

AGENDA



Time	Title	Speaker
10:00 – 10:05	Welcoming and Introduction	Lorenzo Malerba, CIEMAT, CONNECT-NM Coordinator
10:05 – 10:15	Introductory words by European Commission	Mykola Džubinský, EC
10:15 – 10:25	Overview of the CONNECT-NM Partnership	Lorenzo Malerba, CIEMAT
10:25 – 10:45	Information on the Call 2025 - Eligibility, process overview, and guidance for Phase 1 applications	Marjorie Bertolus, CEA
10:45 – 10:55	General Q&A session	
10:55 – 11:25	Presentation of the Research Lines <ul style="list-style-type: none">• Knowledge and data management (RL1)• Advanced materials development and manufacturing (RL2)	<ul style="list-style-type: none">• Michal Pecelerowicz, NCBJ• Marialuisa Gentile, Newcleo
11:25 – 11:40	Coffe Break	
11:40 – 12:25	Presentation of the Research Lines <ul style="list-style-type: none">• Materials and component qualification: testing, standardisation and design rules (RL3)• Non-destructive examination and materials health monitoring (RL4)• Advanced materials modelling and characterisation (RL5)	<ul style="list-style-type: none">• Massimo Angiolini, ENEA• Madalina Rabung, Fraunhofer• Maria Oksa, VTT
12:25 – 12:55	Q&A session on Research Lines	
12:55 – 13:00	Closing Remarks	Lorenzo Malerba, CIEMAT



Coordination of the
European Research
Community on Nuclear
Materials for Energy
Innovation

CONNECT-NM Information Day

Welcoming and Introduction

Lorenzo Malerba, CIEMAT, CONNECT-NM Coordinator



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EURATOM 2021-2025 PROGRAMME

European Partnerships: competitive calls

Connect-NM Info Day, 28/01/2025

Dr. Mykola Džubinský
EC, DG RTD, C4 – Euratom unit



OVERVIEW

- **European Partnerships**
- Connect-NM co-fund EP
- Connect-NM Call for proposals: main principles



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European Partnerships 1/2

- The aim of European Partnerships is to **deliver on global challenges** and to **modernise industry**.
- European Partnerships are designed to respond to ambitious and complex objectives that are the most effectively addressed by providing a framework for collaboration at the **programme level** between the **European Union/Euratom** and **public and private partners**.
- **Critical mass** and a **long-term vision** that is agreed and committed to by the respective actors

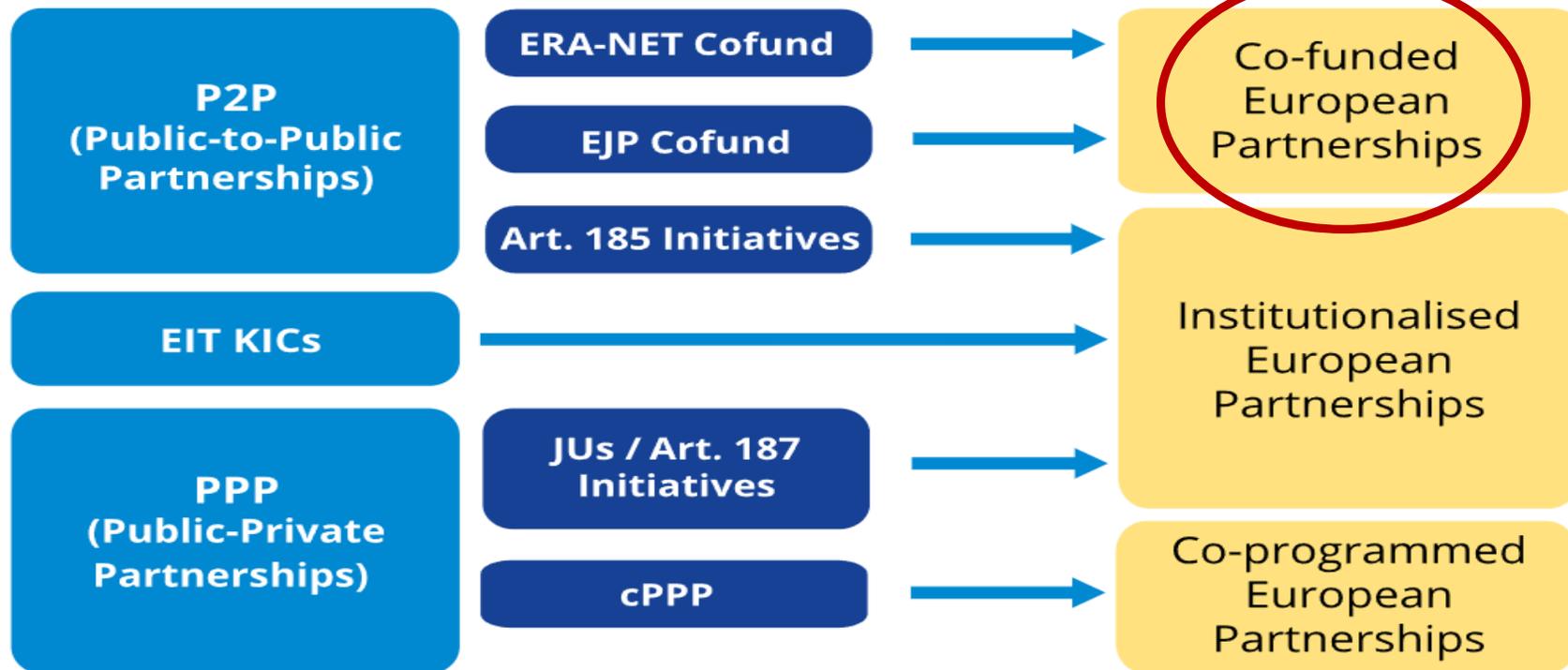
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European Partnerships 2/2

