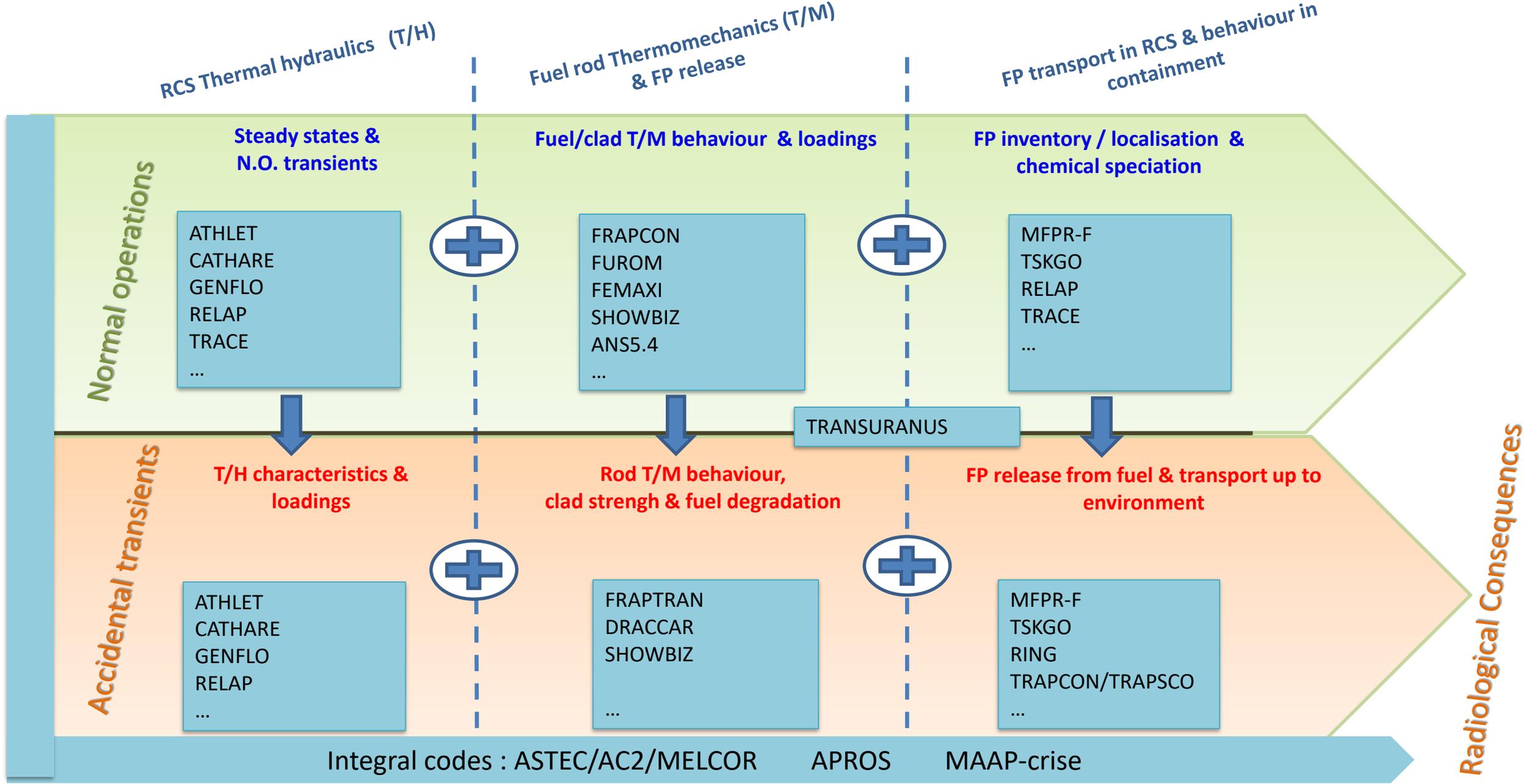
# Structure – WP2 METHOD

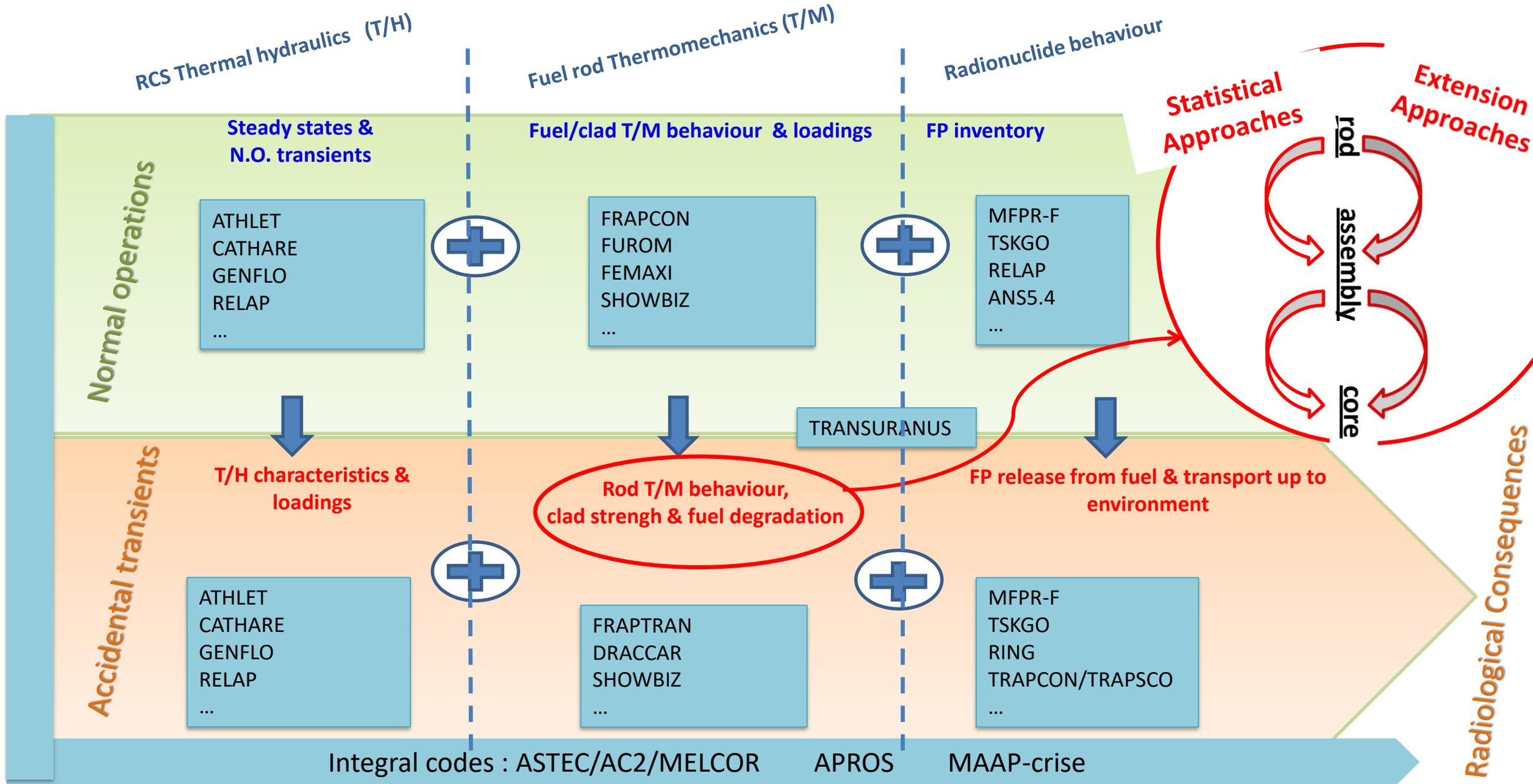
- Generic evaluation methodology (phenomena + supporting codes): LOCA



