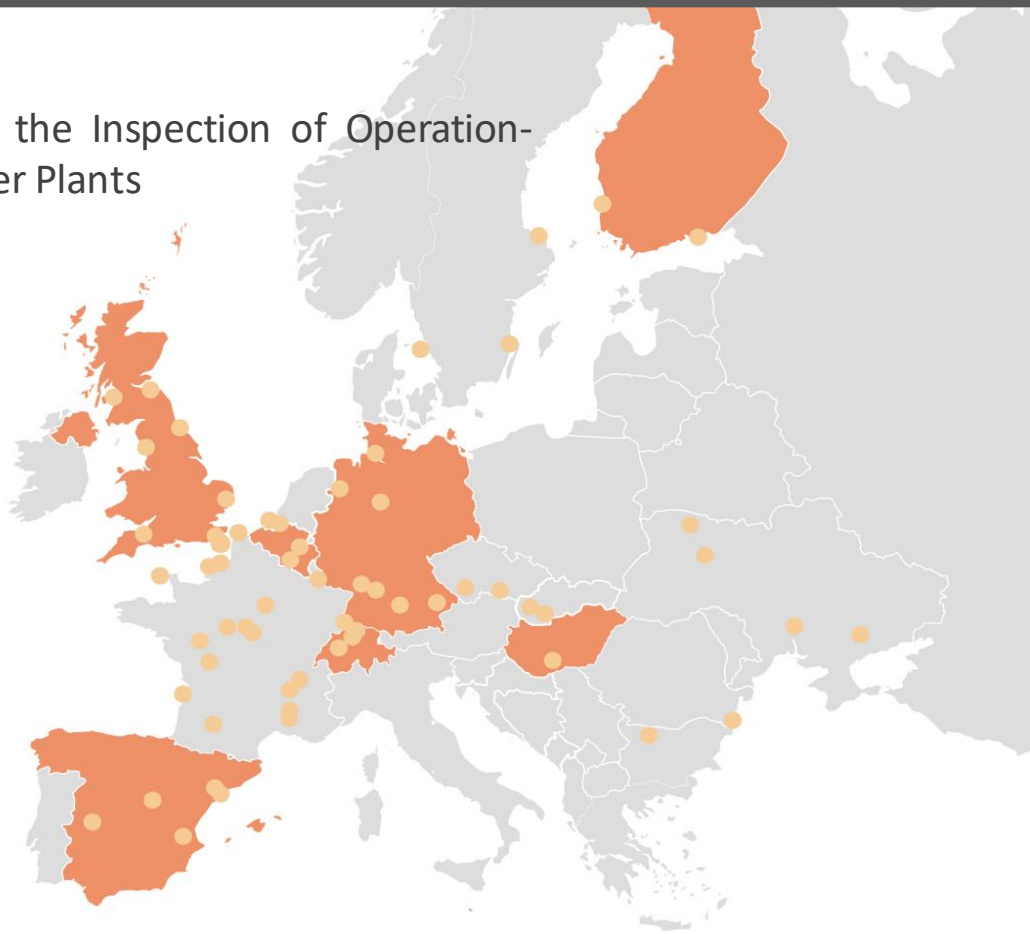
NOMAD

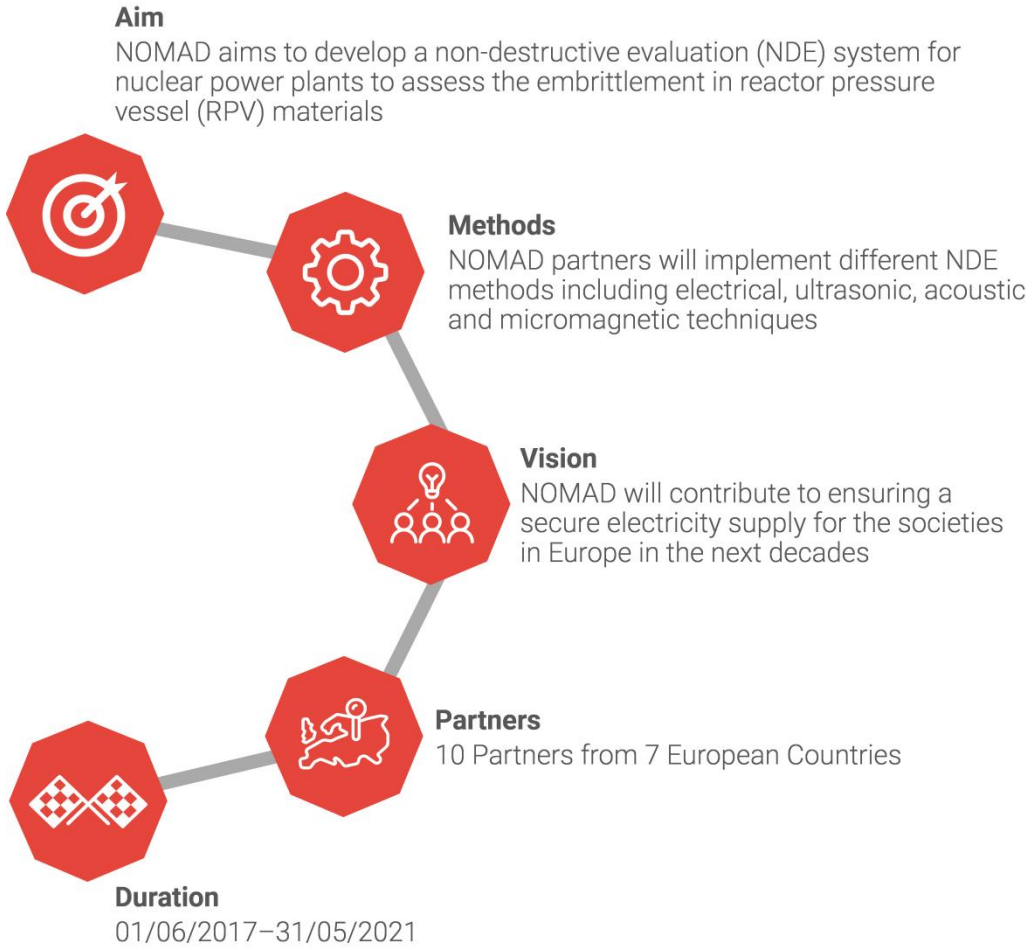
Nondestructive Evaluation (NDE) System for the Inspection of Operation-Induced Material Degradation in Nuclear Power Plants



www.nomad-horizon2020.eu

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 755330.

