Supplement of Saf. Nucl. Waste Disposal, 1, 27–28, 2021
https://doi.org/10.5194/sand-1-27-2021-supplement

Supplement of

LD-SAFE: laser dismantling environmental and safety assessment

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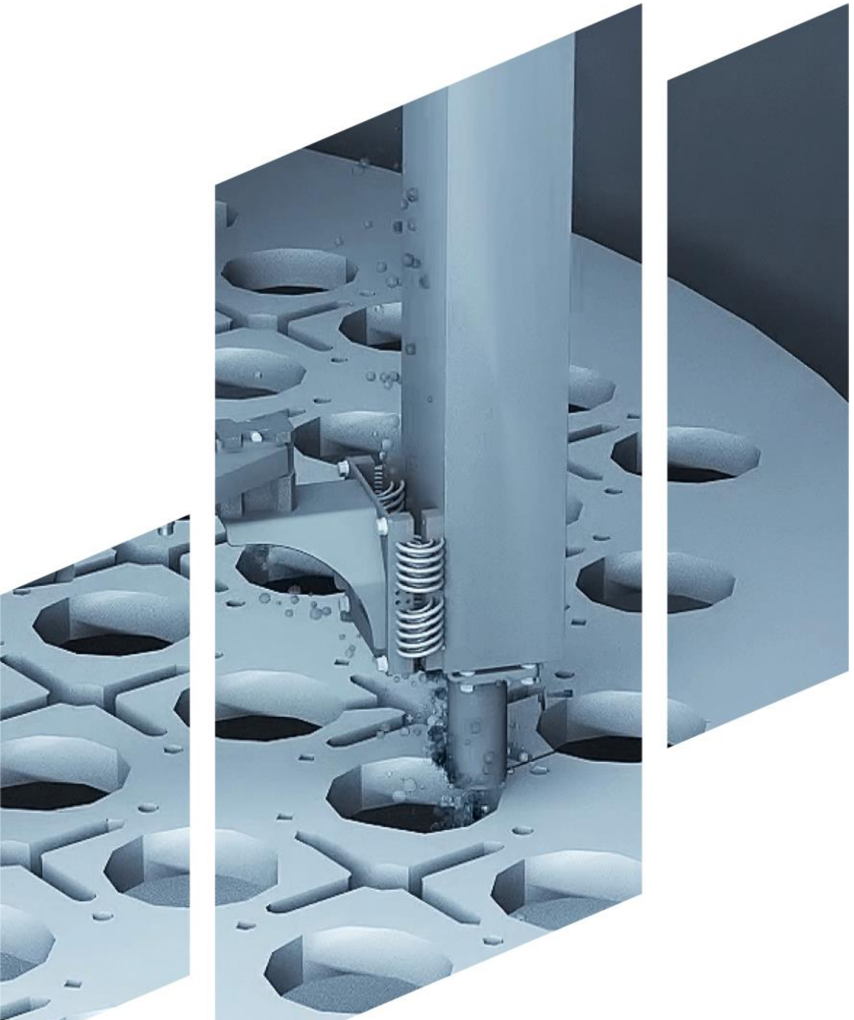

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BASE symposium (safeND)
Project presentation

Author: ONET TECHNOLOGIES

Date: Nov. 12, 2021

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

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Summary

CONTENT

1. INTRODUCTION
2. CUTTING TECHNIQUES
3. LASER CUTTING
4. LD-SAFE
5. SAFETY ASPECTS
6. CONCLUSION

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Decommissioning of a power reactor

- Commonly scheduled to be completed over a **long period (over 20 years for PWR/BWR in general)**
- Change in strategy (**immediate dismantling** after permanent shutdown)
- **New challenges** (acceleration of the decommissioning project schedules)
- Need to improve the **dismantling processes** and **existing techniques**