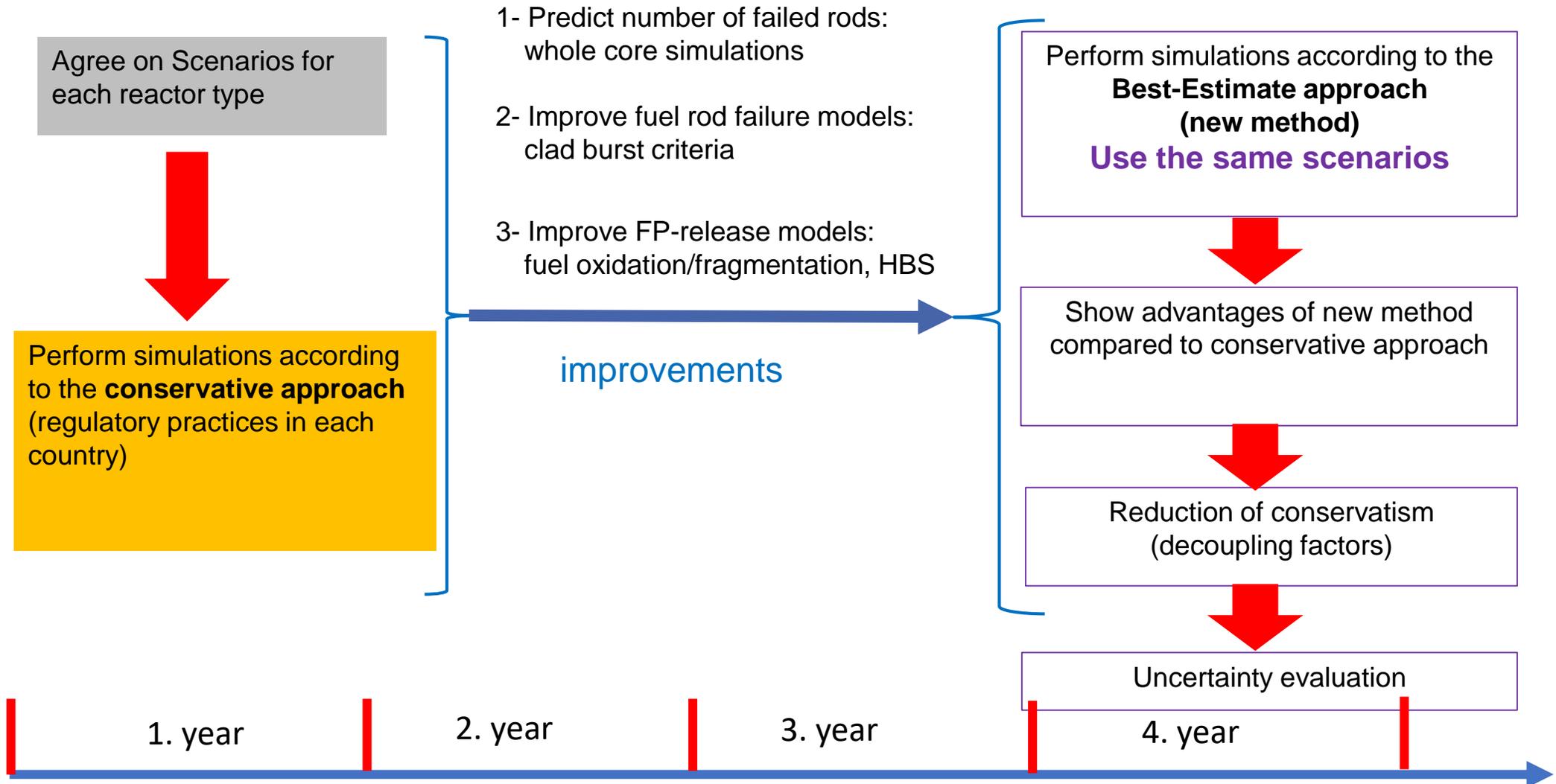
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