The project at a glance



Overview

(1) Motivation

(2) Goal / Idea / Vision

(3) Concept

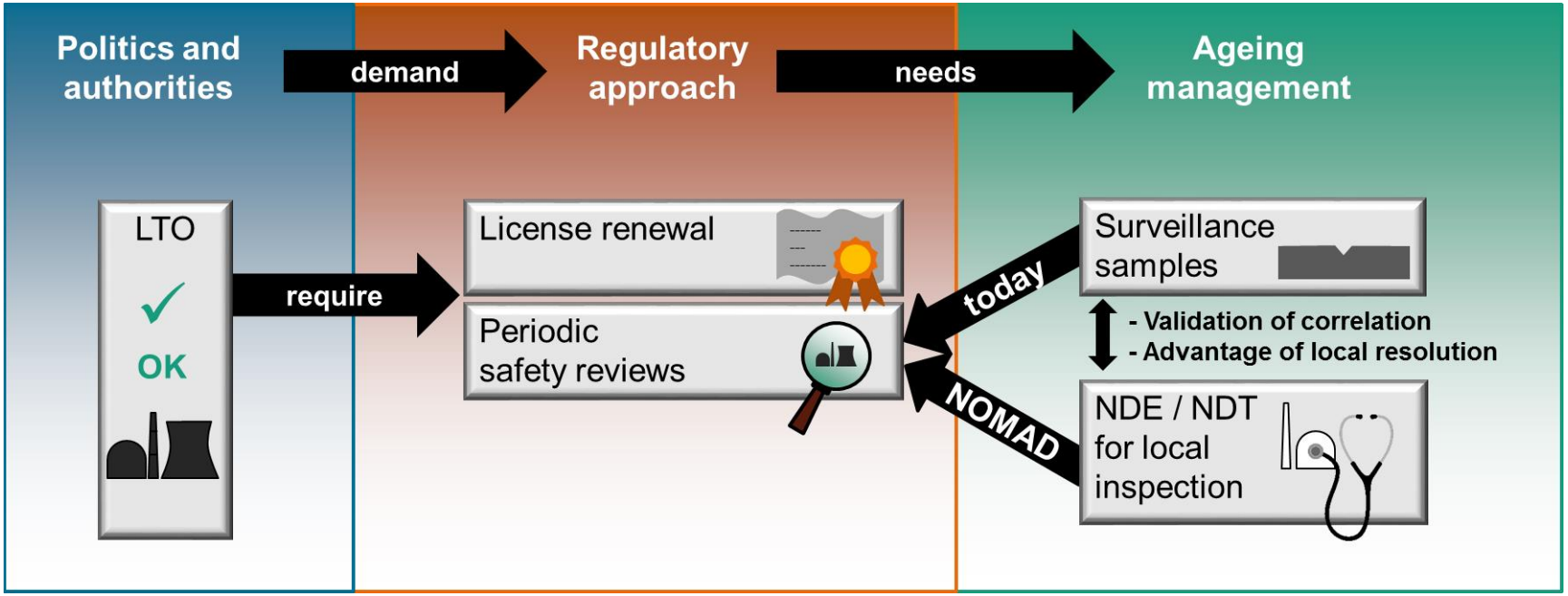
(4) Impact & Innovation

(5) Implementation

(6) Consortium

(7) Cooperation

(1) Motivation



Are data obtained by surveillance programs representative for the real state of the vessel taking into account material heterogeneities?

- Relation to EURATOM call NFRP-01: Improved safety design and operation of fission reactors

(2) Goal / Idea / Vision

Overall goal

- Demonstrate a hybrid (multi-method) NDE approach that can quantify material degradation (in terms of DBTT etc.) by measuring through cladding under field conditions.

Idea

- Identify a common, material-independent trend in NDE data of multiple methods as a function of degradation
- Use the fact that part of the RPV is not degraded since radiation is low to recalibrate (zero-offset) the NDE hybrid approach

Vision

- Use the difference between degraded and non-degraded condition of cladded material as degradation quantifier

(3) Concept

Development of an NDE system for the inspection of operation-induced material degradation in cladded RPV material containing possible microstructure heterogeneities (macro-segregated regions, voids, hydrogen flakes, etc.)

- Apply different NDE methods to test their capacity to evaluate the degradation
- Identify correlations between mechanical, microstructural and NDE parameters regarding degradation due to neutron irradiation on laboratory samples including quantification of reliability and uncertainty
- Extend database of neutron-irradiated materials and add NDE results
- Determine material properties through the cladding
- Adjust laboratory conditions to imitate inspections under real conditions
- Apply NDE methods in order to investigate if material properties obtained within the surveillance programs correspond to the actual state of the vessel (equivalence of radiation damage accumulation)

(4) Impact & Innovation

- Extending the existing database containing materials data, degradation parameters, progression of the mechanical properties → better understanding of the degradation phenomena
- Providing of an optional procedure to determine the degradation parameters additionally to the standardized methods used for the assessment of LTO
- Equivalence between destructive and nondestructive tests
- Application of NDE to real RPV material (with cladding), not only to Charpy samples
- Inspection of material inhomogeneity
- Combined NDE approach based on electrical methods, ultrasound and micromagnetics in a single software-based tool

(5) Implementation

Samples and destructive (reference) characterization
Properties of well-defined neutron-irradiated samples

↓

Correlations and trends between NDE and material properties
for laboratory samples

↓

Evaluation and selection of NDE methods
large samples, final evaluation at NDE method level, correlation with reference

↓

Data fusion and validation of the NDE tool
Empirical algorithm → application to and validation on cladded material

(5) Implementation – WP1

Provision and reference characterization of materials

WP1: Description and delivery of the sample sets (including cladded material) and irradiation conditions, sample provision, microstructure characterization and determination of the mechanical properties