➢ **Key operation to improve: cutting of Reactor Pressure Vessel and Internals**

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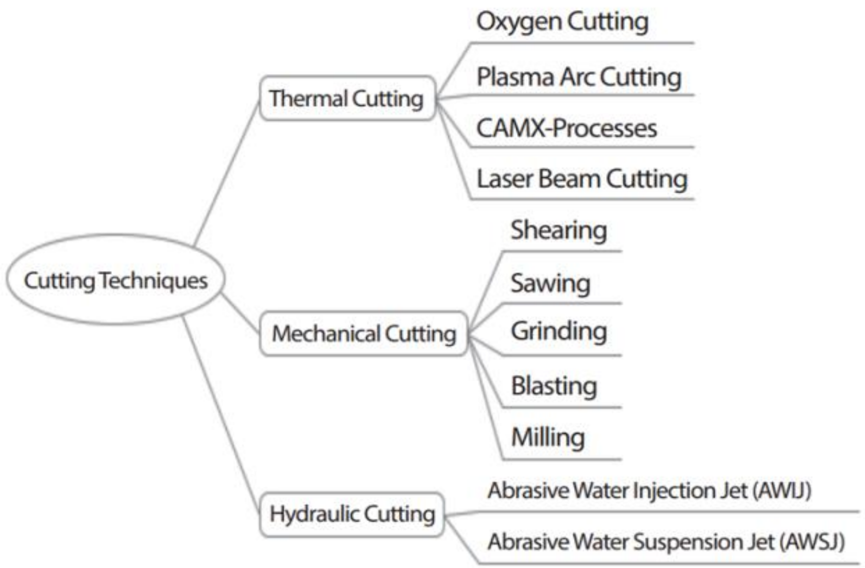
Cutting techniques

Main categories / Main tools used

- Thermal cutting (Plasma Arc Cutting)
- Mechanical cutting (Band Saw Cutting)
- Hydraulic cutting (Abrasive Water Jet Cutting)



Classification of remote handling technologies

Comparison / Limitations

	Plasma Arc cutting	Band Saw cutting	Abrasive Water Jet cutting
Advantages	Large dimensions Fast Less maintenance on site	Cut large thicknesses All materials Limited contamination	Complicated shape All materials Few air pollution
Drawbacks	**High degree of filtration** Slower underwater Electrically conductive material	**Slow (cutting speed)** Maintenance Wear part replacement	**Water treatment** High cost Required space

For cutting RPV/RVI in-air and underwater

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Need

- Development of **innovative technologies**
- Improve **safety**, **radiation protection**, **waste management**, **time** and **cost** aspects

Why adapting laser cutting technology for RPV and RVI?

- **Key benefits** in comparison with conventional cutting techniques
- More than **10 years of R&D (laboratory testing)**
- **Mature** and **operational technology** for dismantling activities (already used for fuel cycle / research facilities)

Examples of operational experience

- *Dissolvers of **UP1 MAR200** fuel reprocessing facility at CEA in France*
- *Piping at Creys-Malville NPP (**SUPERPHENIX** prototype fast reactor)*
- *Radioactive waste evaporator at **La Hague** site*

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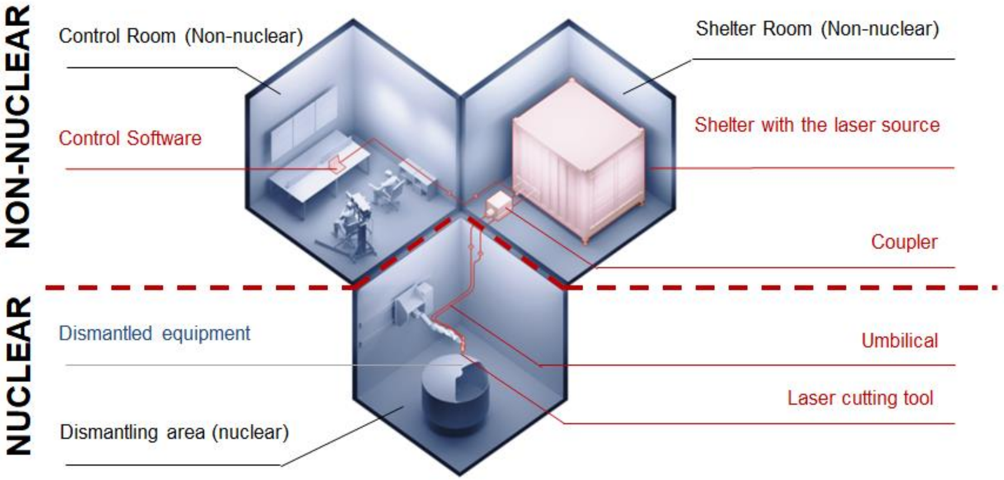
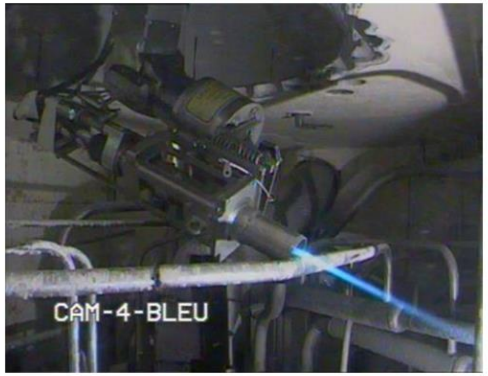
Laser cutting