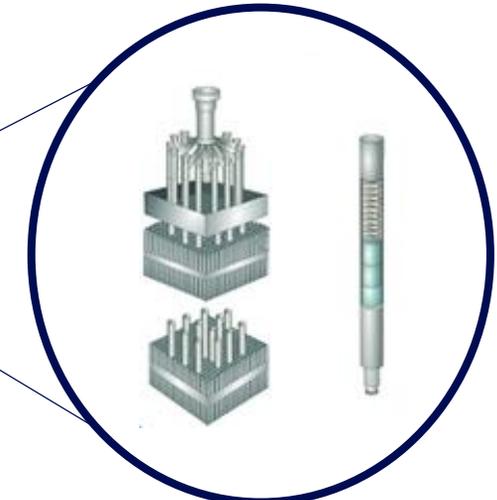
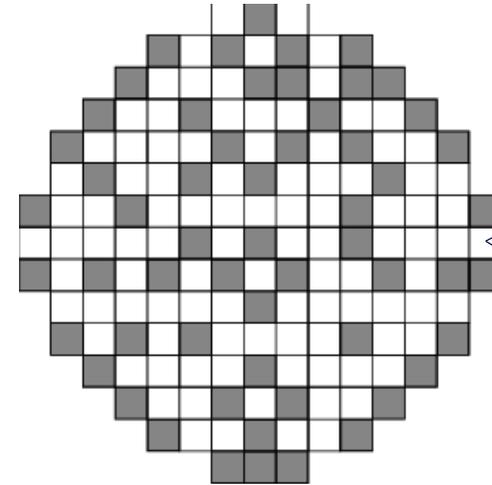
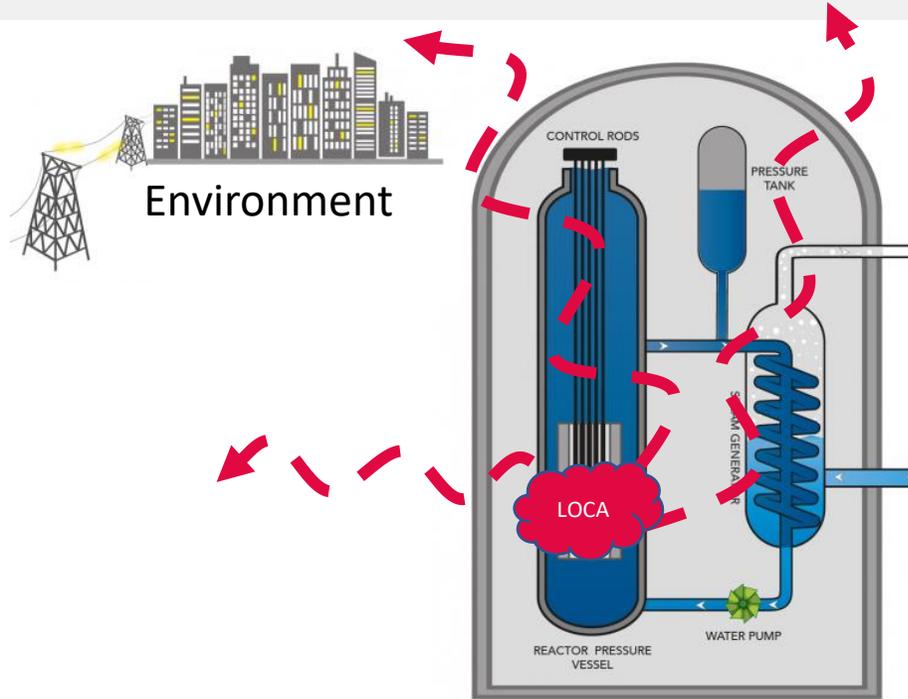






