EU-H2020- SHARE-Decommissioning
On-line Workshop, December 1-3, 2020

Group D
Session 6: Dismantling technologies

Session will start at 13:50, CET

Muhammad Junaid Chaudhry- KIT

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement nº 847626.

Group D
Session 6: Dismantling Technologies

Agenda

Dec. 1st Link teams 1st Plenary	**9:00 CET- 13:40: Plenary session (see general program) and switch to breakout sessions**		
Dec. 1st Link teams Dec 1st Group D	**International initiatives**		
	13:50	6A	Zoom on EPRI achievement et perspectives, by Rick Reid *(10min)*
	14:00	6B	NEA EGRRS "Expert Group on the Application of Robotic and Remote Systems in nuclear back-end", by Rustam Stolkin, UK National Centre for Nuclear Robotics *(10min)*
	14:10	6C	Presentation of EU-H2020 Project INNO4GRAPH by EDF *(10min)*
	14:20	6D	Presentation of EU-H2020 Project LD-Safe by Daniel ROULET, ONET ***(10min)***
	14:30	6E	EU-H2020 RoMaNS by Rustam Stolkin ***(10min)***
	14:40	6F	Presentation of first achievements from SHARE in this area + introduction to post it session, by Junaid Chaudhry, KIT
	15:00 – 16:50: Post it session by sub-thematic area		
	Link MURAL 60	60	Robots and remote controlled tools for dismantling
	Link MURAL 59	59	Demolition of large, reinforced concrete structures

Group D
Session 6: Dismantling Technologies

Agenda

Dec 2d	**9:00- 12:00: Post it session by sub-thematic area**		
Link teams Dec 2d Group D	Link MURAL 58	58	Management (characterization, decontamination, removal) of radiological embedded elements)
	Link MURAL 71	71	Mechanical Radioactive material decontamination
	Link MURAL 72	72	Electrochemical Radioactive material decontamination
	Link MURAL 57	57	In situ decontamination of building surface (concrete)
	12:00- 13-00: Lunch Break		
	13:00- 16:50: Post it session by sub-thematic area		
	Link MURAL 54	51	Segmentation of large irradiated metallic components (reactor vessel internals, etc.)
	Link MURAL 51	54	Segmentation of large surface-contaminated components
	Link MURAL 52	52	Handling, segregation and loading of segmented elements and secondary waste
	Link MURAL 55	55	Dismantling of surface-contaminated piping and small components
	Link MURAL 56	56	Segmentation of interior concrete structures (e.g., bioshield)

Overview of Select EPRI Decommissioning R&D Projects

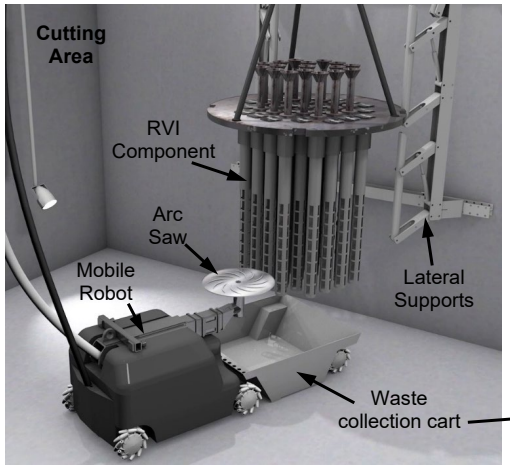
Richard Reid, PhD
Technical Executive

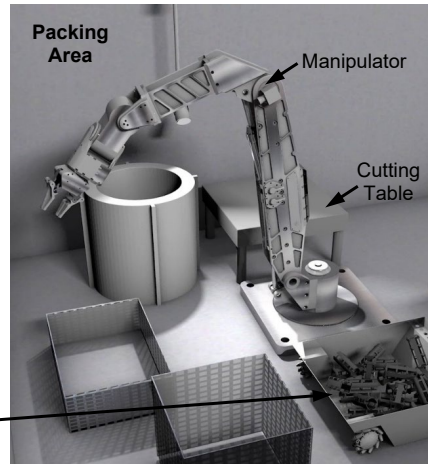
SHARE Workshop
01 December 2020

Completed Project
Conceptual Design for an Improved Reactor Internals Segmentation System

Reactor Internals Segmentation System Conceptual Design

- Completely new approach to reactor internals segmentation
- Time and Motion studies suggest 60% time-savings
  - Potential cost-savings more than $10M
- Based on use of existing equipment
- Technical report includes specifications for all system components
- Service providers consulted in design development
- Technical report publicly available





Conceptual Design of System for Reactor Vessel Internals Segmentation, 3002018418

Completed Project
Application of System Automation to Radiological Characterization

Automation of Radiological Characterization

- Radiological surveys intentionally follow a prescribed protocol and can readily be automated
- System Development
  - Confirmed no suitable systems existed
  - Developed system specifications
  - Evaluated system components
  - Assembled prototype system
- Successful demonstration at the Kewaunee October 2019
- Technical report is publicly available

Prototype Autonomous Site Characterization System

Design and Demonstration of an Autonomous System for Radiological Characterization, 3002018420

Summary:
EPRI Autonomous Site Characterization Vehicle Demonstration

- System able to perform radiation surveys of building interior and outdoor land areas autonomously
  - Nuclide identification rather than simply gross gamma
- Building Floor Surveys:
  - System achieved the required detection sensitivity for site characterization surveys when background levels are relatively low
- Open Land Surveys:
  - The EPRI system achieved the Final Status Survey detection sensitivity requirement for Cs-137
  - Demonstrates that in backgrounds similar to those surveyed at Kewaunee, the system has the potential for use in Final Status Surveys
- More detailed video available on YouTube at https://youtu.be/4R6QPVqEcOo

On-Going Project
Development of Training Modules

Development of Training Modules
Overview

- Objective: to develop training materials covering a broad range of decommissioning topics
  - Training materials will be developed to support both classroom and computer-based training (CBT) approaches
- Background:
  - The International Atomic Energy Agency (IAEA), the U.S. Department of Energy (DOE) and other groups provide guidance documents and training on decommissioning
    - These materials are general to any type of nuclear facility (that is, not specific to commercial power reactors)
    - Tend to be at an overview level
  - EPRI has guidance documents on critical decommissioning topics, but companion training materials are not available

Development of Training Modules

Training Topics

General overview of the decommissioning process
Decommissioning planning, including cost estimation
Transition to decommissioning
Industrial and radiological safety
Site characterization, including historical site assessment and an overview of the MARSSIM protocol
Management of radiological and non-radiological waste
Dismantlement of large components
Mechanical and chemical decontamination techniques
General commodity removal and building demolition
Site remediation and release

Utilities may Suggest Additional Topics

Development of Training Modules
Content and Delivery

EPRI | U™

- Materials for each module will include
  - Guidebook with practical examples
  - Instructor's guide
  - Slides, videos or other instructional media
  - Exams to assess knowledge mastery
- Materials will be developed for both instructor-led classroom training, and computer-based training (CBT) to be provided via the existing EPRI-U platform
- Materials will be developed to support a nominal training session duration of four hours for each module

Development of Training Modules
Schedule

Activity Description	Date
Develop outline for module 1, Decommissioning Process Overview	February 2021
Prepare guidebook, instructor's guide, training media and exam questions for module 1	June 2021
Develop CBT content for module 1	August 2021
Trial run of CBT for module 1	September 2021
Revise, finalize and release CBT for module 1	November 2021
Complete materials for additional modules	Annually from 2022; 1-2 per year

Other Projects Recently Started

- Best Practices for Decontamination, Reuse and Recycle of Contaminated Metal and Concrete
  - Review of experience with decontamination of materials for recycle and/or reuse
  - Results of will be presented as lessons learned to identify best practices, and will be evaluated to identify technology gaps
- Evaluation of Decommissioning of Advanced Reactors
  - Evaluate dismantlement and waste management of three prototype advanced reactors
    - Molten Salt
    - TRISO fuel/graphite moderated
    - One other TBD
  - Project funded by U.S. DOE

Together…Shaping the Future of Electricity

NEA EGRRS

EXPERT GROUP ON APPLICATION OF ROBOTIC AND REMOTE SYSTEMS IN THE NUCLEAR BACK-END

Martin BRANDAUER

RWMD Division, NEA

EU-H2020- SHARE-Decommissioning
On-line Workshop, December 1-3, 2020

EGRRS Status Overview

- Mandate: 15 November 2019 – 14 November 2021
- Deliverable: Draft Report expected by the end of 2021 (publication in 2022)
- Members: 49 nominations from 13 countries and the EC

  IAEA as observer

GOALS & OBJECTIVES

EGRRS work is addressed in two stages:

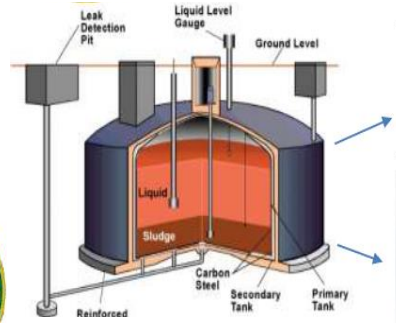
1. focus on a **global overview of the situation in RRS application**, identification and analysis of factors, influencing the RRS application.
2. to **develop and publish recommendations**. Necessary standards and approaches will be developed and proposed for implementation to all interested parties.

