NUCOBAM

Innovation Action (IA)

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NUCOBAM public website

Authors : Dr. Myriam BOURGEOIS (CEA)

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Project officer: Cristina FERNANDEZ RAMOS

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Summary

The NUCOBAM public website will provide information about the project, publications, news and events

Approval

Date	By
2022-03-11 17:06:25	Dr. Romain VERLET (EDF)
2022-03-15 17:54:53	Dr. Myriam BOURGEOIS (CEA)

Disclaimer

Preface

This project named NUCOBAM NUclear COmponent Based on Additive Manufacturing has received funding from the EURATOM research and training programme 2014-2018 under grant agreement No 945313. The partners are CEA: Commissariat à l'énergie atomique et aux Energies Alternatives, EDF: Electricité de France, LABORELEC: Belgisch Laboratorium van de Elektriciteitsindustrie Laborelec cvba, TRACTEBEL: Tractebel engineering, NAVAL: Naval group, FRAMATOME: Framatome GmbH, CIEMAT: Centro de investigaciones energeticas, medioambientales y tecnologicas-ciemat, UDSD: The university of Sheffield, VTT: Technical Research Centre of Finland Ltd, SCK.CEN: Centre d'etude de l'energie nucleaire fondation d'utilite publique, JRC: Jrc -joint research centre- european commission, RAMEN VALVES: Ramen valves ab, IRSN: Institut de radioprotection et de surete nucleaire.

History

Date	Version	Submitted by	Reviewed by	Comments
12/03/2021	N°1	Pierre-François Giroux	Submitted to Executive Board (all WP leaders)	
26/01/2022	N°2			All remarks included
11/03/2022	N°3	Myriam Bourgeois	Romain Verlet	Screen printing of the website included in Appendix

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Abbreviations and Acronyms

Acronym	Description
WP	Work Package
AM	Additive Manufacturing

Executive Summary

This deliverable describes how the NUCOBAM public website was designed and structured to explain the context, description and content of this project in a non-expert language. The purpose of the public site is to be understandable to the general public and to give contacts for more information.

Keywords

Nuclear, additive manufacturing, qualification

1. Menu

About	**Resources**	**Partner Area**	News
The Project		(link to FLEXX)	
Consortium			
Additive Manufacturing			

2. HOME

(header image with **NUclear COmponent Based on Additive Manufacturing** written on top)

NUCOBAM is an EU-funded project that will develop the qualification process and provide the evaluation of in-service behaviour of Additively Manufactured (AM) components in a nuclear installation.

NUMBERS

13 PARTNERS 6 COUNTRIES 4 YEARS

AMBITIONS

- To validate metal additive manufacturing as a safe and competitive solution for component obsolescence in nuclear industry
- To qualify the AM process to optimize the design cycle for enhanced performance of critical nuclear components
- To demonstrate compatibility of AM stainless steel 316L in Light Water Reactor (LWR) irradiated environment.

CONSORTIUM

Partner scrolled (*partner logos*)

3. ABOUT THE PROJECT

Additive manufacturing (AM) (also known as 3D printing) presents an opportunity for nuclear power plants to replace machinery and parts with relative ease and speed compared to traditional methods using processes such as welding, machining and casting. In order to be able to use AM in nuclear facilities, nuclear stakeholders must have confidence in the manufactured components. This means that before installing these components, they must go through rigorous testing and quality control.

NUCOBAM aims at developing the qualification process and evaluating in-service behaviour of nuclear components made by AM. NUCOBAM will conduct the required studies to implement the AM process in nuclear design codes and standards to produce components for nuclear power generation equipment.

The project will be based on two coupled strategies:

1. The first part will consist of a collection of the physical, mechanical, and microstructural characterisation of the materials from 4 manufacturers that result from the AM process (using 4 heat treatments) in order to establish a qualification and codification process.
2. The second part will be dedicated to the evaluation of AM material behaviour in-service, especially regarding main degradation mechanisms that occur in Light Water Reactors (LWR) (thermal ageing, irradiation…). Materials will be manufactured and some of them will be submitted to post-treatment (heat treatment or high isostatic pressure).

