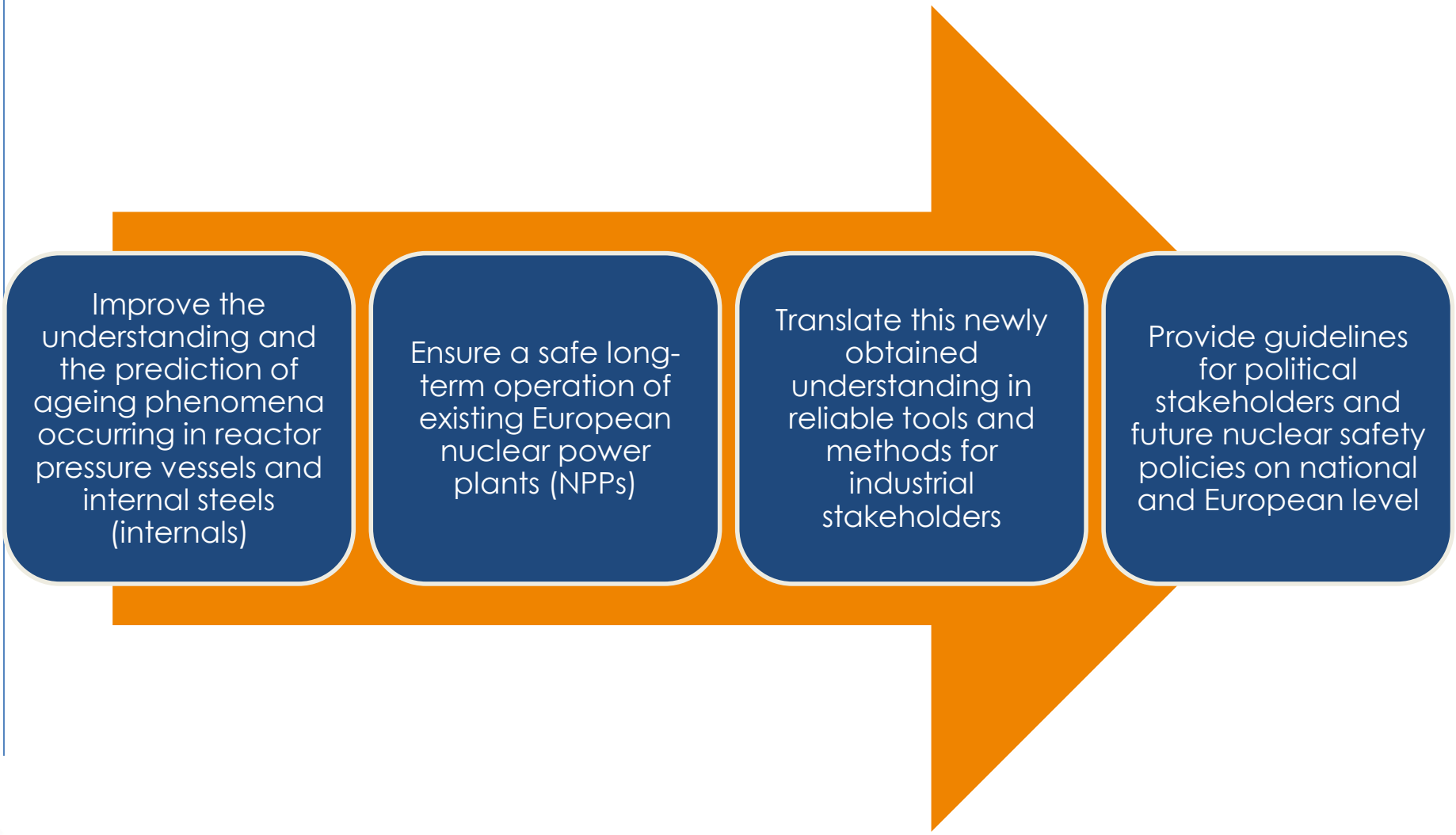
SOTERIA

Safe L**o**ng-**Ter**m operation of light water reactors based on **i**mproved understanding of radiation effects in nuclear structural m**a**terials.