While:

- **promote the exchange of information** on RRS;
- **study the main and emerging challenges** concerning the RRS application;
- **develop recommendations** to members on establishing a framework, allowing the wider application of RRS in the nuclear back-end area; **support the development and implementation of common procedures**, rules, standards, to facilitate the application of RRS;

Scope of the Group (Examples)

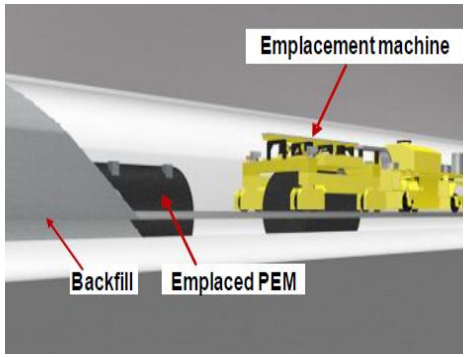
Characterisation & Inspection

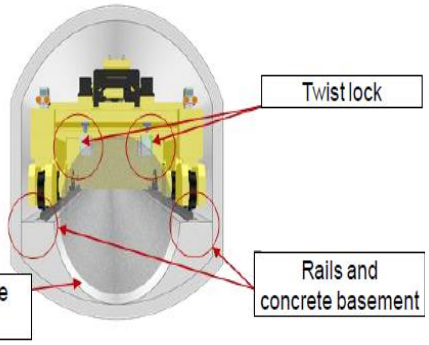


Manipulation

For example AI controlled cutting or Nuclear waste sorting & Conditioning

Waste Logistics and Transportation





(Source: NUMO (2012), NUMO-TR-12-04)

For example exoskeletal application in the nuclear area

Human/Machine Interface

(Source: https://www.nikkei.com/article/DGXNASDG1800V_Y2A011C1CR0000/)

EGRRS Development

- Creation of three **ad hoc groups** to explore the main topics of concern identified in the kick-off meeting 09 – 10 December 2019:
  - ➢ The **Status** of current technologies and usage*
  - ➢ **Cost-Benefit** analysis
  - ➢ **Barriers** and impediments of their application

EGRRS Matrix

	Topics				
	Technical, Safety and Environmental	**Economical**	**Societal**	**Legal and Regulator Framework**	**Organizational and Structural Framework**
Systematic description of the status Challenges	• First of the kind application challenge • Transference from human to AI • Multi-purpose use/ cost-efficiency • Grading of autonomy • Application bringing together end user and developer • Standardization • Foot-print of robotic application / secondary waste • Maintenance and intervention concepts • Adapting existing technologies • Standard approaches (e.g. grinding) • Tracking of waste streams	• First of the kind application challenge • Multi-purpose use/ cost-efficiency • Societal and economical benefit from radiation protection and other hazards • Business case (commercialization) • Unknown AI challenge • Identification of investment needs • Justification of investments • Use of the RRS in routine activity -> maturity • Opportunities for new economical activities (services)	• Transference from human to AI • Educational factor • Societal and economical benefit from radiation protection and other hazards • Lack of willingness of technology in the back-end (traditions, ageing work force) • Encouragement of students/young professionals in back-end (WM) activities • Perception of replacement of work place (high-value jobs being created at the same time) • Improve public perception of nuclear/ AI (the unknown) • Distinguish social and human challenges (the why question) / collective and individual view point • Liability associated with automation, AI, etc.	• Grading of autonomy to ease the application • Gap between the regulatory framework and the used/existing technology • Way to implement innovation • Standards • Not to make it more strict as necessary • Benchmarking of technology/ reproduction of results/ technology validation -> mechanism of how to address this! • Relevant state policy / provision • Certification • Specific Radiation Hardness Assurance process	• Educational factor • Lack of recommendation where to use robots and what point we need to start considering robots • Organizational changes implied by the applications of RRS • How to minimizing gap between end user and developer • Inform benefits and costs • Keep R&D realistic and optimized • Adapted existing practices for influencing the back-end activity • Use developments in other areas • Retrain of workforce allowing acceptance and perspectives for people decommissioning their own workspace • Collaborative work of different teams (technical, economics, etc.) in the organization and work together on a combined goal reaching • Use developments in other areas identifying synergies with other applications domains
Cross-cutting issues	• Match what is available and existing applications (Gap-analysis); Possible tool: survey • Refocus of the drives: to consider all the columns; focus on challenge, not the technology • Economic, safety, technological maturity • Clear definitions of what is being talked about (e.g. robotics/co-botics) • Keep the whole waste stream in mind (end-product) • Health and safety of workers • Promote modularity			• Guidance and principals of usage of RRS • User RRS in the whole fuel cycle process (including new builds) • In nuclear economical focus, which is not the case in other areas • Bottom-up push development: end-user pushing developers (instead the other way around) • Playbook would be useful tool for member states (feasible) • Diversity in the field	

- Two surveys for Barriers and Status (draft) have been created, while **Barriers Survey** is ongoing:

  https://ec.europa.eu/eusurvey/runner/EGRRSBarriers
  Password: **Oecd202*** (replies ASAP would be very much appreciated)
- The **Status Survey** (draft ready) will follow soon.

More Information

The new NEA-Webpage includes an **EGRRS page**:

https://www.oecd-nea.org/jcms/pl_25235/expert-group-on-the-application-of-robotics-and-remote-systems-in-the-nuclear-back-end-egrrs (mandate can be found here)

EGRRS-1 2020 Plenary Meeting is being planed. It will be on the **07 December from 1-6 pm CET**. Participation requires an official nomination by the national delegation of the NEA Member State.

For more information please contact:

martin.brandauer@oecd-nea.org

Registration and logistics:

Lisa.SMADJA@oecd-nea.org

Thank you for your attention.

EGRRS Kick-off Meeting, 09 – 10 December 2019

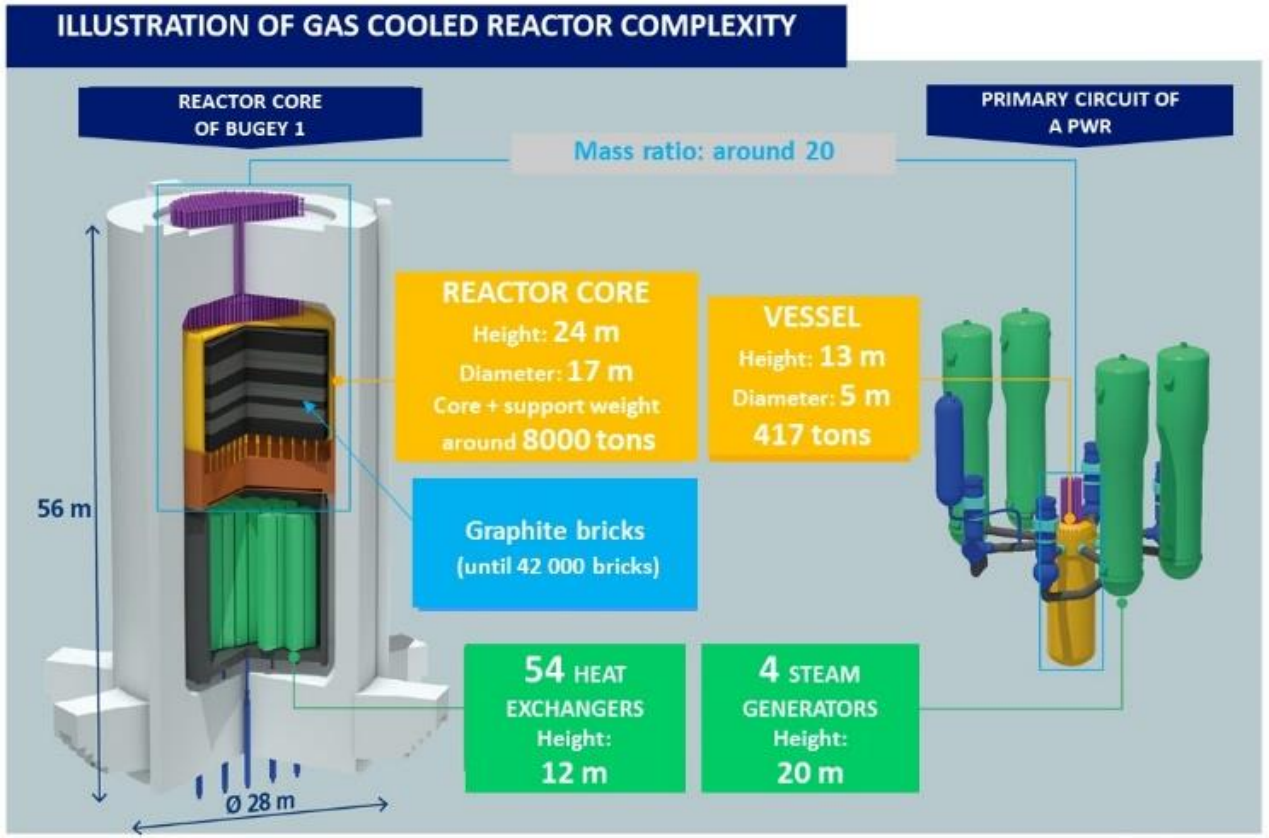
Questions about this document can be addressed to:
Dr. Martin BRANDAUER
Tel.: +33 (0)1 73 21 28 52
martin.brandauer@oecd-nea.org

A SHORT OVERVIEW OF EU H2020 INNO4GRAPH PROJECT

EU H2020 SHARE PROJECT WORKSHOP - 01/12/2020

INTRODUCTION : THE TECHNOLOGICAL CHALLENGE OF GRAPHITE REACTORS DISMANTLING

- More than 15 years of international practices on 4 different reactors technologies → **Learning : all the reactors are not equivalent in terms of dismantling ;**
- It has been proved that **PWR can be dismantled in 15 years** ;
- **Operations are a lot more complex for graphite reactors,** because of their design, their size and their compacity



International benchmark :

→ Most of graphite reactors will be dismantled remotely **under air.**

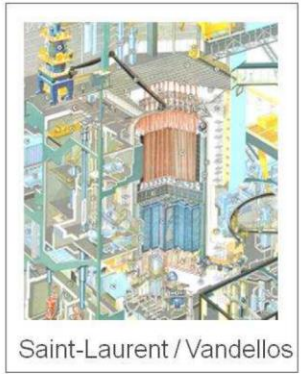
→ **A limited feedback : 2 small graphite reactors have been dismantled worldwide** (WAGR in UK and Fort Saint Vrain in USA with a size scale factor of 10 compared to RBMK or EDF's ones)

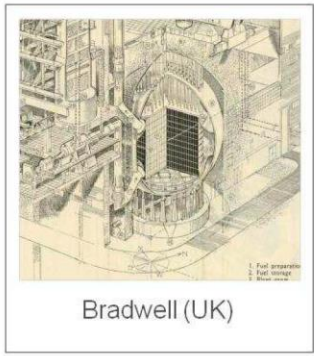
→ At the European scale, possible simultaneity of the operations between France, Lituania and UK. Many technical challenges are also the same between these countries, Spain and Italia and can be mutualized.