This work will allow manufacturers and designers to evaluate and deduce the main parameters required for specification. By gathering the main European industrial and research/academic players in the nuclear sector to participate in the project, NUCOBAM will directly contribute to the development of future nuclear safety policy. The project was awarded the SNETP label (formerly the NUGENIA *(https://snetp.eu/nugenia/)* label) for addressing issues in several Technical Areas (find the project factsheet on SNETP here *(https://snetp.eu/portfolio-items/nucobam/)*).

Developments proposed in NUCOBAM will be used for 3 main applications in 3 different time frames.

Short Term

In the short term (by the end of the project), NUCOBAM results will be used in existing nuclear power plants in order to continue safe operation and optimise maintenance.

Midterm

NUCOBAM achievements will provide high value for nuclear power plants with new possibilities for components design with improved performances and safety.

Long term

NUCOBAM results will allow for the optimisation of designing future reactor components (large reactors or small modular reactors), ex-vessel pressure retaining components and possibly non pressure retaining classified components.

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3.1. PROJECT OBJECTIVES:

1. To establish a qualification methodology for AM nuclear components to be proposed for standardization and to be communicated to nuclear design code committees
2. Develop a laser powder bed fusion-manufacturing plan that ensures and demonstrates process stability, repeatability and reproducibility that meet nuclear quality standards.
3. Demonstrate that laser powder bed fused material performance meets qualification requirements.
4. Evaluate the effect of irradiation on the behaviour of the laser powder bed fused in-core use case to see whether it meets its safety-related function and operational requirements
5. Assess the operational performance of ex-core AM components regarding safety-related function and operational requirements.
6. Disseminate and prepare the exploitation of results with nuclear industries and regulatory bodies in support to codification and industrialization of AM.

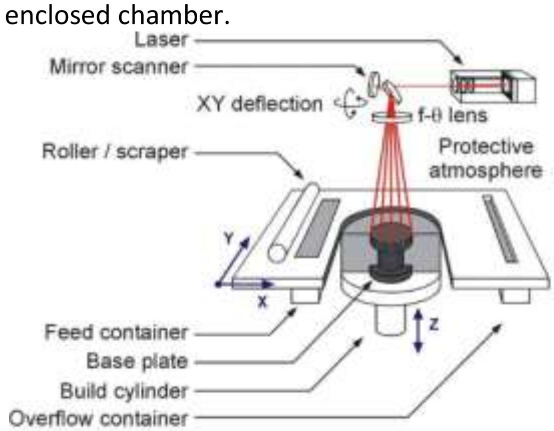
3.2. IMPACTS

Impacts of NUCOBAM:

- Nuclear industry profitability, both for new Nuclear Power Plant (NPP) designs and for existing NPP operation
- Improve nuclear safety with optimized component design for higher performances
- Development, qualification and standardization of an innovative AM technology
- Creation of a new manufacturing industry in Europe.

4. Additive Manufacturing

NUCOBAM will use an Additive Manufacturing (AM) process called Laser Powder Bed Fusion to produce objects from powdered materials. This uses one or more lasers to fuse or melt the particles at the surface, layer by layer, in an enclosed chamber.



Schematic view of the laser melting process

J.-P. Kruth et al., Part and material properties in selective laser melting of metals, Department of Mechanical Engineering, Catholic University of Leuven, Leuven, Belgium, 2010, ISEM XVI

4.1. POWDER MATERIALS

Manufacturing complex nuclear equipment produces metal shavings as a result of the machining process (i.e. taking large blocks of metal and machining them down into smaller components). Although those shavings are recycled, they are still considered as waste. The AM process is a solution to produce less waste, as using powder allows the manufacturer to use a more accurate quantity of starting material. Metallic powder is also more easily recycled when compared to metal shavings and has the valuable benefit of being recycled on-site.

During the production of the demonstrators, powder will be part of different printing processes and cycles. Therefore, it is crucial to verify the quality of the powder and ensure that its properties stay stable over time. To do so, NUCOBAM will perform a careful study on powder characteristics and will implement a powder quality management system. Stainless steel 316L powder (X2CrNiMo17–12–2 (1.4404) according to EN standards) was chosen, as it is already extensively used throughout the existing nuclear fleet for Reactor Pressure Vessels (RPV) internals, primary pumps, pipes, external components (valves), and tools.