Horizon 2020

Horizon Europe



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OVERVIEW

- European Partnerships
- **Connect-NM co-fund EP**
- Connect-NM Call for proposals: main principles



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Connect-NM co-fund EP 1/2

- Array of “classical” Euratom projects dealing with **materials problems of LTO, structural materials for advanced reactors, nuclear fuels** – at least over FP6, FP7, Horizon 2020 and Horizon Europe (2003 – today).
- Discussion about **European Joint Programme in nuclear materials** started **>10 years ago**.
- Consolidation of the domain via **EERA Joint Programme on Nuclear Materials** – initially structural materials, later extended for nuclear fuels.

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Connect-NM co-fund EP 2/2

- **Orient-NM** (Organisation of the European Research Community on Nuclear Materials) Euratom project, October 2020 – March 2023.
- Orient-NM produced **Vision Paper, Strategic Research Agenda** and (draft) **EJP structure**.
- Call for proposals in **Euratom WP 2023-2025** for co-funded European Partnership in nuclear materials
- **Connect-NM** (Coordination of the European Research Community on Nuclear Materials for Energy Innovation) Euratom co-funded European Partnership, October 2024 – September 2029 (+?).

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OVERVIEW



- European Partnerships
- Connect-NM co-fund EP
- **Connect-NM Call for proposals: main principles**

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Connect-NM Call for proposals: main principles 1/2

- Funding modalities possible in co-fund EP:
 - either via **direct implementation** of Description of Work (“classical project”)
 - or **cascading call** (or **mix**)
- 25/01/2025 call for (cascading) proposals in Connect-NM has been published on [EU Funding and Tenders Portal](#) and on [Connect-NM web-site](#)
- 2 phase call, **Project Ideas** and **Project Proposals**, with a **Brokerage Event** in-between

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Connect-NM Call for proposals: main principles 2/2