CONTEXT: COLLABORATIONS AROUND GRAPHITE REACTORS

Many similarities in the design of graphite reactors :

- Large thickness of concrete, including metal and cables to be cut
- Thousand of graphite bricks to retrieve
- Complex internal structures

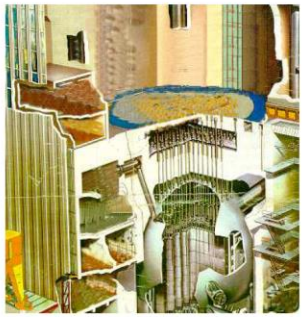

Saint-Laurent / Vandellos

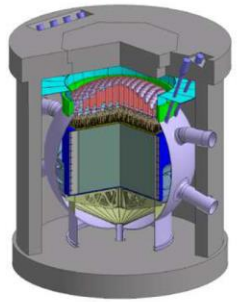

Bradwell (UK)

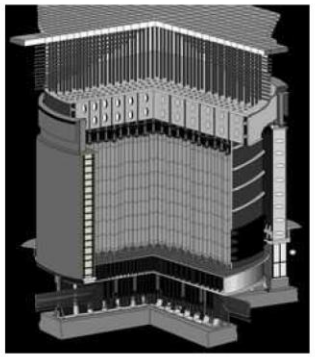

Latina (Italy)

Common issues to solve thanks to mutualized technological development programs :

- Pre-stressed concrete cutting (until 9 meter thick)
- Until 20 cm thick metallic structures cutting
- Graphite dust management
- Deployment of remote tools on large distance (until 30 meters)

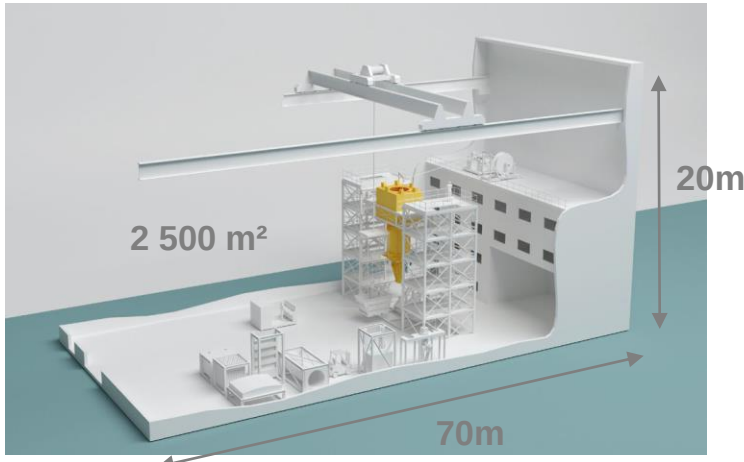

CHINON A2 (France)


TOKAI MURA 1 (Japan)


RBMK (Russia)

The EDF's industrial demonstrator facility (under construction, operational in 2022) and Inno4graph project :

an opportunity to test in the same place for different European graphite reactor dismantling project



INNO4GRAPH PROJECT : *INNOvative tools FOR dismantling of GRAPHite moderated nuclear reactors*

A collaborative project funded by the European Commission (**3 011 060 € for a total budget of 3 813 658 €**)

European Commission | Horizon 2020 European Union funding for Research & Innovation

Supported by Nugenia (SNETP) and Nuclear Valley :

SNETP Sustainable Nuclear Energy Technology Platform

NUCLEAR Valley FEDERER LES ENERGIES

Partners :

EDF

GRAPHITECH

enresa

cyclife digital solutions GROUPE EDF

ARTTIC a PNO international management services company

cea

SOGIN

LEI

Westinghouse

tecnatom

CIRTEN Consorzio Interuniversitario per la Ricerca TEcnologica Nucleare Inter-University Consortium for Nuclear Technological Research

ANSALDO NUCLEARE Ansaldo Energia Group

MANCHESTER 1824 The University of Manchester

End users :

NDA Nuclear Decommissioning Authority

AE

EDF

OBJECTIVES AND EXPECTED RESULTS

The INNO4GRAPH project has set up five scientific and technical objectives:

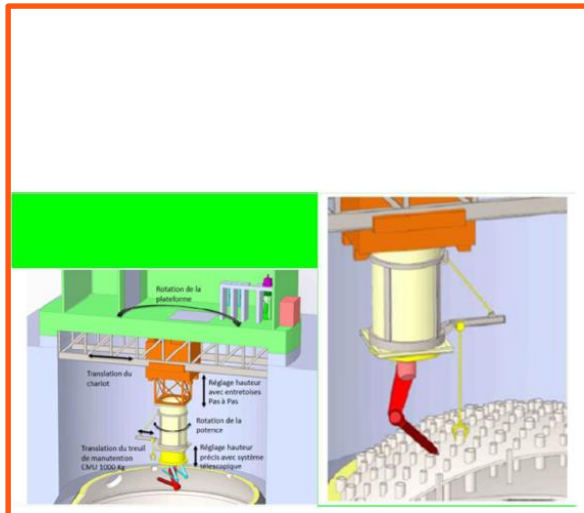
OB1: Develop a multi-criteria grid analysis tool, which takes into account dismantling operators' needs and regulatory requirements, to support the choice between different dismantling scenarios

OB2: Develop and test digital and physical tools and models to characterise graphite properties after its exploitation as moderator in nuclear reactors and also forecast its behavior during dismantling operations

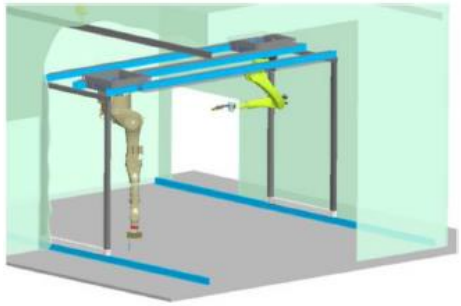
OB3: Develop and test tools for the extraction of graphite bricks during dismantling (retrieval, handling, conditioning…)

OB4: Develop a set of tools to evaluate, optimize and qualify operational dismantling tools and the final scenario

OB5: Generate new 3D models to evaluate different graphite reactors dismantling scenarios in terms of costs and safety