Key benefits for dismantling

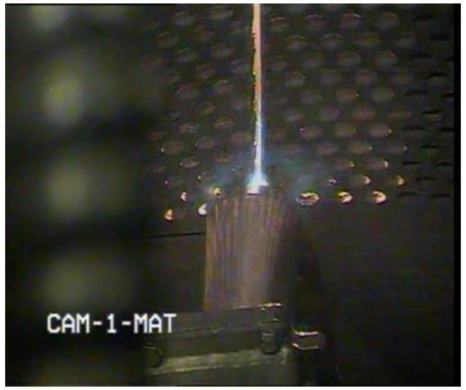
- **Safe** for the workers (remote operations)
- **Time** reduction and **cost** efficiency in operation
- **Effortless** cutting with high performance
- Ability to cut **complex geometries**
- **Minimization of the secondary waste** (aerosols and mass removed)
- **Cleaner** than most of other thermal techniques (especially for dust & fumes)
- **Robustness** and **reliability**, **no maintenance** or wear parts in controlled area



On-site **implementation** for dismantling activities



Up to **200mm in thickness** in air (14kW laser power)



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Laser cutting

Not yet widely used in the nuclear decommissioning industry?

- Laser considered as new technology (**never used** for power nuclear reactor dismantling)
- Compliance with **safety requirements** need **to be checked**

Most challenging task

- Dismantling Reactor Pressure Vessels and Internals (**RPV and RVI**) of Power Nuclear Reactor

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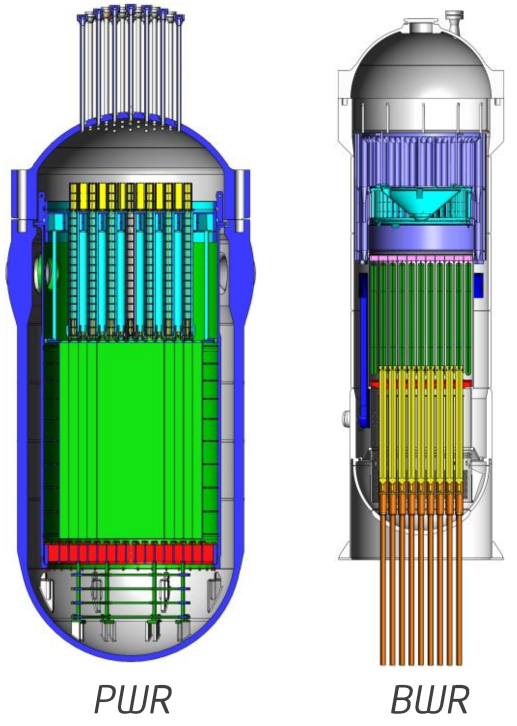
➢ To promote the use of laser cutting technology for dismantling PWR and BWR (the most used in Europe)



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Organization

H2020 program

- **R + D + i project**
- Funding by **EC (Euratom)**
- **4 years** (July 2020 to June 2024)

Consortium

ONET TECHNOLOGIES - France
EQUANS (ENGIE) - Belgium
CEA - France
VYSUS GROUP - Sweden
IRSN - France
TECNATOM - Spain

Overall organization

1 Project officer — European Commission

6 partners — Consortium

3 groups — Advisory Board — EG/EUG/SG

Expert Group (EG)
End User Group (EUG)
Support Group (SG)