- Methodology for reactor calculations





**WP3.1**

**FP releases (from primary circuit)**

Revisiting and reassessing database for FP transport in the primary circuit and **FP behaviour (iodine) in containment**, FP release to environment.

**WP3.2**

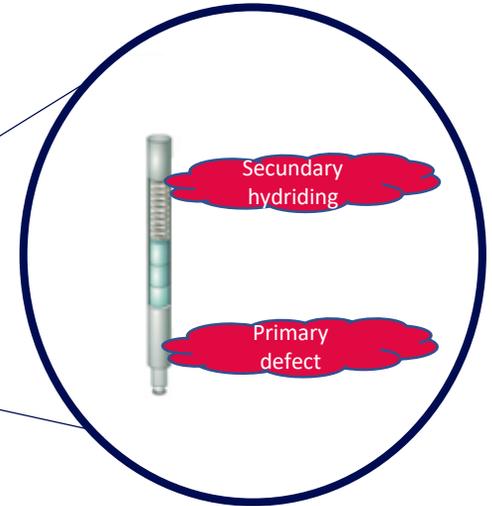
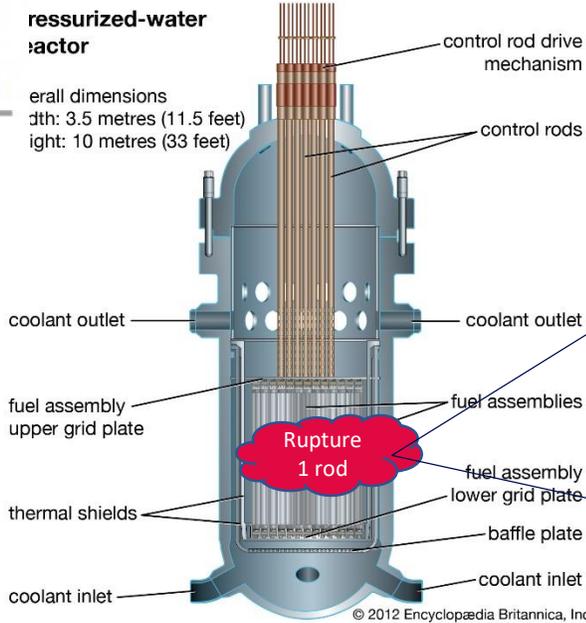
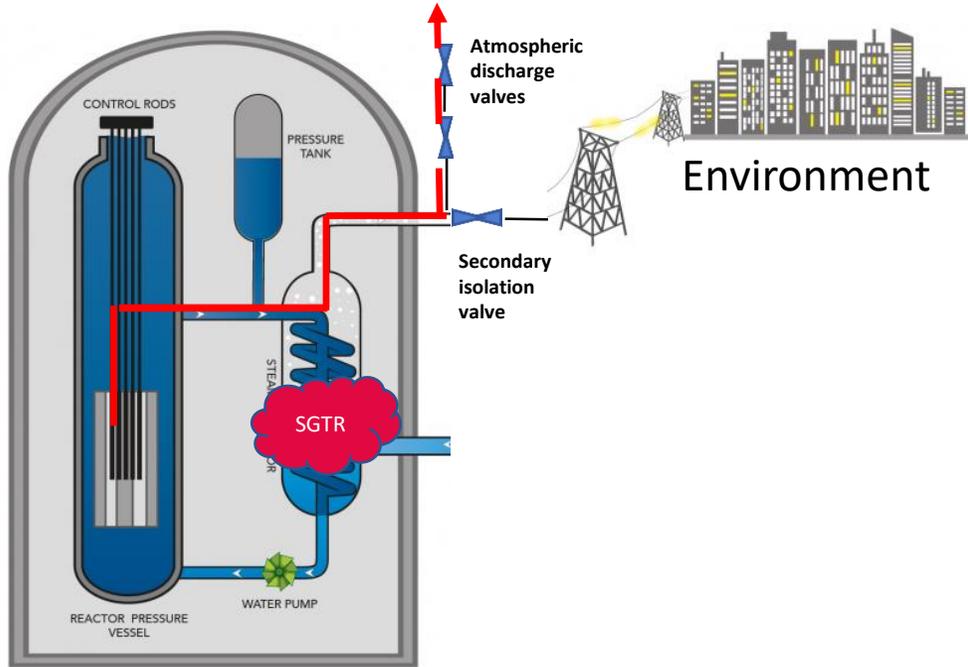
**Clad failure (n° failed rods? )**