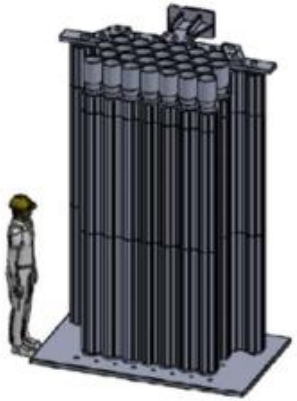


Deployment system of graphite retrieval tools

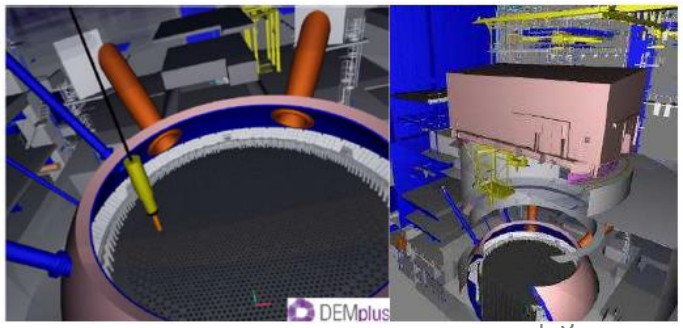


Multi-joint manipulator

LASER cutting



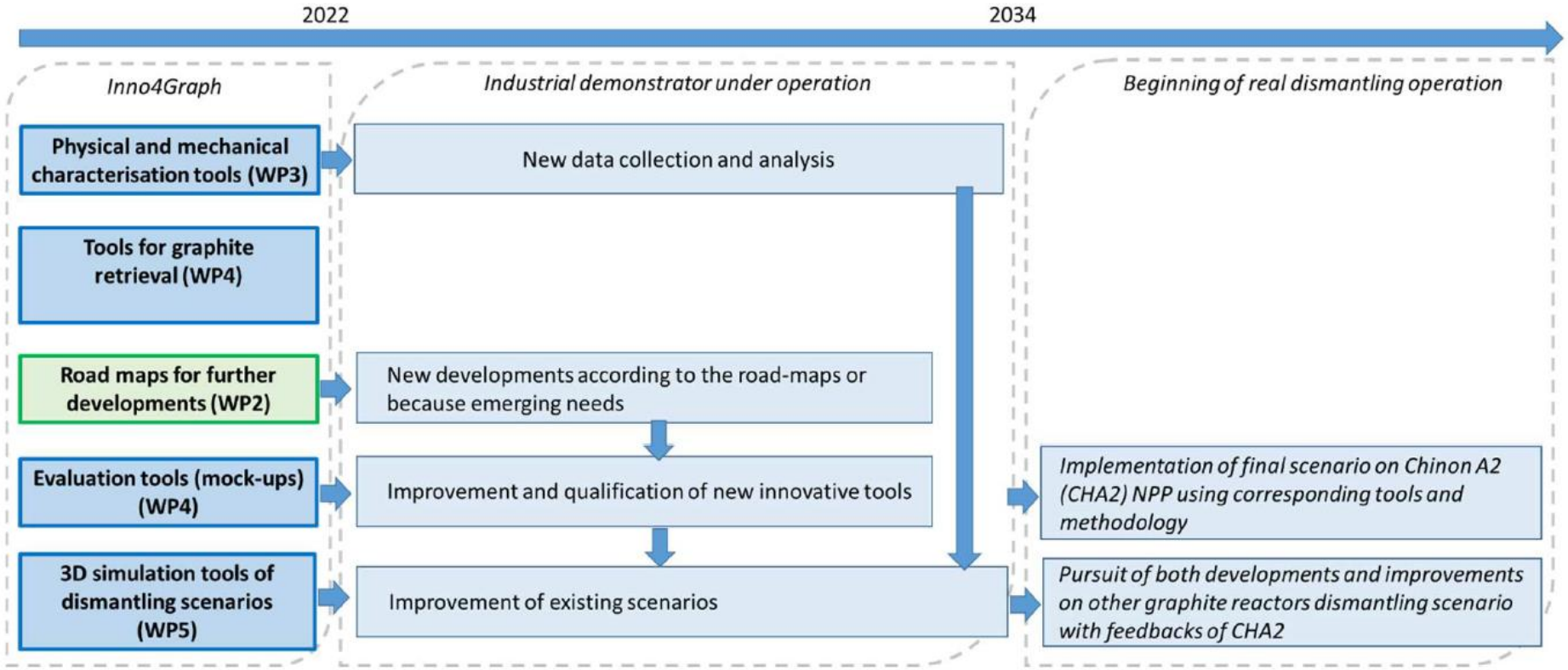
Mock-up of graphite stack



Numerical models for dismantling operation simulation

CONCLUSIONS AND PERSPECTIVES

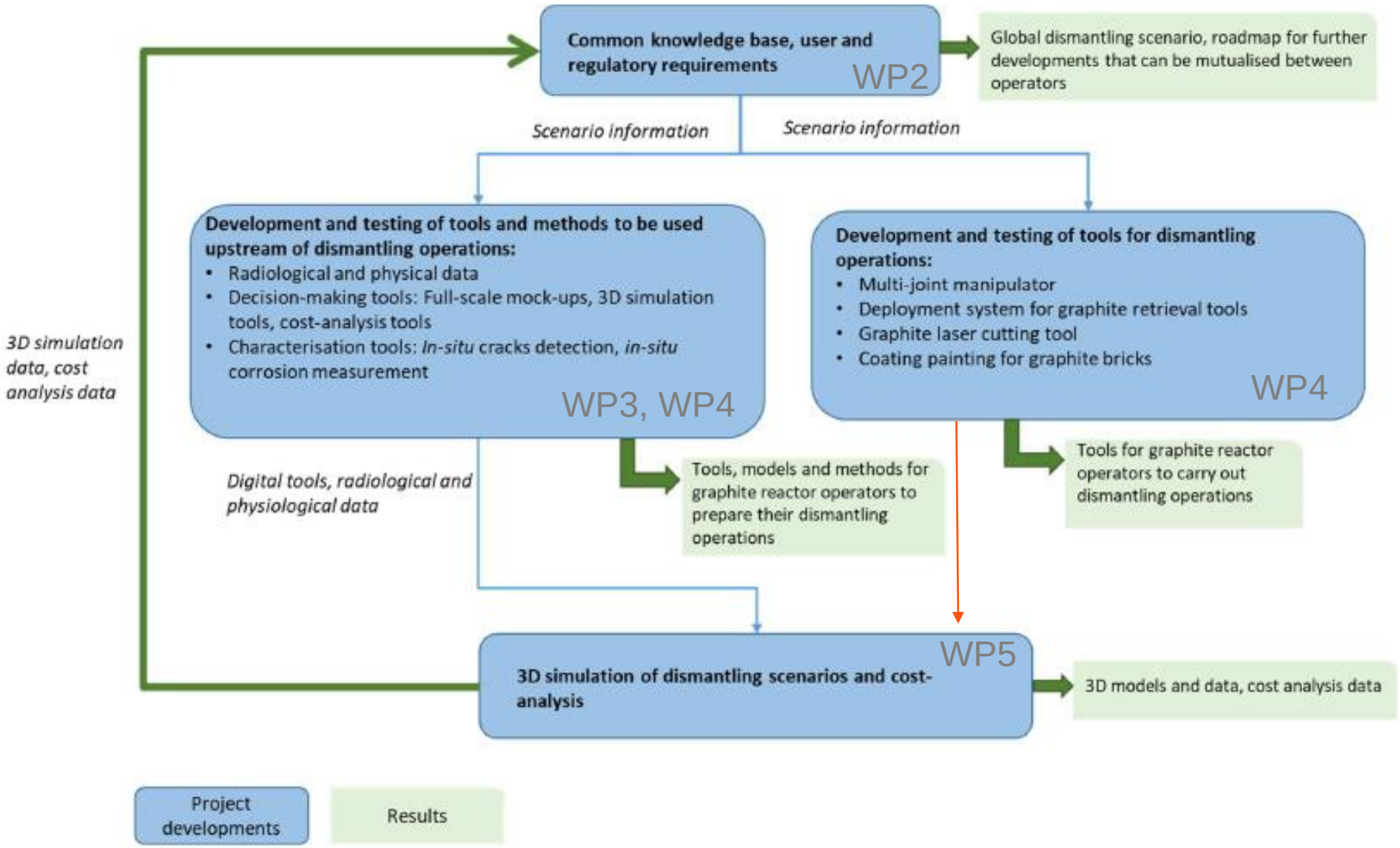
INNO4GRAPH : a first step to allow graphite reactor dismantling operations to benefit from innovative and digital solutions to be more successful and more efficient



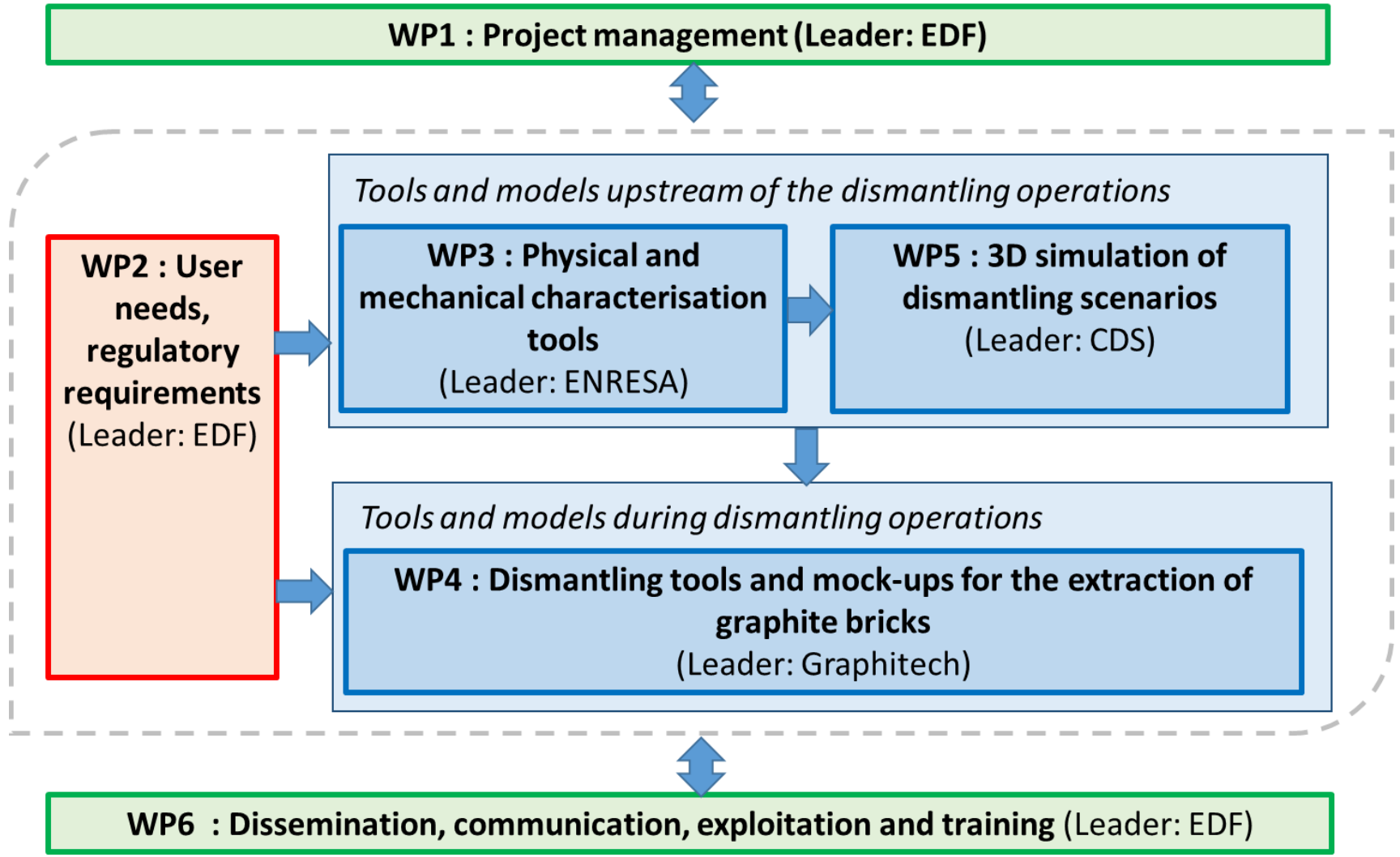
INNO4GRAPH : a collaborative approach to be continued on other issues than graphite retrieval and management