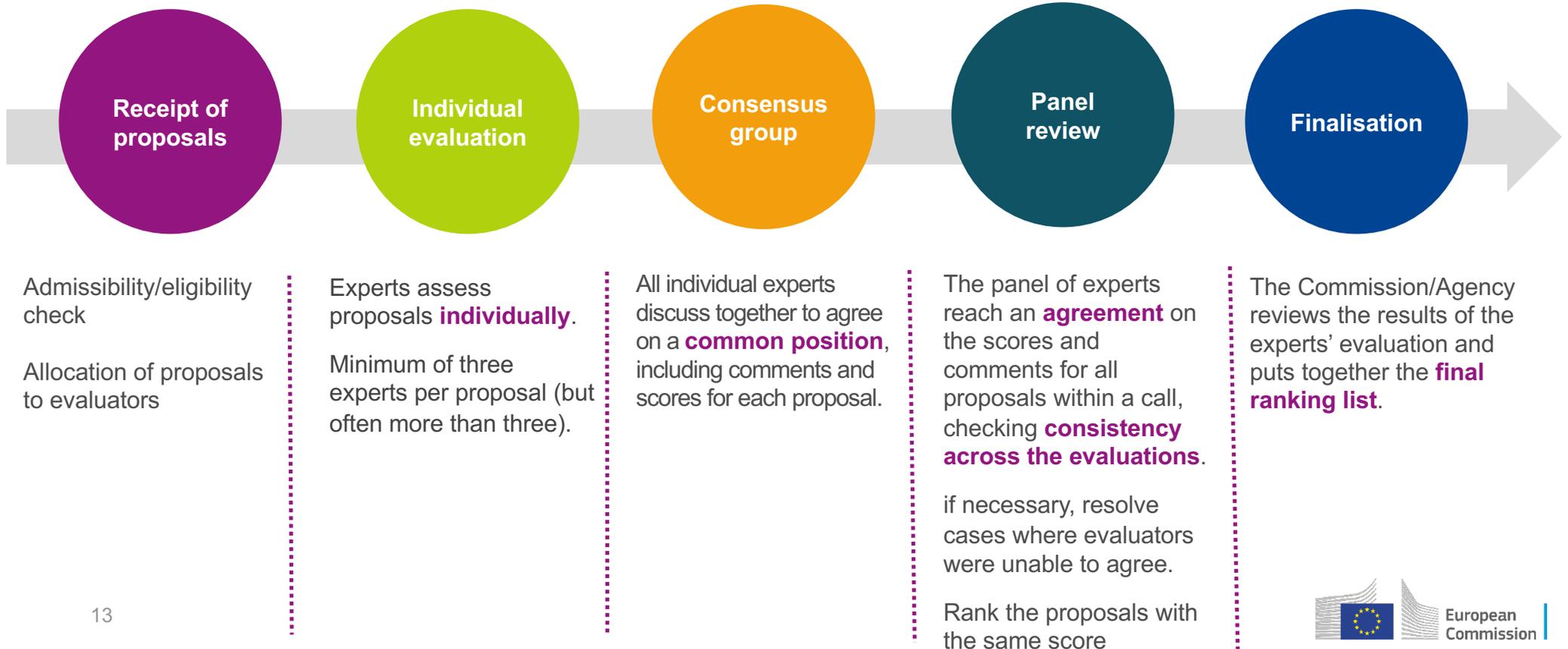
- **Competitive character** of the call (opened, transparent, no preferential treatments within defined call conditions, etc.)
- Proposals/projects correspond to the **thematic priorities defined by Description of Action**.
- **Impartial/Independent** evaluation (**no conflict of interests** for experts!)

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Standard evaluation process (example!)





Guiding principles for experts (example!)

Independence

- You are evaluating in a personal capacity.
- You represent neither your employer, nor your country!

Impartiality

- You must treat all proposals equally and evaluate them impartially on their merits, irrespective of their origin or the identity of the applicants.

Objectivity

- You evaluate each proposal as submitted, meaning on its own merit, not its potential if certain changes were to be made.

Accuracy

- You make your judgment against the official evaluation criteria and the call or topic the proposal addresses and nothing else.

Consistency

- You apply the same standard of judgment to all proposals



Conflicts of interest (example!)

You have a COI if you:

Were involved in the preparation of the proposal.

Stand to benefit directly/indirectly, if the proposal is successful or fails.

Have a close family/personal relationship with any person representing an applicant legal entity.

Are a director/trustee/partner of an applicant or involved in the management of an applicant's organisation.

Are employed or contracted by an applicant or a named subcontractor.

Are a member of an Advisory Group or Programme Committee in an area related to the call in question.

Are a National Contact Point or are directly working for the Enterprise Europe Network.

Are involved in a competing proposal.



Thank you!