4.2. STANDARDISATION

Currently, the lack of transferability of process parameters among different machines is one of the main issues in Laser Powder Bed Fusion technology. This is true not only among different manufacturers but also among different models within same manufacturer. As the final quality of the component should be sufficiently high regardless of the specifics of the manufacturing process, NUCOBAM will produce a methodology aiming to handle the influence of the process in the result. In addition, the project will evaluate novel quality control methods ensuring process stability, repeatability, and reproducibility resulting in high-quality components.

Other tests (such as tensile tests, hardness, toughness, corrosion and fatigue and creep behaviour) will be performed to evaluated the quality of the process, materials, and resulting components in AM.

4.3. DEMONSTRATORS

The project will create two components that will be used to demonstrate the process and allow for testing of the materials and methods.

1. Valve body
2. Debris filter

The fuel debris filter was chosen, as it is an example of a complex shape that can benefit from design/manufacturing optimization, and the valve is an example of a strategy to cope with obsolescence, which is a major concern in manufacturing.

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In addition to the qualification methodology, two types of tests will be performed to qualify the NUCOBAM equipment for nuclear use:

- Hydrostatic pressure test (for the valve): required by the construction codes, it demonstrates that the equipment design holds up under a given pressure;
- Functional test: according to manufacturers' procedures and/or client requirements, it demonstrates that the equipment fulfils its functions.

Assembled valve Body with internals (Ramèn Valves)

Debris filter (Framatome)

Figure 1: Nuclear Components.

5. CONSORTIUM

NUCOBAM brings together 13 partners from 6 different countries and each partner will bring their own complementary expertise and capabilities to the project. The consortium aims to demonstrate and validate the use of AM components in nuclear installations.

The partners include electricity utilities, operating nuclear assets, component manufacturers, design owners, public service experts in nuclear and radiation risks as well as research and competence centers involved in mechanical assessment, metal powder qualification, metallurgical characterization, materials irradiation capabilities and nuclear power research.

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1. CEA	2. EDF	3. ENGIE LABORELEC
4. ENGIE TRACTEBEL	5. NAVAL GROUP	6. FRAMATOME
7. CIEMAT	8. UFSD	9. VTT
10. SCKŸCEN	11. JRC	12. RAMEN VALVES
13. IRSN		

Table 1: Partners list

6. NEWS

(Articles shown on these pages)

7. RESOURCES

Find resources such as public project reports and related initiatives:

Deliverables list:

- D1.4 Standard text WP1
- D4.4 Scientific article WP4
- D6.1 Communication plan WP6
- D6.2 NUCOBAM public website WP6
- D6.5 EUG lessons learnt WP6

Related Initiatives:

- SNETP Factsheet *(https://snetp.eu/portfolio-items/nucobam/)*
- European Energy Research Alliance (EERA) *(https://www.eera-set.eu/index.php?index=6)*
- Energy Homepage from the European Commission *(https://energy.ec.europa.eu/index_en)*

8. FOOTER

Disclaimer	Contact	Link to Partner area
This project has received funding from the Euratom 2014-2018 under grant agreement No 945313. The content of this website reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.	**Coordinator :** Myriam Bourgeois, CEA contact.nucobam@cea.fr	Access partner area here (members only) Button with link (*https://app.flexx.camp/nucobam*)

9. Appendix 1 : some website views: https://nucobam.eu/

ABOUT RESOURCES PARTNER AREA NEWS

Additive manufacturing (AM) (also known as 3D printing) presents an opportunity for nuclear power plants to replace machinery and parts with relative ease and speed compared to traditional methods using processes such as welding, machining and casting. In order to be able to use AM in nuclear facilities, nuclear stakeholders must have confidence in the manufactured components. This means that before installing these components, they must go through **rigorous testing and quality control.**

> **NUCOBAM** aims at developing the qualification process and evaluating in-service behaviour of nuclear components made by AM. NUCOBAM will conduct the required studies to implement the AM process in nuclear design codes and standards to produce components for nuclear power generation equipment.