ANNEXES

CONCEPT OF THE PROJECT



WORK BREAKDOWN STRUCTURE

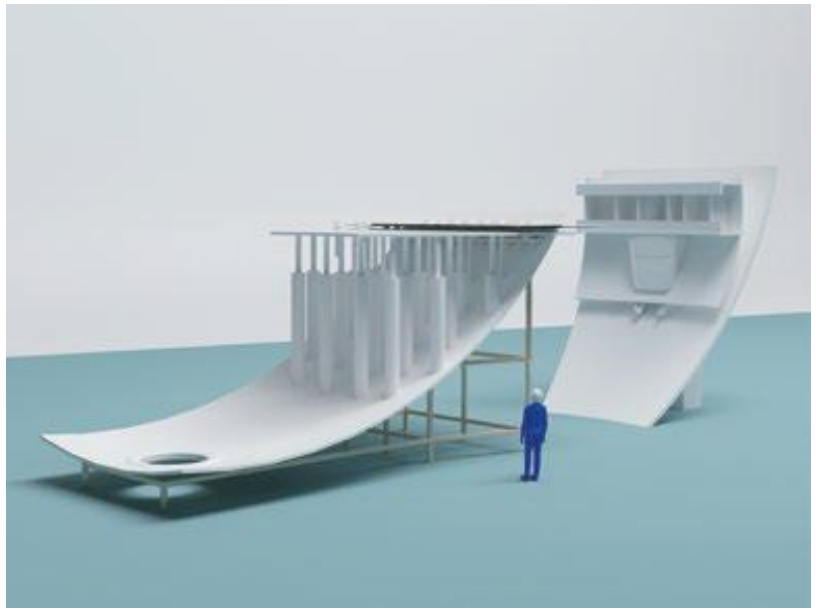


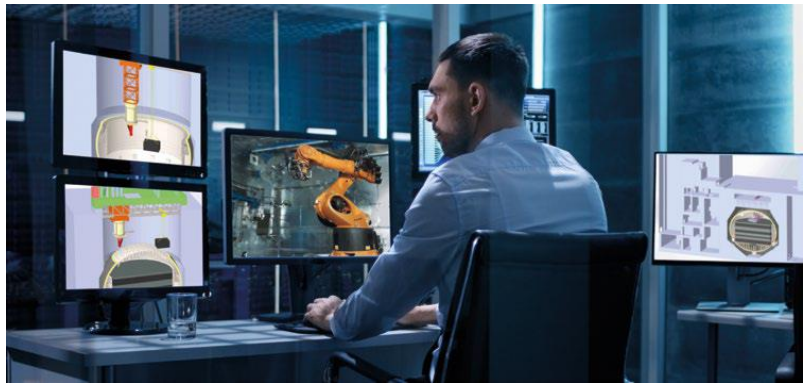
THE OBJECTIVES OF GRAPHITE INDUSTRIAL DEMONSTRATOR

The objectives of the Industrial Graphite Demonstrator are:

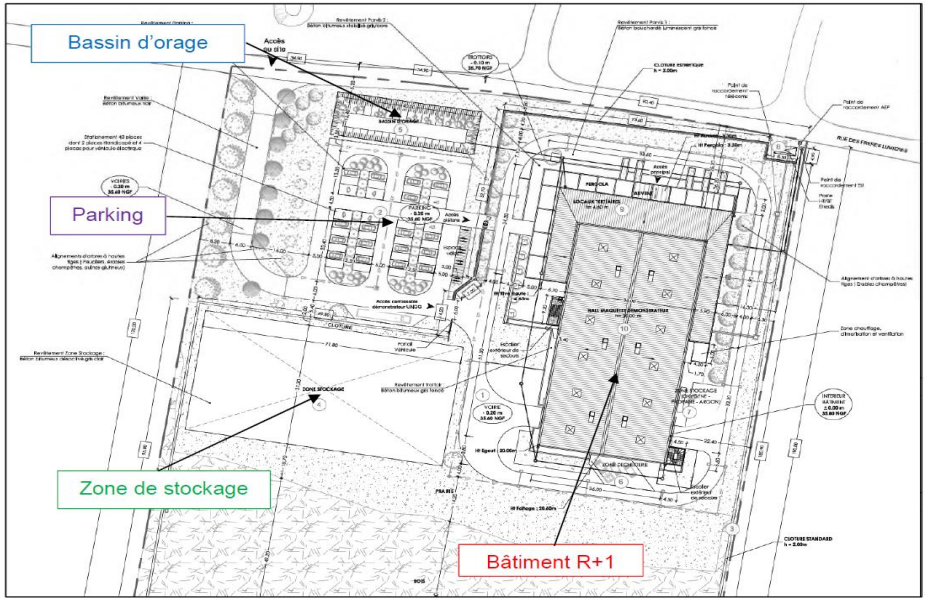
- To develop and qualify the remotely operated tools that will be used for the future dismantling ;
- To improve safety by securing the schedule of dismantling operations thanks to full-scale preliminary tests and an optimized scenario ;
- To promote collaboration between the actors of the decommissioning project ;
- To ensure radiation protection and the safety of workers, by training them as close as possible to operations, and reducing waste volumes.

This is equipment built and operated by EDF scheduled for commissioning in 2022





THE GRAPHITE INDUSTRIAL DEMONSTRATOR : BRIEF DESCRIPTION

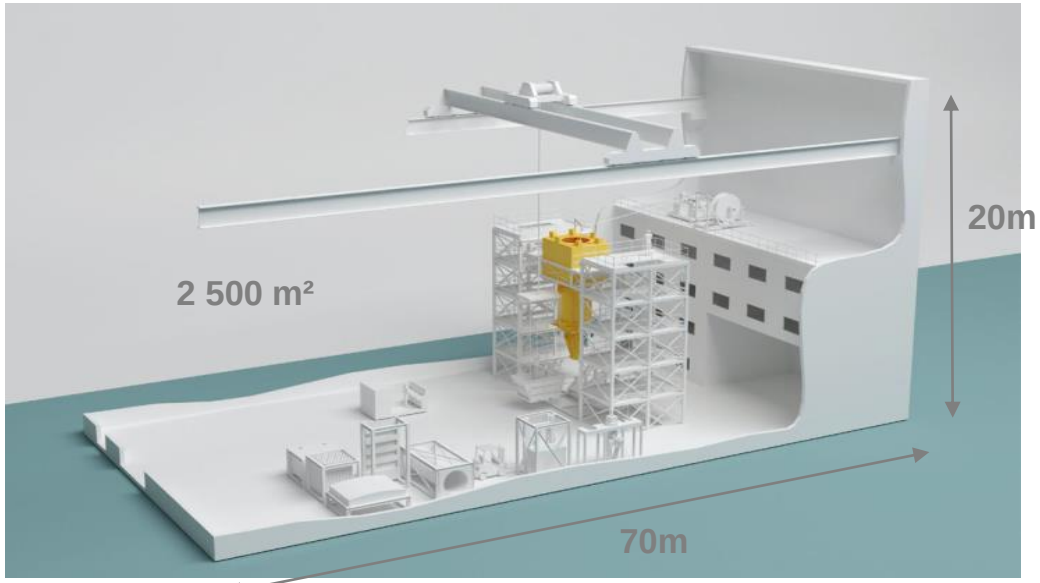


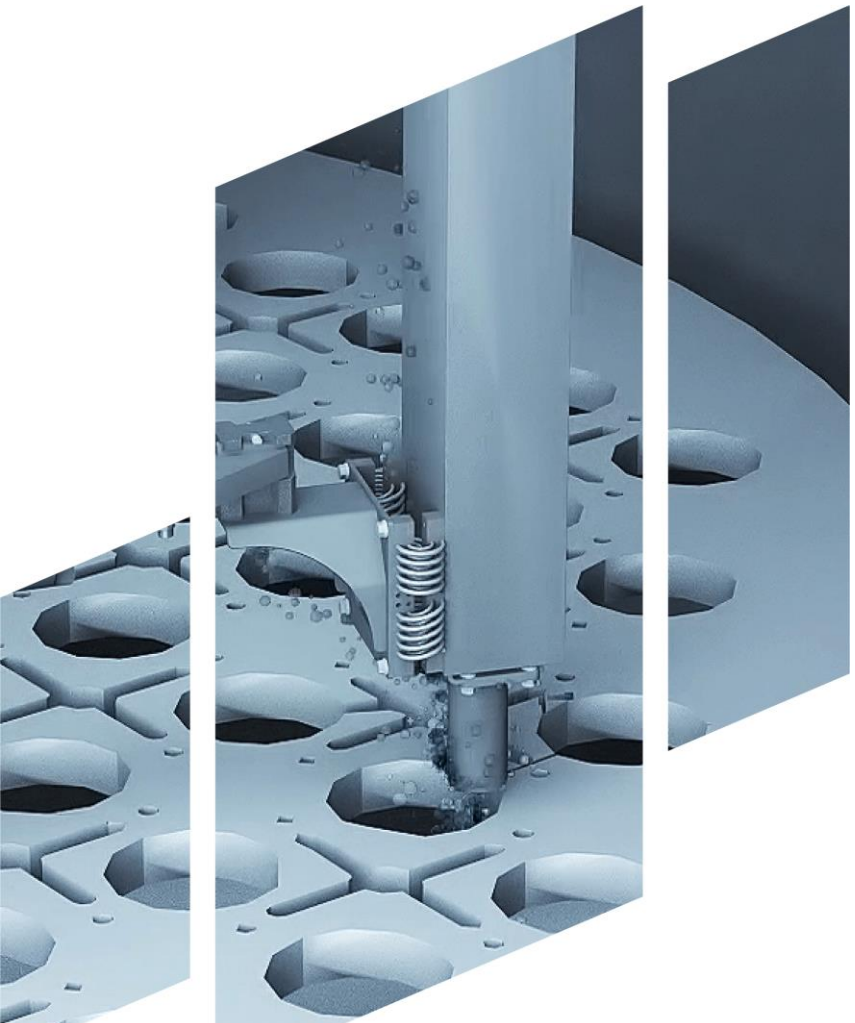
The Industrial Graphite Demonstrator will consist of :

- a test hall with scale 1 models of various representative parts of the reactor vessel. This 2,500 m² building will make it possible to develop the tools, carriers and dismantling platforms for the caissons.

- a digital simulation room for scenario optimization as well as operator training.