Euratom

https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/euratom-research-and-training-programme_en



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CONNECT-NM: The EURATOM Co-funded Partnership on Nuclear Materials

Lorenzo Malerba, CIEMAT, CONNECT-NM Coordinator



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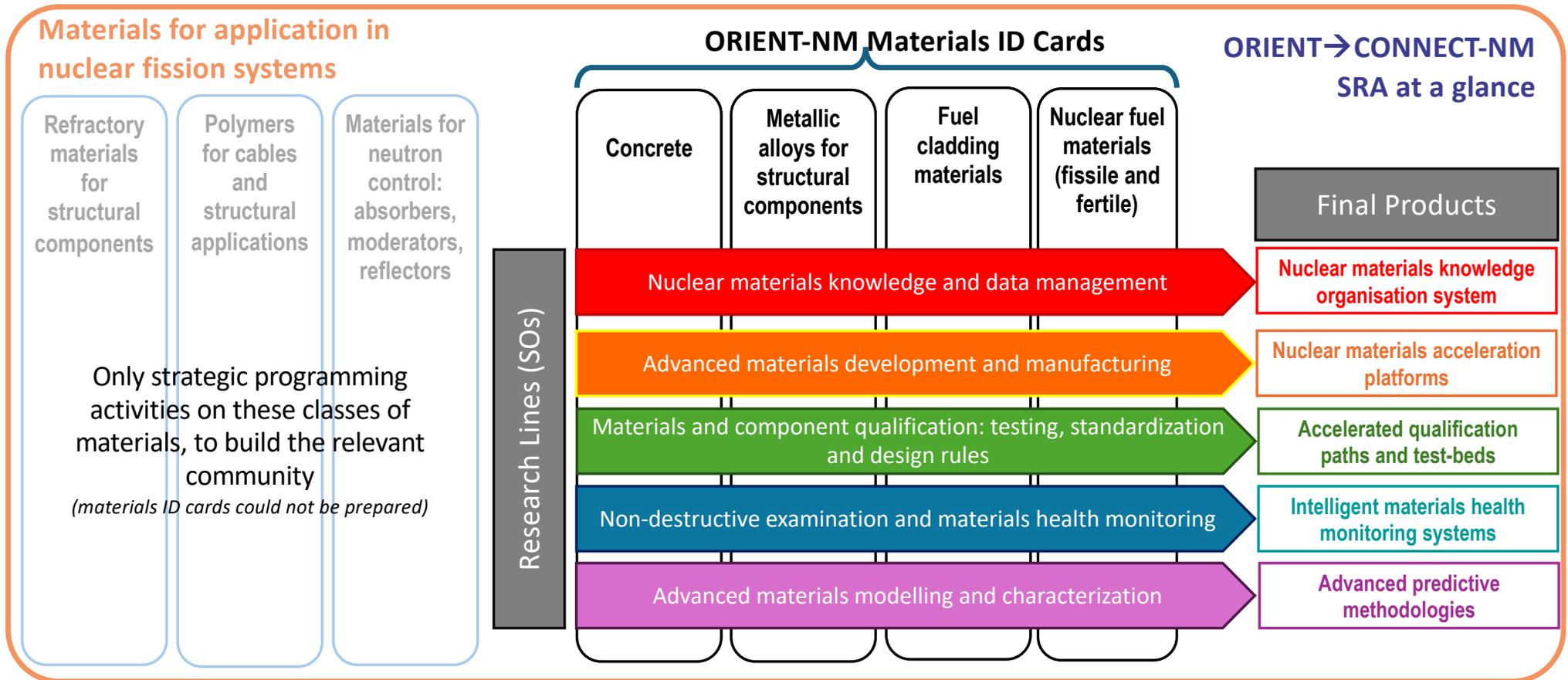
CONNECT-NM ambition and objectives

The ambition of CONNECT-NM is to strengthen safety and sustainability of nuclear energy by promoting innovation in the field of materials, through the coordinated use of national competences, facilities and infrastructures in Europe, in pursuance of the common goal of a shift of paradigm in nuclear materials research: from ‘observe and qualify’, to ‘design and control’