End User Group

Support Group

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Objectives

Main objectives

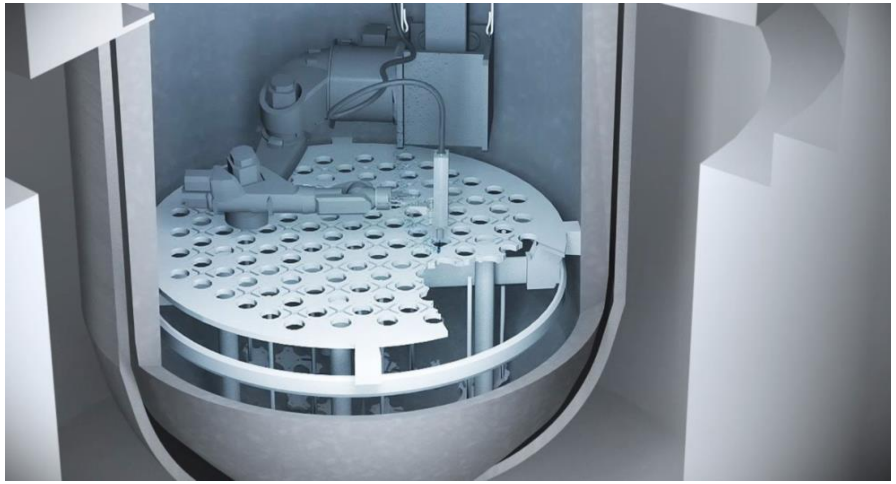
To demonstrate in-air and underwater technical capabilities, safety, economic advantages and suitability for power nuclear reactor dismantling activities.

Objective 1: Demonstration of the capabilities of a versatile laser cutting solution to address key technical challenges in large NPPs decommissioning.

Objective 2: Environmental and safety assessment of the implementation of laser cutting for nuclear reactor decommissioning.

Objective 3: Technical validation of the laser cutting prototype in operational environment.

Objective 4: Demonstration of the economic advantage of using laser cutting technology for the forthcoming reactor decommissioning market.



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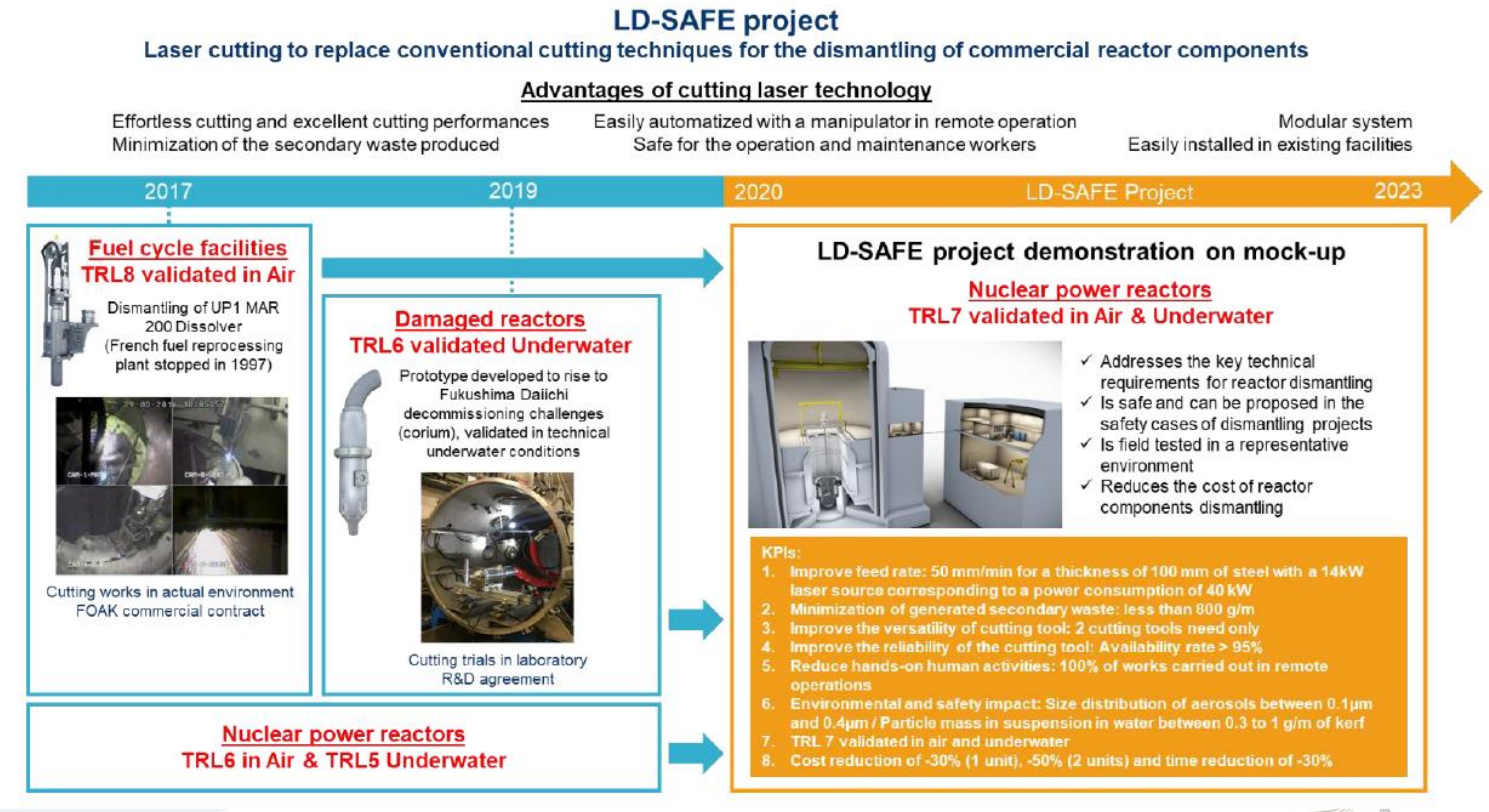
Concept