- offices (about twenty)





LD-SAFE presentation

SHARE - Workshop

Author: Pierre DAGUIN

Date: 01/12/2020

This project has received funding from the Euratom research and training programme 2014-2018, work programme 2019-2020 under grant agreement No 945255

European Commission | Horizon 2020 European Union funding for Research & Innovation

LD-SAFE presentation

SHARE - Workshop

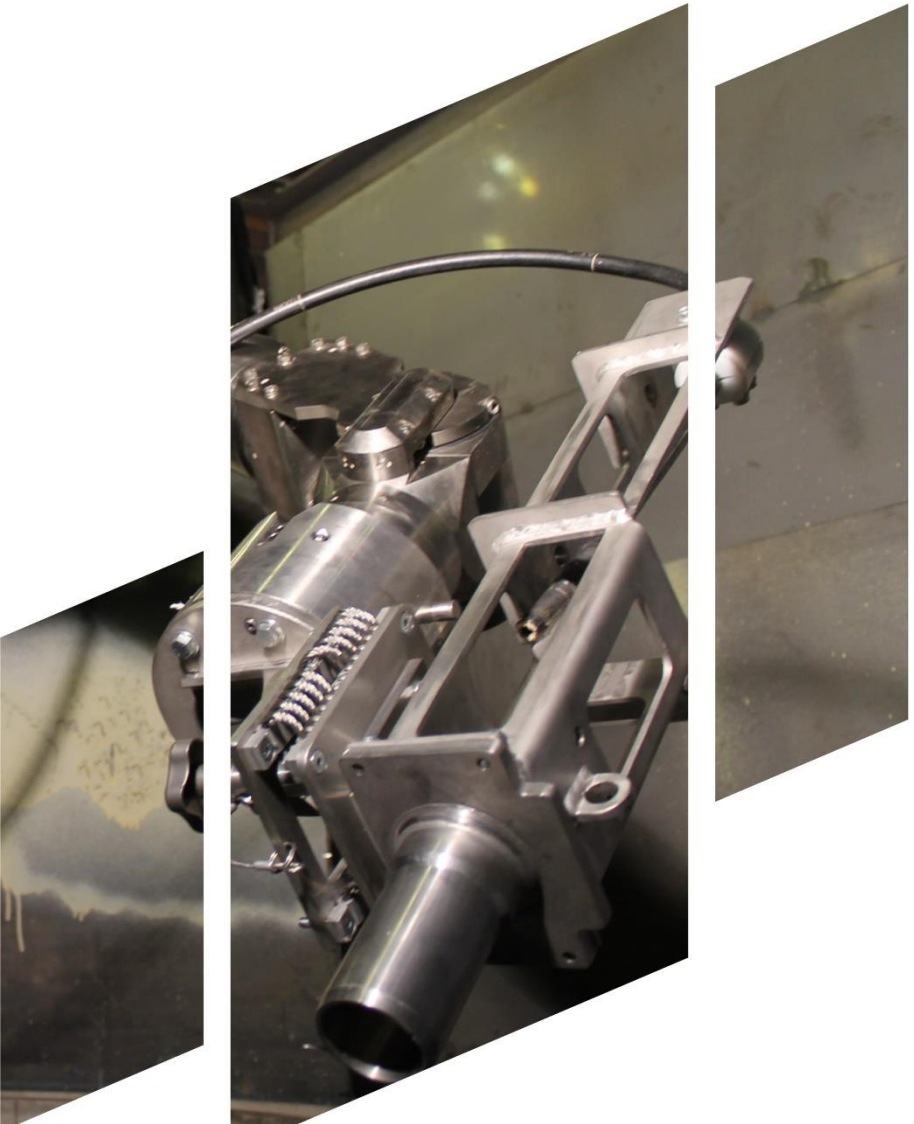
CONTENT

1. INTRODUCTION
2. OBJECTIVES
3. ORGANIZATION
4. MAIN ACTIVITIES
5. NEXT STEPS

European Commission
Horizon 2020
European Union funding
for Research & Innovation

LD SAFE
Laser Dismantling Environmental and Safety Assessment

ONET TECHNOLOGIES · tecnatom · cea · IRSN INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE · Lloyd's Register · ENGIE Solutions



LD-SAFE

Introduction

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Introduction

Context

Decommissioning of a power reactor

- Commonly scheduled to be completed over a **very long period**
- Change in practices (**immediate dismantling** after permanent shutdown)
- Strategy changes depends on **societal and environmental context**
- **Reduction of the total cost** of decommissioning
- **Immense challenge** (financial and technical point of view)
- Dismantling process and **cutting operation** needs **improvements**.

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Cutting technique innovation

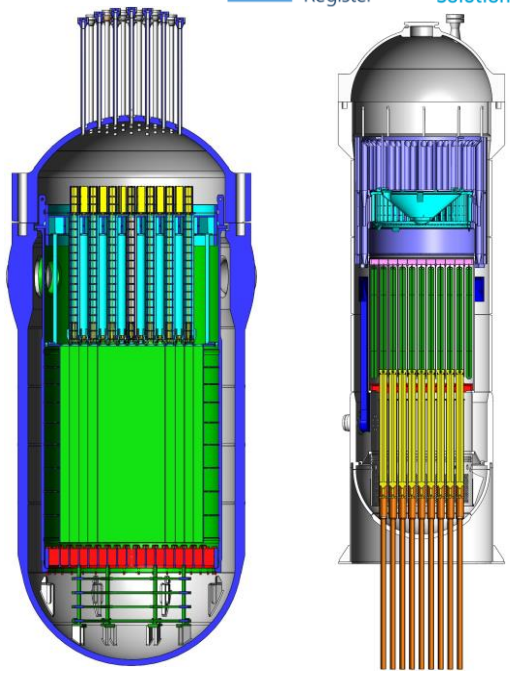
- Improve **safety**, **radiation protection**, **waste management**, **time** and **cost** aspects
- Development of **innovative technologies => Laser** cutting technology
- **Already used** for the dismantling of fuel cycle /research facilities and laboratory trials

Why laser is not yet widely used in the nuclear decommissioning industry?

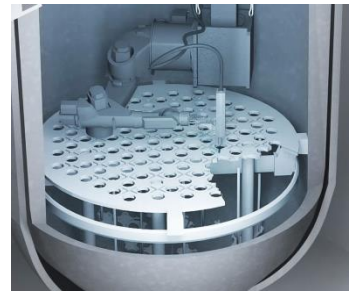
- New technology (**never used** for power nuclear reactor dismantling)
- Compliance with **safety requirements**

Most challenging task

- Dismantling reactor vessels and internals (**RPV and RVI**) of Power Reactor



PWR *BWR*



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✓ To assess the maturity of laser cutting technology for dismantling PWR and BWR (the most used in Europe)

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Laser Dismantling Environmental and Safety Assessment

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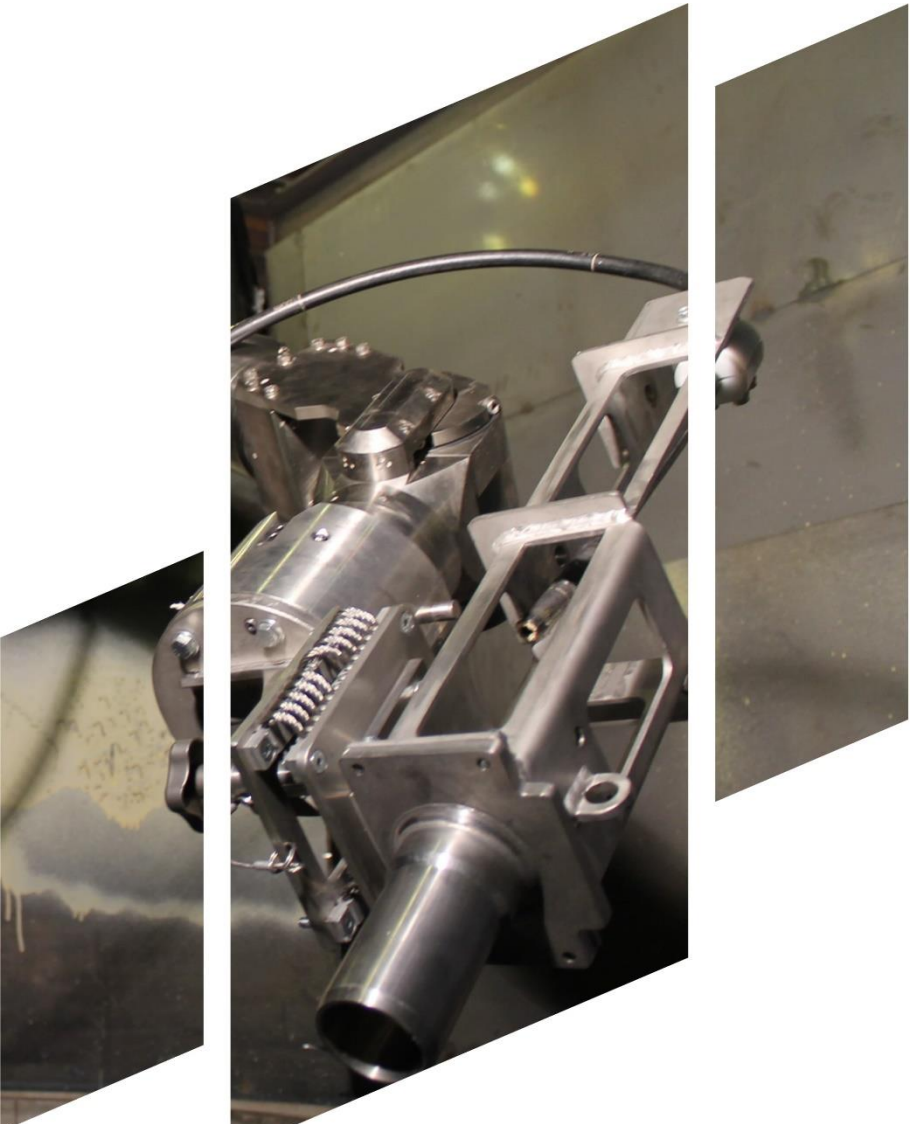

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Objectives

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Objectives

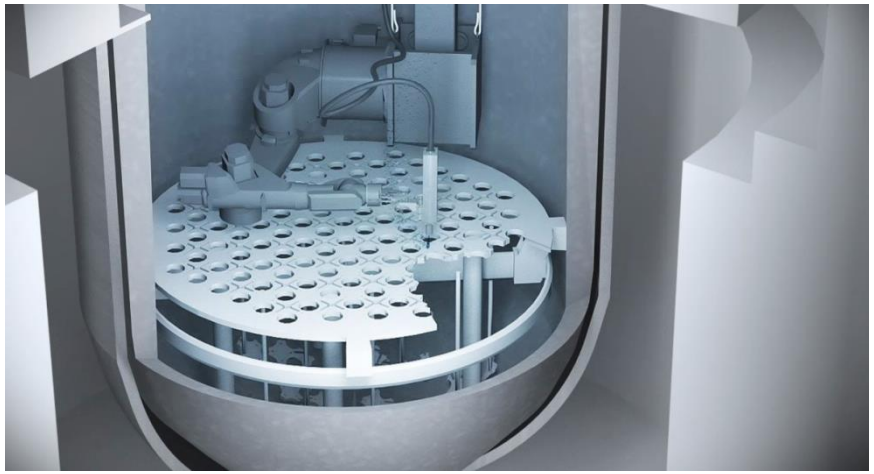
Focus

Main objectives

- The **validation** of the laser cutting technology for the dismantling of the **most challenging components** of power nuclear reactors in air and underwater
- The demonstration that laser cutting technologies is a relevant **alternative to the conventional techniques** used for the segmentation of the power nuclear reactors internals (RVI) and pressure vessels (RPV)