Facts & figures

- An H2020 project awarded early 2015, started 1 September 2015
- 48 months
- 13,9 M€ budget with 4,9 M€ EU funding
- 24 partners from 10 countries
- Coordinated by CEA

SOTERIA Overall aim



Consortium: a complementary expertise

- SOTERIA brings together a total of 24 partners from 11 European countries.

- The most important players in the European nuclear field, all stakeholders involved in the life cycle of materials of nuclear interest:
  - Research institutes,
  - Manufacturers and suppliers,
  - Power plant operators.

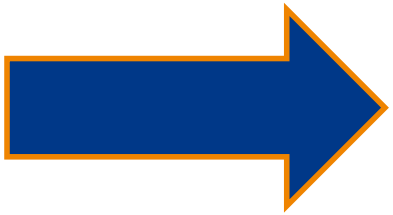
- Based on the partners' complementary technical and scientific expertise, SOTERIA proposes a *comprehensive research approach* in order to achieve its ambition and thereby significantly contribute to the safety of today's operating nuclear power plants.

SOTERIA specific objectives

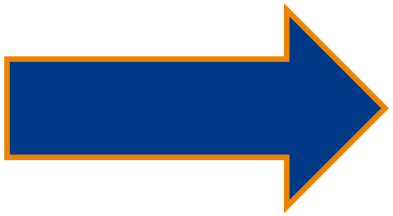
1. Carry out experiments assessing neutron flux and fluence effects on reactor pressure vessels and internal steels in pressurised water reactors
2. Evaluate the residual lifetime of reactor pressure vessels by taking into account metallurgical heterogeneities
3. Assess the effect of the chemical and radiation environment on the integrity of internal structural components
4. Develop models for the assessment of ageing mechanisms in RPV and internals and set of an integrated computer-based platform including the new modelling tools
5. communicate on the project achievements towards the nuclear engineering and research community in order to improve and harmonise the knowledge of ageing phenomena in nuclear power plants

Overall context

- The safety of nuclear energy has come back to the frontline of public debate in recent years through events (e.g. Fukushima Daiichi nuclear plant in 2011)



A priority for regulators and nuclear power providers to continue operating existing NPPs beyond the originally anticipated time frame by extending their service life



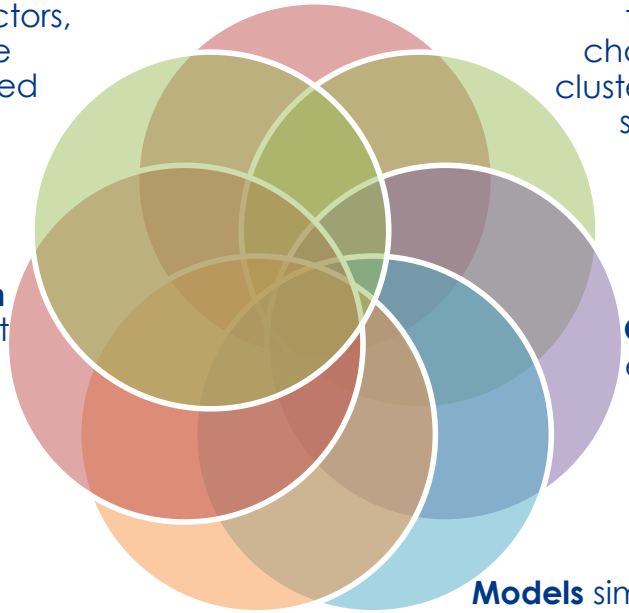
A need to guarantee a continuous safe long-term operation of existing power plants, it is a *sine qua non* to get an improved understanding of the role of ageing phenomena in reactor structures

SOTERIA Expected results

A deeper **understanding** of initial microstructure heterogeneities effects on fracture models and radiation-induced degradation of reactor internal steels

Guidelines for better use of modelling, material testing reactors, and surveillance data in the prediction of radiation-induced ageing phenomena

A **database** collecting the results from the experiments carried out in the project (microstructural characterisation such as defects cluster density/size/shape, chemical segregation, or mechanical properties)



A specific **industry-adapted version of the modelling platform** to support the evaluation of reactor safety margins, assessed in a user environment