The project will be based on two coupled strategies:

1. The first part will consist of a collection of the physical, mechanical, and microstructural characterisation of the materials from 4 manufacturers that result from the AM process (using 4 heat treatments) in order to establish a qualification and codification process.
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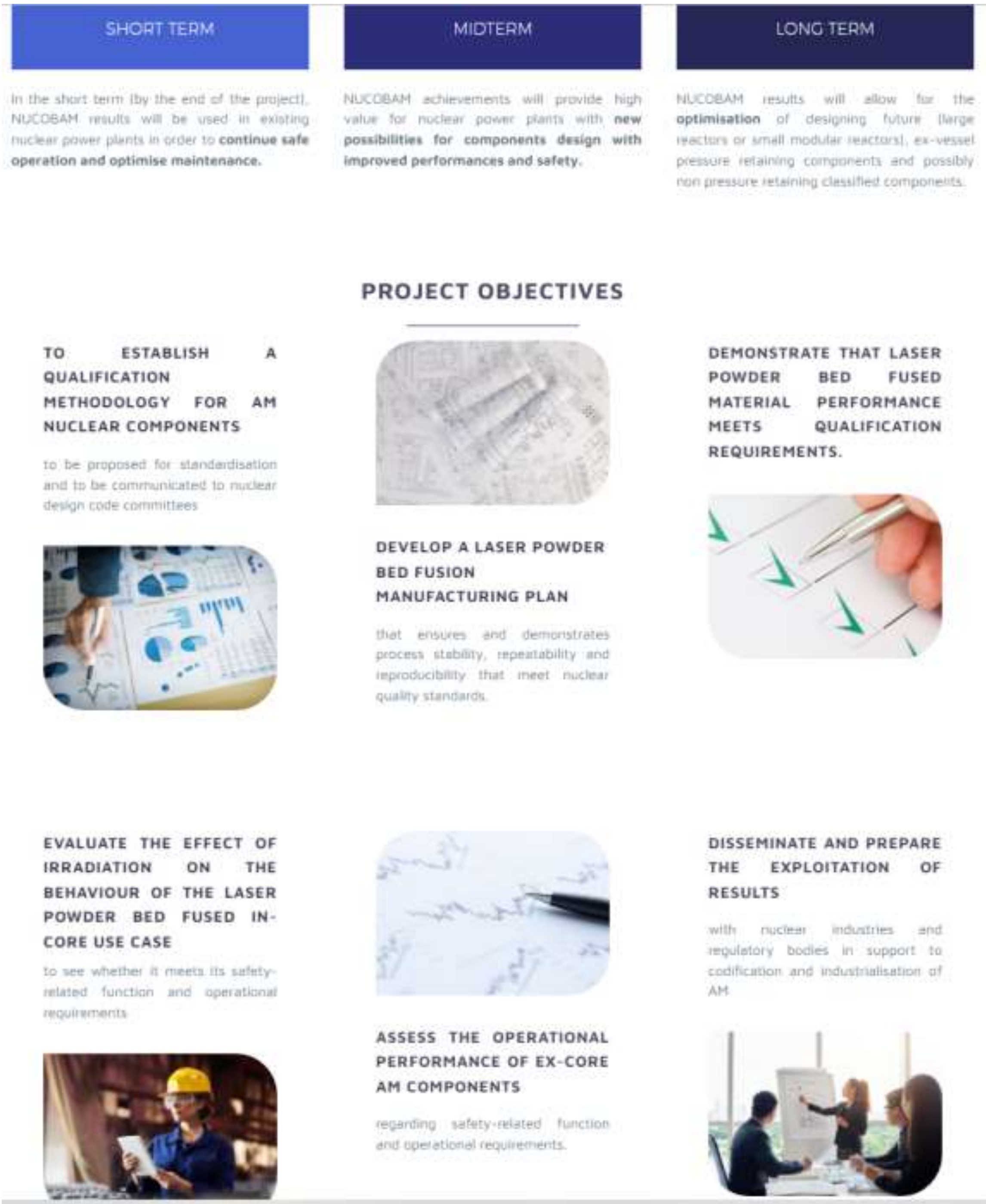
This work will **allow manufacturers and designers to evaluate and deduce the main parameters required for specification**. By gathering the main European industrial and research/academic players in the nuclear sector to participate in the project, NUCOBAM will directly contribute to the development of future nuclear safety policy. The project was awarded the SNETP label(formerly the NUGENIA label) for addressing issues in several Technical Areas (find the project factsheet on SNETP here).