Specific objectives

- Demonstration of the **technical capabilities** of the laser cutting technology to address the key challenges of the dismantling of power nuclear reactors RVI and RPV
- **Environmental and safety assessment** for the implementation of laser cutting in nuclear reactor environment and definition of countermeasures
- **Validation of technology in operational environment**, with in-air and underwater demonstrators including the safety system, confirming that TRL 7 is reached (Technology Readiness Level)
- Demonstration of the **economic advantage** of using the laser cutting technology for RVI and RPV dismantling



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Objectives

Global ambition

Expected impact

- Providing **tools to the European industry** to create a robust world-leading decommissioning sector based on EU safety culture and know-how.
- To propose an **innovation** (in terms of safety, economic and technical aspects)
- Improving the segmentation of RPV/RVI
- To support European **RTO and industry**

Achieving a world first laser dismantling of a power nuclear reactor

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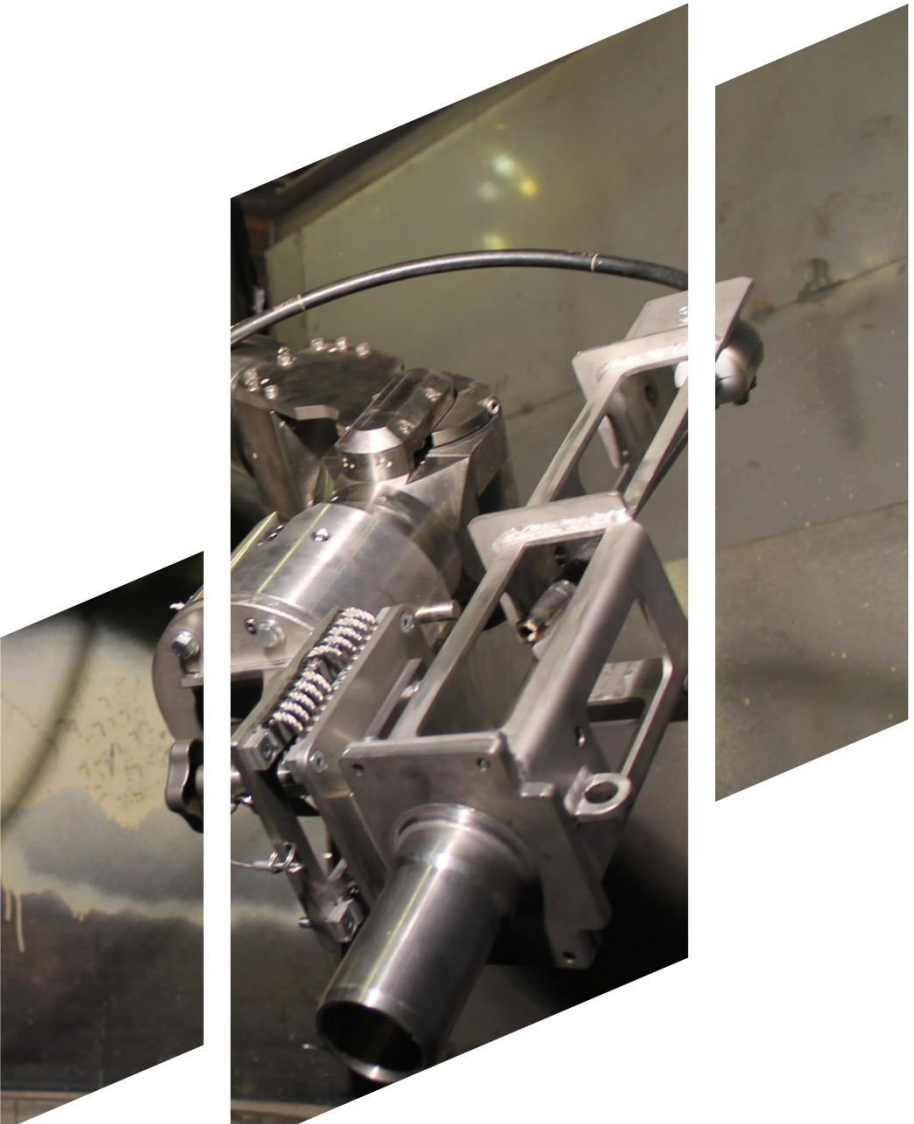

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Organization

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Organization

Main information and stakeholders

H2020 project

- **Funding by Euratom**
- **4 years** (July 2020 to June 2024)

European Consortium

- **ONET TECHNOLOGIES** – France
- **CEA –** France
- **IRSN** – France
- **ENGIE SOLUTIONS** - Belgium
- **LLOYD's REGISTER**- Sweden
- **TECNATOM** - Spain

Overall organization

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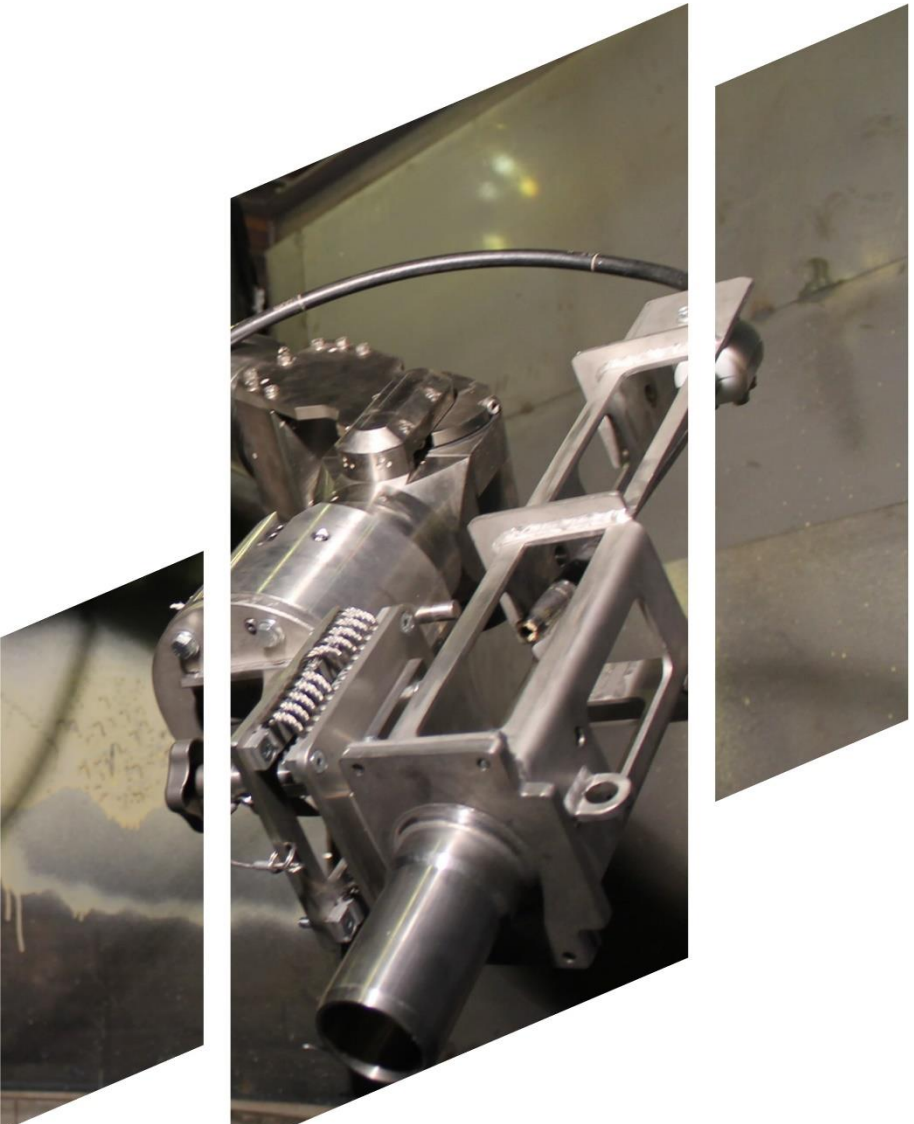

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Main activities

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Main activities

Overview

5 technical activities

2 specific activities

- ❑ Dissemination activities
- ❑ Project Management

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Main activities

Work Packages and methodology

7 Work Packages

WP1: Analysis of reactor dismantling with laser cutting (Leader: ENGIE)

WP2: Laboratory trials and calculations (Leader: CEA)