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Main technical activities

Laser Cutting Development	Environmental and worker protection	Safety Assessment	Decommissioning of nuclear facilities
Analysis of the reactor dismantling with laser cutting (ONET Technologies, EQUANS)	**-Technology qualification**	**-Risk analysis**	**Demonstrators in two phases: in air and underwater**
Laboratory tests and calculations:	**-Guidelines for the industry for the use of laser cutting** (Vysus Group)	**-Generic Safety Assessment** (Tecnatom)	**Validation of the implantation and the use of the laser cutting technology in operational environment** (ONET Technologies, CEA, EQUANS)
-Laser beam residual power		**-Independent review** (IRSN)	**+ End-users**
-Hydrogen gas generation during underwater cutting (CEA)			
-Aerosols (IRSN)			

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Safety aspects

Preliminary risk analysis performed

- Identifying and evaluating radiological and conventional risks,
- Identifying safety systems, measures and controls,
- Identifying uncertainties.

Risk Analysis (preliminary)

Compilation of WP2/WP3 results

Referencia para potenciales usuarios finales

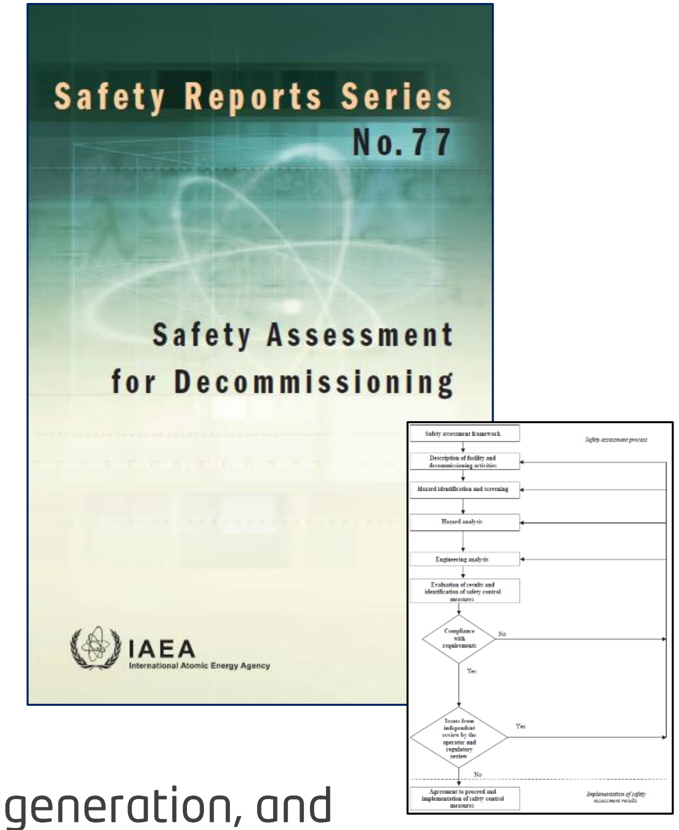
Generic Safety Assessment

Independent review (IRSN)