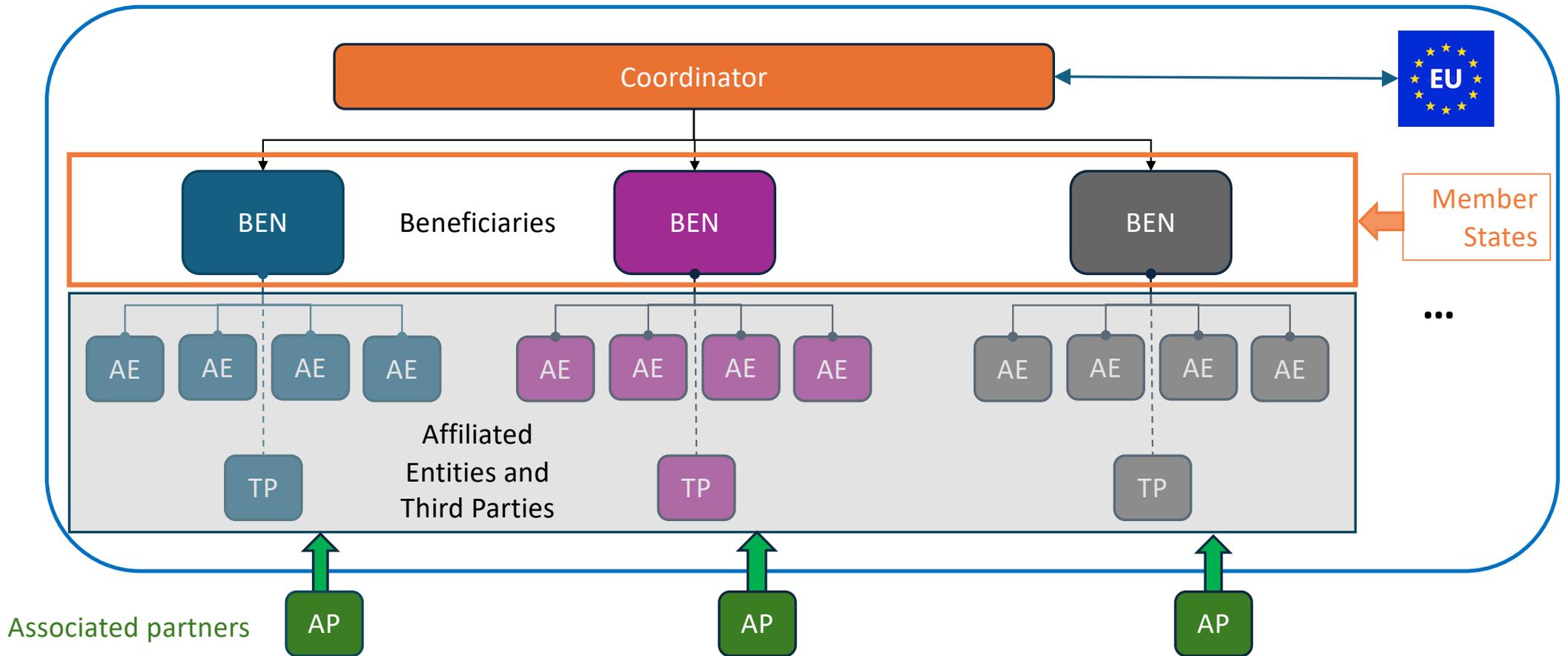
(Annex to Grant Agreement)

Specific objectives
SO1: To <u>reduce drastically the time</u> required to improve, develop, and even discover new or advanced nuclear materials and elaborate advanced manufacturing processes
SO2: To <u>accelerate the qualification</u> of nuclear materials for safe operation.
SO3: To enable safer and more efficient <u>management of the lifetime</u> of nuclear components
SO4: To improve the <u>capability of prediction</u> of the behaviour of nuclear materials in operation
SO5: To create the conditions for <u>nuclear materials data</u> to be correctly collected and stored, so as to be fruitfully analysed and used