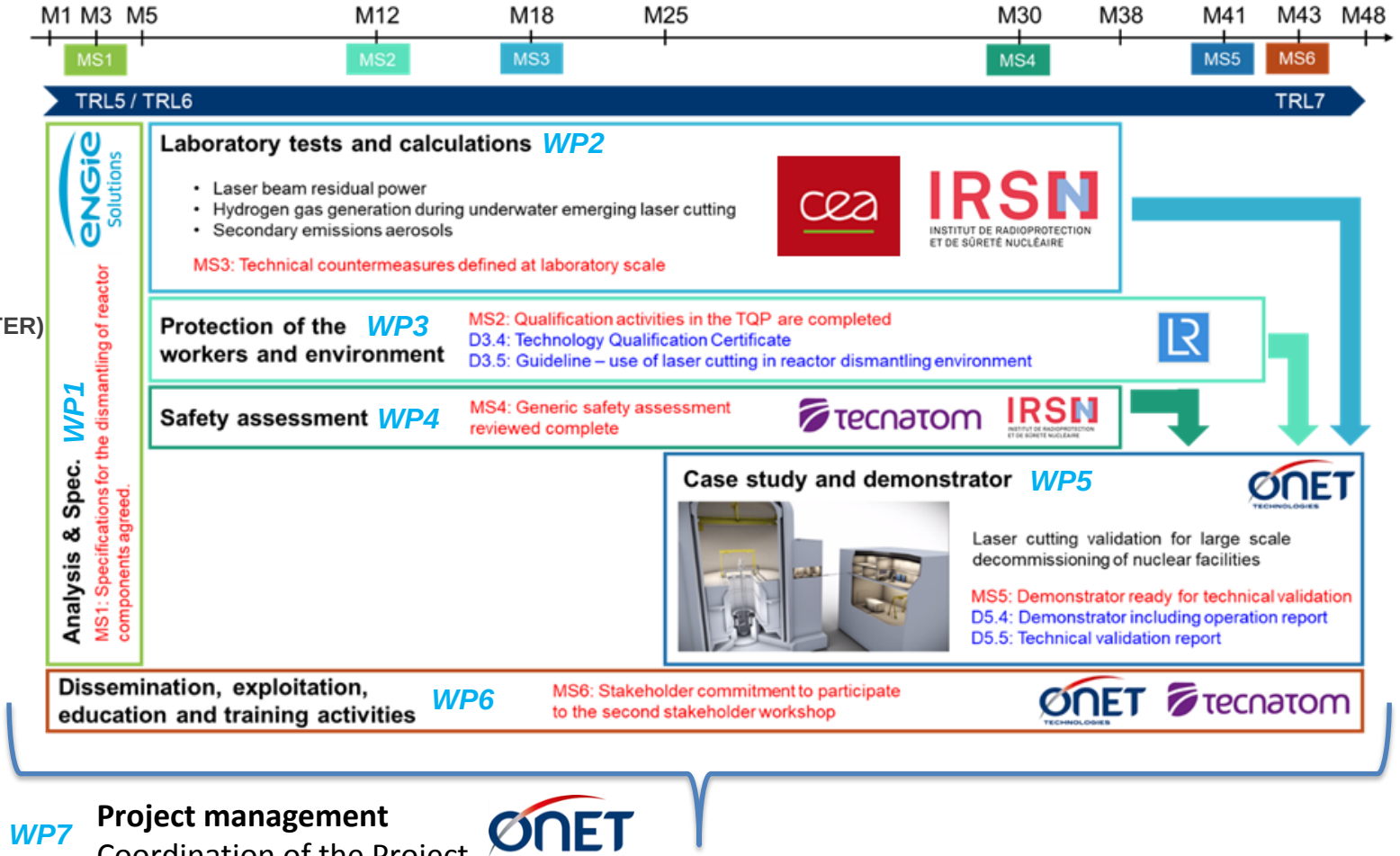
WP3: Protection of the workers and environment (Leader: LLOYD'S REGISTER)

WP4: Safety assessment (Leader: TECNATOM)

WP5: Case studies / Demonstrator (Leader: ONET)

WP6: Dissemination and exploitation activities (Leader: ONET)

WP7: Project management (Leader: ONET)



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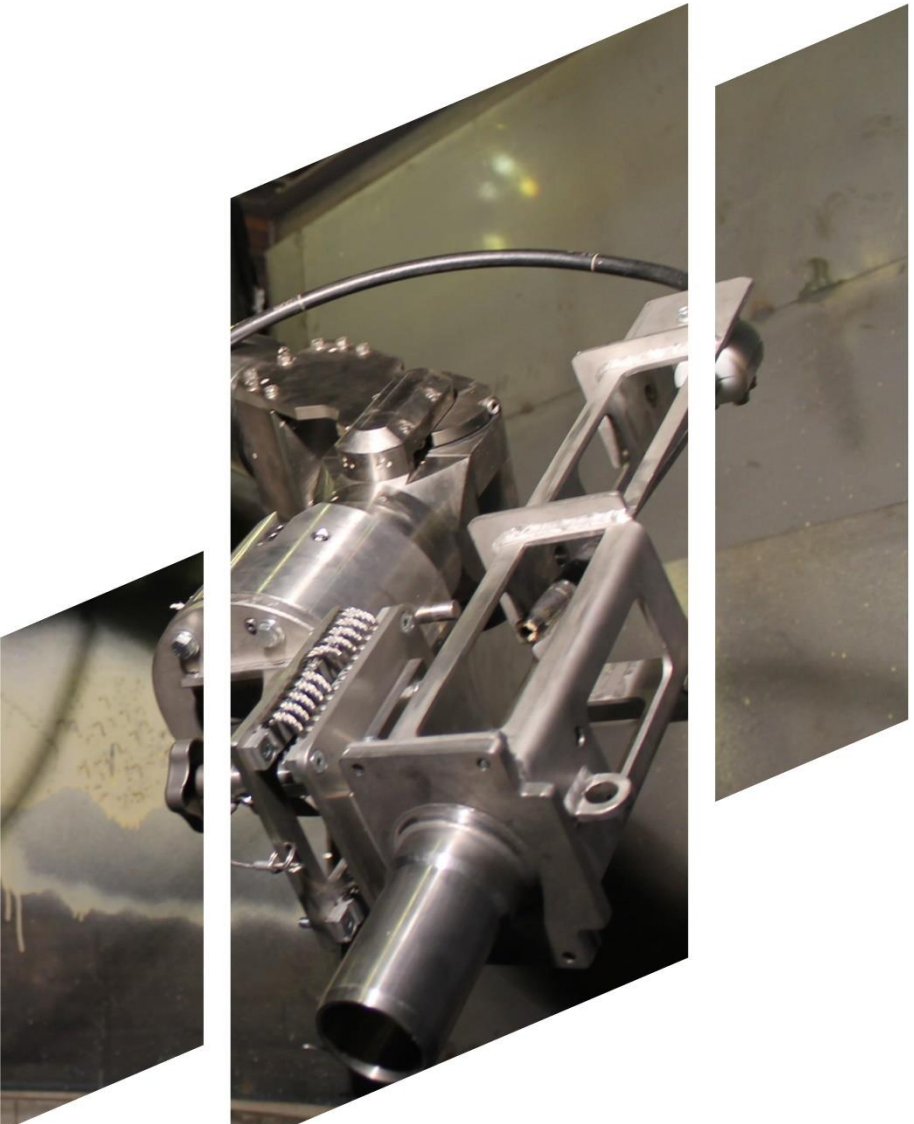

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Next steps

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Next steps

On-going actions

- Constitution of **End User Group** and **Support Group** on-going
- First **Technical Workshop** in December with End User Group
- **Public** Workshop in 2021 (to be confirmed due to Covid-19 pandemic)
- Dissemination of the **first deliverables of the project** (available on website and European Commission platforms)

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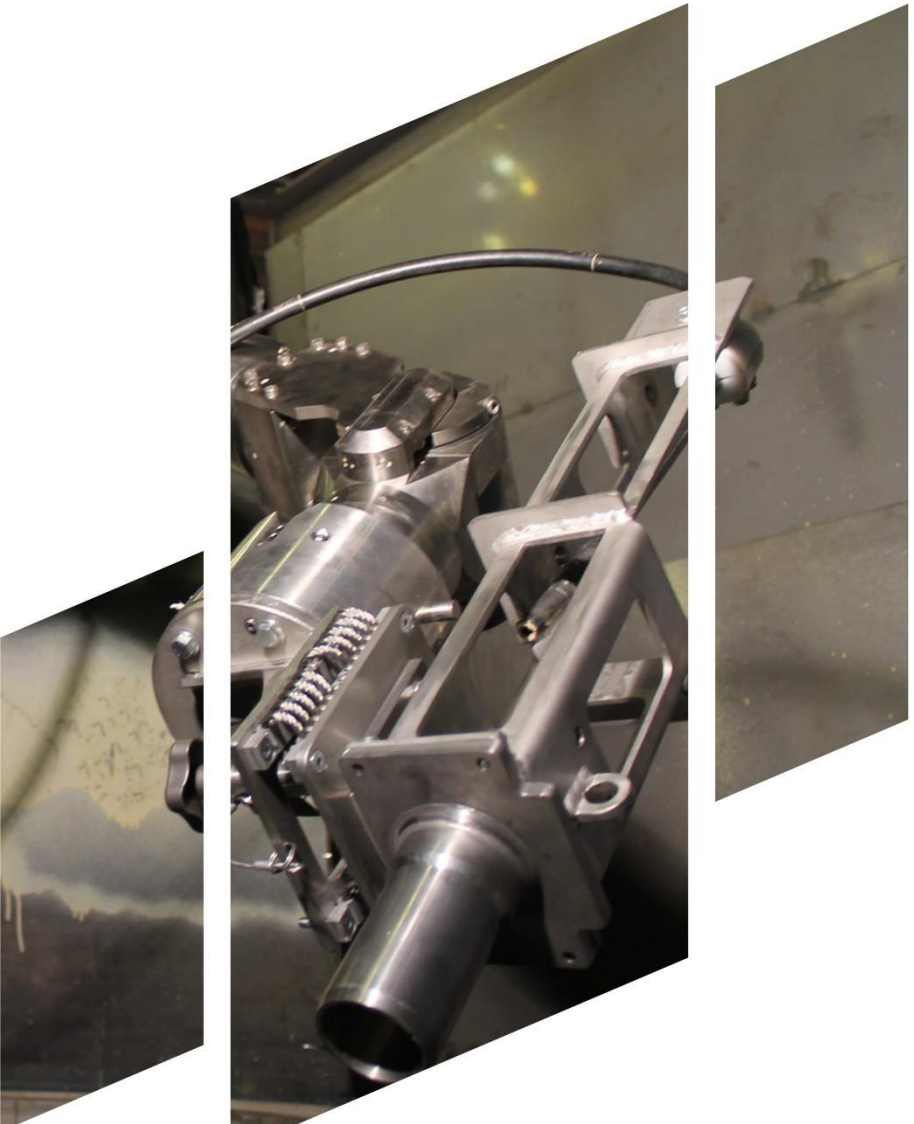

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Greetings

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Greetings

Thank you!

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