Guidelines on the integration of experimental data in modelling tools

A modelling platform embedding improved ageing models for reactor structural components

Models simulating the evolution of the irradiated microstructure and the mechanical behaviour, taking into account flux effect to transfer radiation-induced phenomena observed in accelerated irradiation facilities towards structural components during service life

SOTERIA Starting point (I/II)

- ***Ageing management*** should follow a well-defined procedure with key aspects:
  - Identification of SSCs that are subject to ageing.
  - Performing analysis, comprising the understanding and modelling of the **main relevant ageing mechanisms** concerning each SSC (potential or encountered).
  - Setting up measures to justify integrity of each SSC based on codes & standards, regulations, specifications & guidelines and scientific knowledge of the ageing mechanisms.
  - Feedback of Operating Experience to improve overall process
- **From LONGLIFE** (mainly experimental project) :
  - Collection of significant data concerning microstructural and mechanical evolution under long-term exposure of RPV steels
  - Coupling of complementary techniques to characterise irradiated materials from nanometric to micrometric scales
  - Experimental observation of peculiarities, inter alia, with respect to:
    - *Flux effects* on radiation-induced microstructural features → transferability of experimental observation from MTR to operating conditions?
    - *Data scattering* in surveillance programme → origin of outliers, effect on trend curve derivation used in surveillance programme?

→Lack of modelling part to deepen understanding of observed phenomena

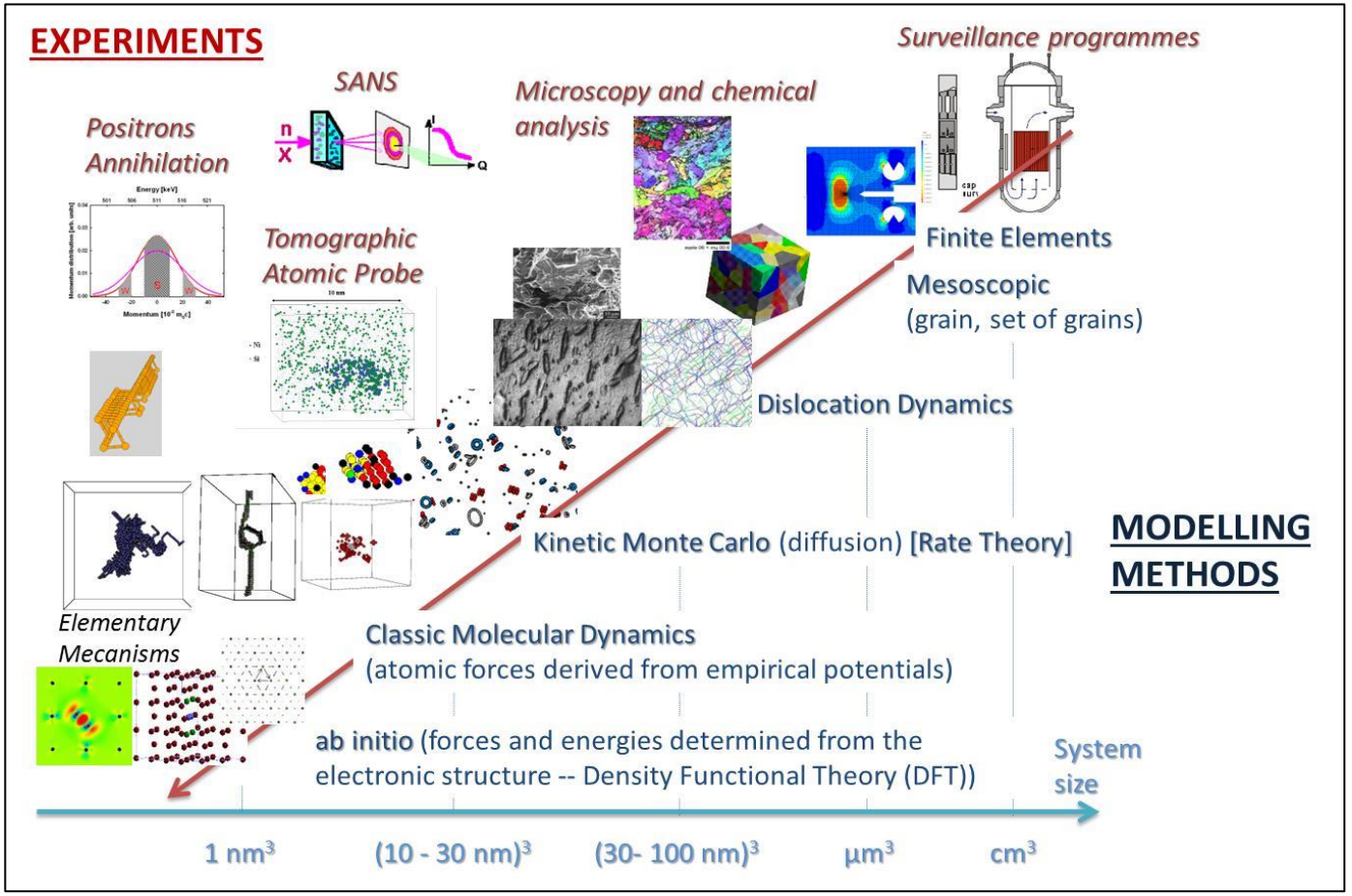
SOTERIA Starting point (II/II)