- Sample set definition, degradation degree, irradiation preparation, microstructure features and mechanical properties
- Results of the reference materials and preparation irradiated materials
- Results of the cladded and laboratory materials

(5) Implementation – WP2

NDE methods development and evaluation

WP2: Nondestructive materials characterization (MC) and evaluation of the progression of the material properties

- NDE results on Charpy samples
- Individual non-destructive evaluation of embrittlement on cladded samples
- Effective individual NDE methods for the characterization of neutron irradiation-induced embrittlement of cladded material

(5) Implementation – WP3

NDE tool development

WP3: Advanced nondestructive evaluation tool for demonstration of materials characterization

- Method classification and database
- Comparison and selection of measurement techniques
- Demonstration of the tool for advanced non-destructive materials characterization

(5) Implementation – WP4

Application & Validation

WP4: Validation = proof of meeting the requirements regarding accuracy and performance; Application = demonstration and optimization of the developed NDE-tool (WP3) under realistic conditions

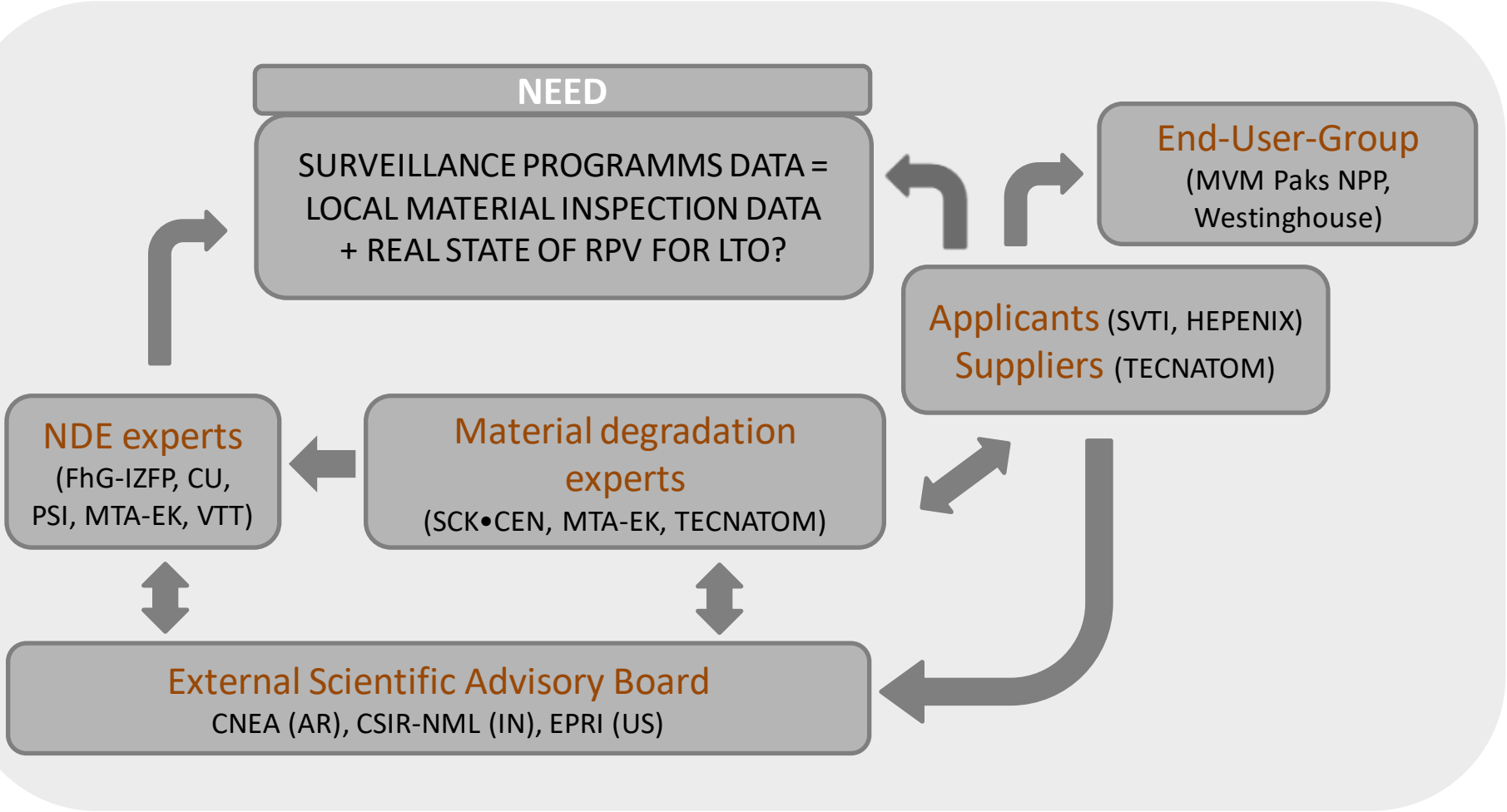
- Identification of essential parameters and test conditions
- Parametric study
- Demonstration and field recommendation