(Regulator submittal)

WP5, Demostrator

- **WP2, Laboratory Tests** : H_2 and aerosols generation, and residual laser beam power
- **WP3, Workers and environment protection**



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Safety aspects

ONET TECHNOLOGIES · tecnatom · cea · IRSN INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE · Vysus Group · EQUANS EMPOWERING TRANSITIONS

Risk Matrixes for Normal and Accident Conditions – "Safety Envelope"

Normal segmentation conditions

			Unoptimized Conditions				Safety Measures and Controls
Situation	**Associated Activities**	**Potential Causes**	**Probability** (1)	**Dose to Workers**	**Dose to Public**	**Environment**	**Design options**
External Exposure Normal conditions	All activities	Activities in radiation and contaminated areas.	All along the process	Very high if no measures are taken due to highly activated materials	Low	N/A	Remote Operation, robust design, easy installation & decontamination. Shielding, dosimeters, and other Radiation Protection (RP) procedures and controls. Area Radiation Monitoring. Water Level Monitoring. Building off-gas system monitoring and filtration. Training.
Internal Exposure Normal conditions	Segmentation activities	Airborne releases during RPV/RVI cutting. Sublimation of ruthenium to gaseous form (in-air cutting).	All along the process	Very low		N/A	Remote Operation. Dust/aerosols collection system. Contamination Control Confinement (Airlock). Area Radiation Monitoring. Building off-gas system monitoring and filtration.
Effluents and secondary waste Normal conditions	Segmentation activities	Airborne releases, dross generation, and water contamination during RPV/RVI cutting.	All along the process	N/A	N/A	Very Low	Protection of cavity floor. Effluents Monitoring. Auxiliary water filtration systems.
Waste management Normal conditions	Radioactive waste handling and fluxes	Cutting pattern choice	All along the process	Very low	N/A	N/A	Minimize waste generation. Shielding. Online removal of waste. Optimization of waste location considering personnel walking paths.
Hazardous materials exposure Normal conditions	Segmentation activities	Potential generation of hazardous chemical compounds during cutting operations, such as ozone, carbon oxides, nickel carbonyl, nitrogen oxide and toluene. Hexavalent chromium generation during stainless steel cutting.	All along the process	N/A	N/A	Toxicity	Dust/aerosols collection system. Contamination Control Confinement (Airlock). Area Radiation Monitoring.
Maintenance operation Normal conditions	Maintenance (nozzle replacement, support equipment - platform-...)	Maintenance activities, repairs, and replacements.	All along the process	Low	N/A	N/A	Robust design, easy and scarce maintenance. RP procedures and controls. Protective personal equipment.

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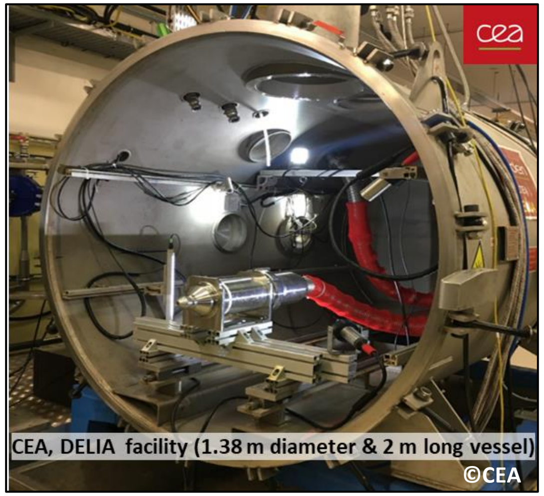
Safety aspects

- **WP2.** Tests and calculations of hydrogen and aerosols generation, and of residual laser beam power (performed in DELIA Facility at CEA Saclay).
- **WP3.** System maturity and integration analysis.
- **WP5.** Demonstration of laser cutting technology safety and efficiency in mock-up (reactor components and conditions simulation).



CEA, DELIA facility (1.38 m diameter & 2 m long vessel) ©CEA

CEA, DELIA Facility, aerosol sampling line ©CEA

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Conclusion

Expected impact

- To support the **European industry** by enhancing the 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

Achieving a world first laser dismantling of a power nuclear reactor!

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Thank you!

Q&A

Upcoming events

- **WNE 2021** - LD-SAFE workshop public session
Dec. 1, 2021 - Paris, France

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