- **From PERFORM60 :**
  - Development of **multi-scale modelling tools** to predict RPV and internals radiation-induced evolution
  - Set-up of an integrated platform whose preliminary version was assessed by end-users from nuclear industry field
  - BUT remaining questions relative to LTO and in-service inspection issues:
    - *Flux effects* on radiation-induced microstructural features and mechanical properties not taken into account in the developed models validated often after accelerated irradiation/ageing process → transferability of prediction to operating conditions?
    - Bridging between models developed at different scales not complete
    - Limited comparison of mechanical models with experiments
    - IASCC issue not dealt with respect to operating conditions (chemical transients, GB influence…)

→Need smart experiments at appropriate scales to calibrate and validate the proposed models

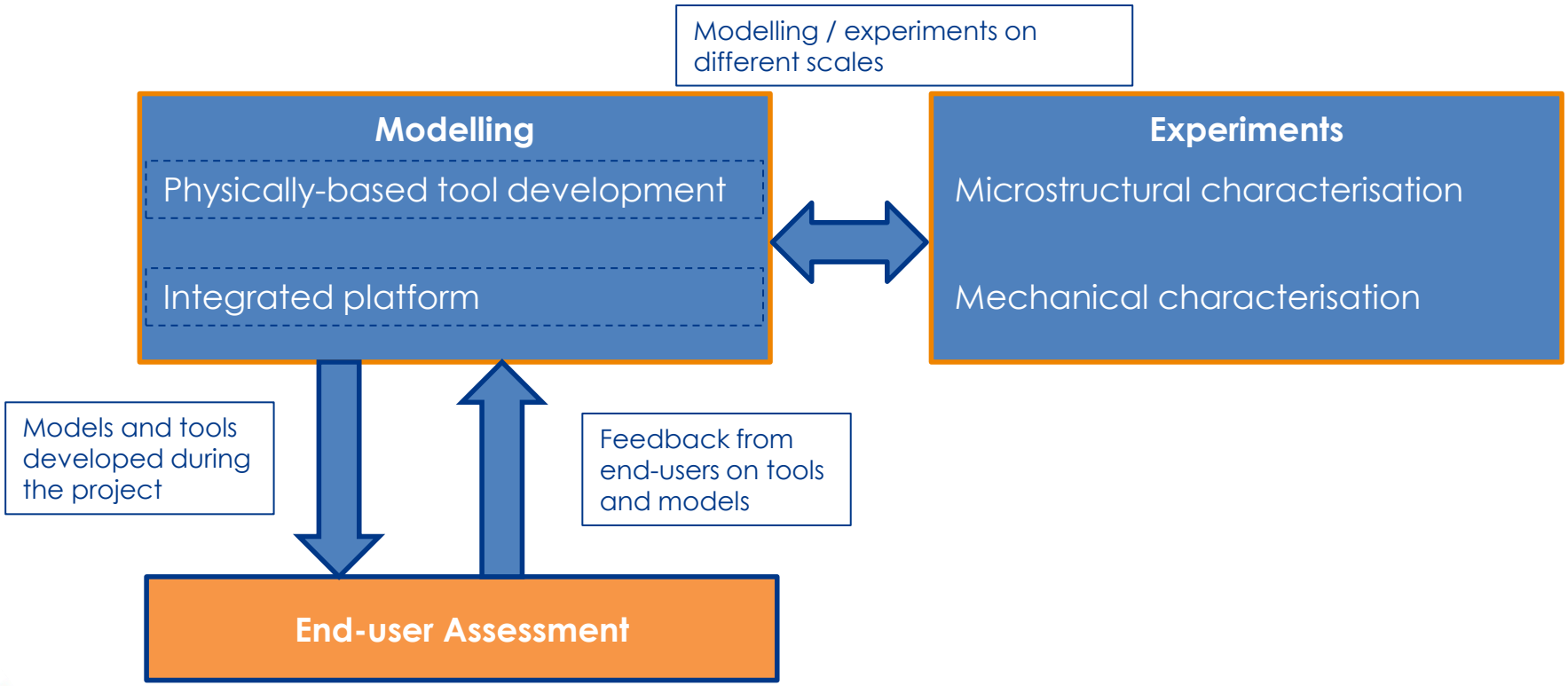
The SOTERIA approach (I/II)