(5) Implementation – WP5

WP5: Management, Dissemination, Exploitation

- Implementation of management structures
  (Project Management Platform)
- Scientific monitoring and outreach to the public
  (Plan for the dissemination and exploitation of project results)
- External project communication and networking
  (External project website)
- IP Management and exploitation strategy
  (Exploitation workshop)
- Valorization of research outcomes

(6) Consortium & Work plan



(7) Cooperation

With important stakeholders

- NUGENIA (NUclear GENeration II & III Association)
- SNETP (Sustainable Nuclear Energy Technology Platform
- IAEA (International Atomic Energy Agency)

With related H2020 Euratom projects

- **ADVISE** (www.advise-h2020.eu)
  Advances Inspection of Complex Strutures
- **TeaM-Cables** (www.team-cables.eu)
  European Tools and Methodologies for an efficient ageing management of nuclear power plant Cables
- **SOTERIA** (www.soteria-project.eu)
  Safe long-term operation of light water reactors based on improved understanding of radiation effects in nuclear structural materials
- **INCEFA+** (www.incefaplus.unican.es)
  INcreasing safety in NPPs by Covering gaps in Environmental Fatigue Assessment
- **ATLASplus**
  Advanced Structural Integrity Assessment Tools for Safe Long Term Operation

(7) Cooperation - overview

Name	Duration	Coordinator	Related to	Synergies
TeaMCables European Tools and Methodologies for an efficient ageing management of nuclear power plant Cables	2017-2022	EDF, France	WP3 - Tool development	Development of an open access tool for condition diagnosis
ATLASplus Advanced Structural Integrity Assessment Tools for Safe Long Term Operation	2017-2021	VTT, Finland	WP3 - Tool development	Development of a tool for safe LTO
INCEFA+ INcreasing safety in NPPs by Covering gaps in Environmental Fatigue Assessment	2015-2020	WOOD, UK	WP4 - Application & Validation	Development of inspection techniques
SOTERIA Safe LTO of LWRs based on improved understanding of radiation effects in nuclear structural materials	2015-2019	CEA, France	WP1 - Sample sets, irradiation conditions, microstructure characterisation, mechanical properties	Radiation effects flux effect on embrittlement mechanismsInfluence of chemical and microstructural heterogeneities
ADVISE Advanced Inspection of Complex Structures	2017-2021	EDF, France	WP2 - Nondestructive materials characterisation and evaluation of the progression of the material properties	Nondestructive characterisation of complex (macro) structures

(7) Cooperation with ADVISE

http://www.advise-h2020.eu/

- Coordinated by EDF - Électricité de France SA (Andreas SCHUMM)
- Funded under the same H2020 EURATOM call NFRP-2016-2017-1 "Continually improving safety and reliability of Generation II and III reactors" as NOMAD
- The objective of ADVISE is to enhance – and in some cases to enable for the first time – the ultrasonic inspection of complex structures materials in order to improve confidence in and reliability of the inspection of Generation II and III reactors.
- Potential synergies for dissemination and training activities:
  - Joint technical workshops
  - Joint mid-term and/or final public workshops

NOMAD

Thank you for your attention!