Developments proposed in NUCOBAM will be used for 3 main applications in 3 different time frames:

SHORT TERM	MIDTERM	LONG TERM


SHORT TERM
In the short term (by the end of the project), NUCOBAM results will be used in existing nuclear power plants in order to continue safe operation and optimise maintenance.
MIDTERM
NUCOBAM achievements will provide high value for nuclear power plants with new possibilities for components design with improved performances and safety.
LONG TERM
NUCOBAM results will allow for the optimisation of designing future (large reactors or small modular reactors), ex-vessel pressure retaining components and possibly non pressure retaining classified components.
PROJECT OBJECTIVES
TO ESTABLISH A QUALIFICATION METHODOLOGY FOR AM NUCLEAR COMPONENTS
to be proposed for standardisation and to be communicated to nuclear design code committees
DEVELOP A LASER POWDER BED FUSION MANUFACTURING PLAN
that ensures and demonstrates process stability, repeatability and reproducibility that meet nuclear quality standards.
DEMONSTRATE THAT LASER POWDER BED FUSED MATERIAL PERFORMANCE MEETS QUALIFICATION REQUIREMENTS.
EVALUATE THE EFFECT OF IRRADIATION ON THE BEHAVIOUR OF THE LASER POWDER BED FUSED IN-CORE USE CASE
to see whether it meets its safety-related function and operational requirements
ASSESS THE OPERATIONAL PERFORMANCE OF EX-CORE AM COMPONENTS
regarding safety-related function and operational requirements.
DISSEMINATE AND PREPARE THE EXPLOITATION OF RESULTS
with nuclear industries and regulatory bodies in support to codification and industrialisation of AM

THE NUCOBAM CONSORTIUM

NUCOBAM brings together 13 partners from 6 different countries and each partner will bring their own complementary expertise and capabilities to the project. The consortium aims to demonstrate and validate the use of AM components in nuclear installations.

The partners include electricity utilities, operating nuclear assets, component manufacturers, design owners, public service experts in nuclear and radiation risks as well as research and competence centres involved in mechanical assessment, metal powder qualification, metallurgical characterisation, materials irradiation capabilities and nuclear power research.

COORDINATED BY:

The CEA is the French Alternative Energies and Atomic Energy Commission (Commissariat à l'Energie Atomique et aux Energies Alternatives). The CEA has a significant experience in both powder metallurgy and additive manufacturing process and play an important role the scientific research field dedicated to materials and new associated manufacturing processes.

Electricité de France (EDF) has the responsibility for generating, transmitting, and distributing electricity in France. EDF low carbon electricity mix is based for a large part on Nuclear Power. EDF operates one of the largest nuclear power plants capacity in the world with more than 70 reactors in operation.

ENGIE Laborelec is a leading expertise and research centre in electrical power technology and is active on the whole electricity value chain.

Tractebel provides a full range of services throughout the life cycle of its clients' projects. Tractebel is able to offer their customers multidisciplinary solutions in energy, water and infrastructure.

Naval Group is European leader in Naval Defense and a major player in Marine Renewable Energies. The Group is an international company with expertise in the design, production and through-life maintenance of submarines and surface vessels, and all their related systems and infrastructures.

Framatome designs, manufactures, and installs components, fuel and instrumentation and control systems for nuclear power plants and offers a full range of reactor services.

CIEMAT (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas) is a public research body assigned to the Ministry of Science, Innovation and Universities, focused on energy and environment and the technologies related to them.

Nuclear Advance Manufacturing Research Centre (AMRC) is owned by the University of Sheffield and part of the world-leading AMRC cluster based at the Advanced Manufacturing Park in South Yorkshire.

VTT is an RTO which activities are focused on three areas: Knowledge intensive products and services, Smart industry and energy systems, and Solutions for natural resources and environment.

SCK•CEN is one of the largest research institutions in Belgium. The Belgian reactor 2 (BR2) reactor group, the mechanical testing and corrosion group (MCA), microstructure and non-destructive examination group (MNA) and infrastructure operation (ICP) group are participating in the NUCOBAM project.

The Joint Research Centre (JRC) supports EU policies with independent scientific evidence throughout the whole policy cycle. Nuclear activities of JRC cover R&D and policy support on reactor safety, nuclear fuels, waste & decommissioning, nuclear security & safeguards and non-energy applications of nuclear energy.

Ramén is a manufacturer and supplier of valves for the industrial market. They will provide a 3D drawing of the valve body so that it can be 3D printed by other participants. Ramén valves will then assemble this 3D body with the valve's internals that will be produced for this project.

The Institute for Radiological Protection and Nuclear Safety (IRSN) is the French public service expert in nuclear and radiation risks, and its activities cover all the related scientific and technical issues.