- SOTERIA combines **multi-scale** modelling approach with smart experimental characterisations at appropriate scales

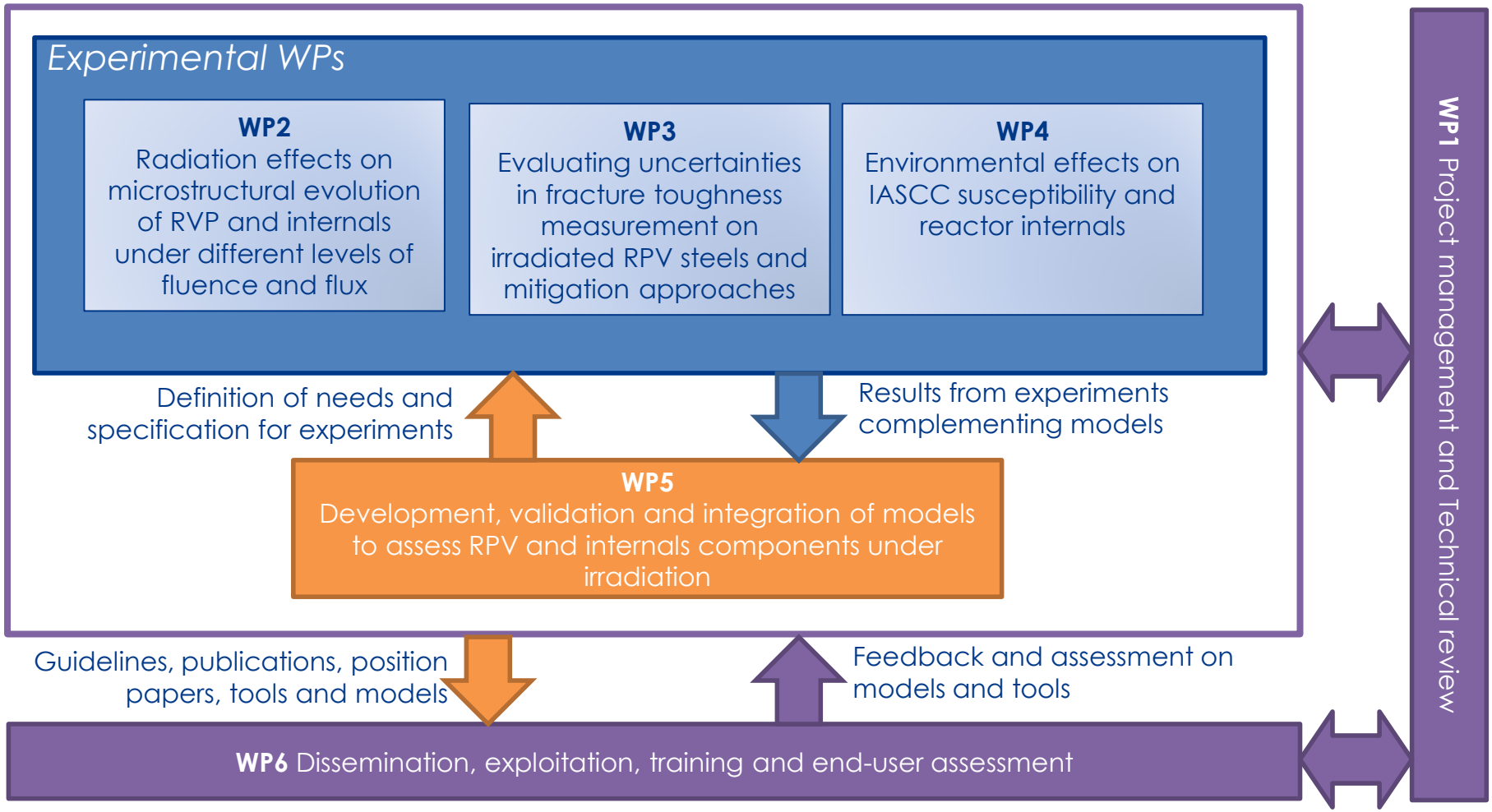


The SOTERIA approach (II/II)

- The approach will start from an end-user perspective, taking into account operators specific problems, through the setup of an end-user group from the project start.
- Set up of simulation-oriented experiments aiming to validate models at different scales:



Structure of the work plan



The SOTERIA User Group

- Purpose:
  - The SOTERIA consortium developers need the feedback of users
  - The SOTERIA proposed tools, models and approaches have to be assessed from the engineering point of view
  - Developed tools shall help utilities and their R&D supports in the understanding of the effect of irradiation and environment on RPV and its internals

- Benefits for User Group members:
  - Assess of SOTERIA End Products for RPV & Internals applications and
    - Become acquainted with models & tools
    - Propose specific applications and benchmarks
    - Test reference data and industrial applications
  - Provide reference data and industrial cases (RPV & Internals):
    - Models alloys and real materials
  - Provide feedback to the developers (Consortium)
  - Interact with the project and attend specific technical meetings, schools and workshops

Cooperations

NUGENIA
NUclear GENeration II & III Association

SNETP
Sustainable Nuclear Energy Technology Platform

IAEA
International Atomic Energy Agency

EPRI
ELECTRIC POWER RESEARCH INSTITUTE

CRIEPI
Central Research Institute of Electric Power Industry

ROSENERGOATOM

ЕНЕРГОАТОМ
ENERGOATOM

Advisors: the technical review committee