Accurate evaluation of the number of fuel rods failure, **clad burst criterion**  
Revisit experimental database (w/o conservative assumptions)

**WP3.3**

**Fuel rod T/M behaviour**

Improve knowledge/models for fuel oxidation ( $U_4O_9$ ?  $U_3O_8$ ?)/HBS & associated **FP release**, clad/fuel large deformation...



## WP4.1

### FP release (from primary circuit)

Improve knowledge/models on FP (specially **iodine**) transport from primary circuit to environment through failed SG (**flashing?** **carry-over ?**) or containment)

## WP4.2

### FP (I) release from defective rods?

Radiological isotopic release from defective rods to the primary circuit and in particular **iodine spike (impact of fuel leaching ?)**

## WP4.3

### Fuel oxidation ? Clad failure ?

Secondary hydriding phenomena of defective fuel rod clads; **impact on clad failure**, impact of **fuel oxidation and fragmentation on FP (I) release**



# Structure – WP5 INNOV

## Develop technological innovations in the reduction of RC of DBA & DEC-A

- *Accelerating* integration of technological breakthroughs (providing *global and long-term vision*)
- Identifying and tackling *technological and scientific challenges*

T5.1 « Pro and Cons of innovative devices and management approaches »

### AMBITION

Best measurement at the right spot for better decisions.

### OBJECTIVES

Improvement of AMP :  
New instrumentation, optimized procedure, neural network

T5.2 « Innovative diagnosis tools and devices »

### AMBITION

In real time, collect, analyse, harvest values of all operating parameters plants to optimise their safety

### OBJECTIVES

Elaborate an expert system based on AI for identification of rod defects from RCS activity variation

T5.3 « E-ATF Enhanced accident tolerant fuel »

### AMBITION

Give all nuclear power plants benefit of a fuel that can even better withstand accidents.

### OBJECTIVES

Evaluate promising ATF (sensitivity analysis on relevant parameters): focus on Zr coated Cr clad and Cr doped & high density fuels





# Structure – WP6 DISSE



- The main actions of the WP6 for the project communication, dissemination, exploitation and educational and training are:
  - **Publications** in scientific journals and international conferences;
  - **Public project website** and **annual newsletter** with the main highlights of the project;
  - **Communication with International Organizations, Networks, Associations** (e.g. IAEA, OECD/NEA, ETSON, SNETP, NUGENIA, etc.) in order to update periodically about the project status and the main achievements;
  - **Creation of social networks accounts**;
  - **Set-up of an End-Users Group** (researchers from institutions not participating to the project, stakeholders, etc.);
  - Organization of **two international open workshops** to disseminate the main achievements and results of the project;
  - Organization of **training sessions** to involve effectively students and young researchers in the R2CA community;
  - Organization of **summer school** for knowledge dissemination and education and training of young researchers;
  - **Mobility program** for supporting doctoral dissertations, PhD students, post-docs and/or young researchers on the R2CA themes.





# Structure – WP6 DISSE



- The **Mobility program** for supporting doctoral dissertations, PhD students, post-docs and/or young researchers on the R2CA themes has been set up.
- Six mobility periods have been proposed**, starting from 2021 (delays due to the COVID-19 situation are to be considered)
  - Possibilities for **MSc students, PhD students and Postdocs**.
  - Total of **9-13 months** of mobility.
  - 8 institutions** involved.
- Incentivize the communication between participants to the program is one of the goals of the activity: it is being considered to organize a “Mobility program” event within the R2CA meetings.
- Still room for new mobility proposal.
- Possibility to update current status of mobility proposals due to the COVID-19 evolution.





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