- The Technical Review Committee (TRC) consists of approved independent international experts in the fields of materials sciences, nuclear technology, and/or ageing management.

- The TRC will:
  - Provide annual independent feedback to the GA
  - Evaluate performance and evaluation of achievements of the project
  - Assess the relevance of training activities
  - Promote the project to non EU groups involved in the field and ensure the NUGENIA qualification of the deliverables

- The committee members have expertise on
  - Radiation effects
  - Mechanics of materials
  - Corrosion
  - Modelling

Foreseen events

- SOTERIA User Group:
  - 6 April 2016, during the NUGENIA Forum, Marseille, Palais du Pharo

- Objectives of the event:
  - Share with User Group members the objectives of SOTERIA
  - Inform the User Group on the main milestones (planning) of the project
  - Define together a working scope of the end-users
  - Establish a dedicated/specific working program with each user with the aim to establish a « win/win » collaboration scheme. This working program shall contain:
    - Planning of the engagement of the participant to perform a specific validation and benchmarking effort and providing well documented and comprehensive feedback on a part or the whole set of End-products
    - Description of the quality and quantity of the participant own data that could be provided to the project

The SOTERIA Consortium

The SOTERIA Contacts

The SOTERIA Project Coordinator

Christian ROBERTSON
CEA
christian.robertson@cea.fr

The SOTERIA Project Office

Elisabeth GRAF
ARTTIC
soteria-arttic@eurtd.eu

www.soteria-project.eu
Under construction

This project received funding under the Euratom research and training programme 2014-2018 under grant agreement N° 661913.