CONNECT-NM: a goal-oriented Partnership

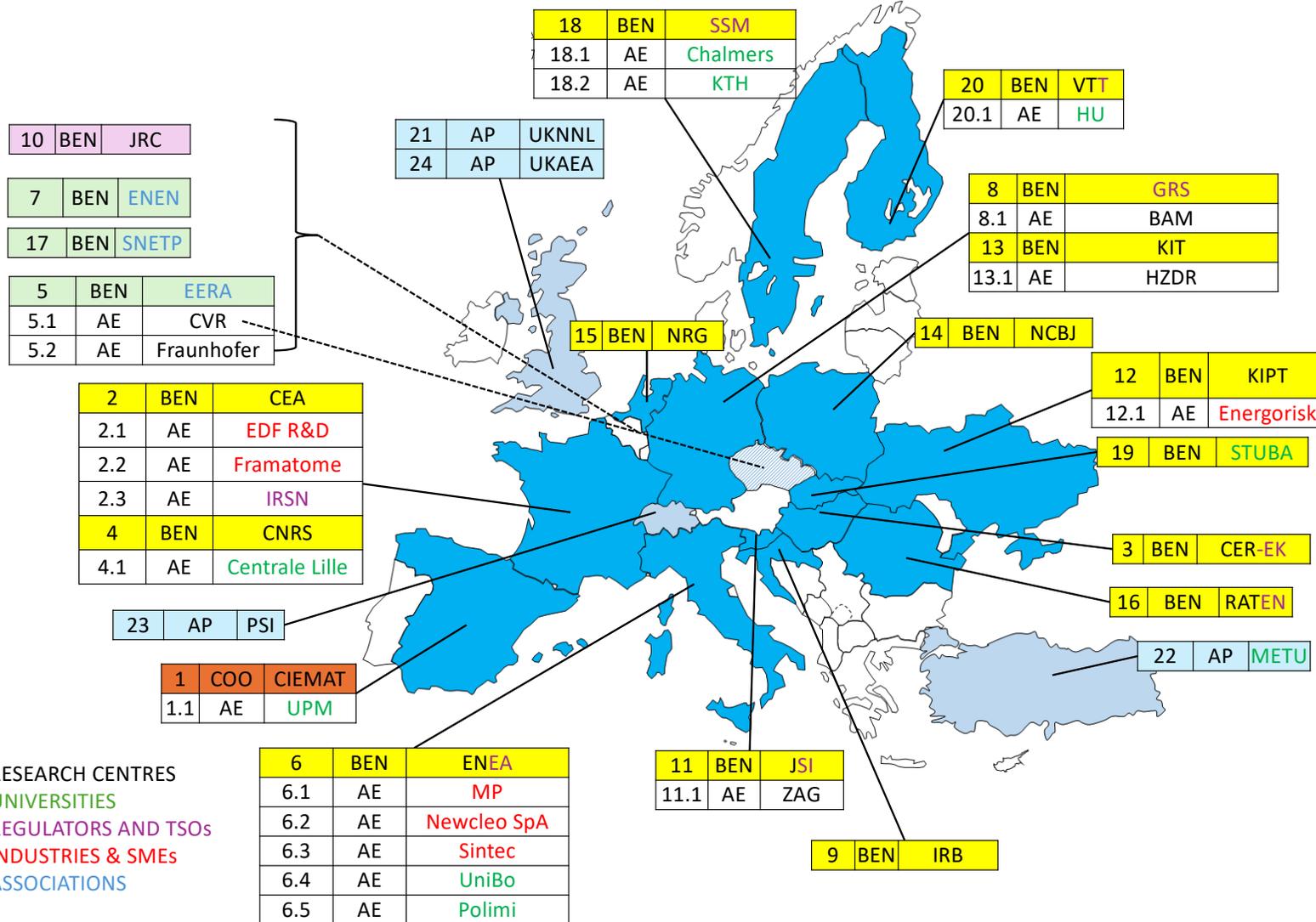


A complex architecture, with the advantage of flexibility



This complexity has several advantages. The formation of national clusters is encouraged. But especially, **participation is open to anyone**, although with different financial rights and treatments, and **participants can be taken on board along the way**.

The current consortium will grow



RESEARCH CENTRES
UNIVERSITIES
REGULATORS AND TSOs
INDUSTRIES & SMEs
ASSOCIATIONS

In total **18 countries** are represented: 14 through beneficiaries, 3 as associated partners, 1 as affiliated entity.

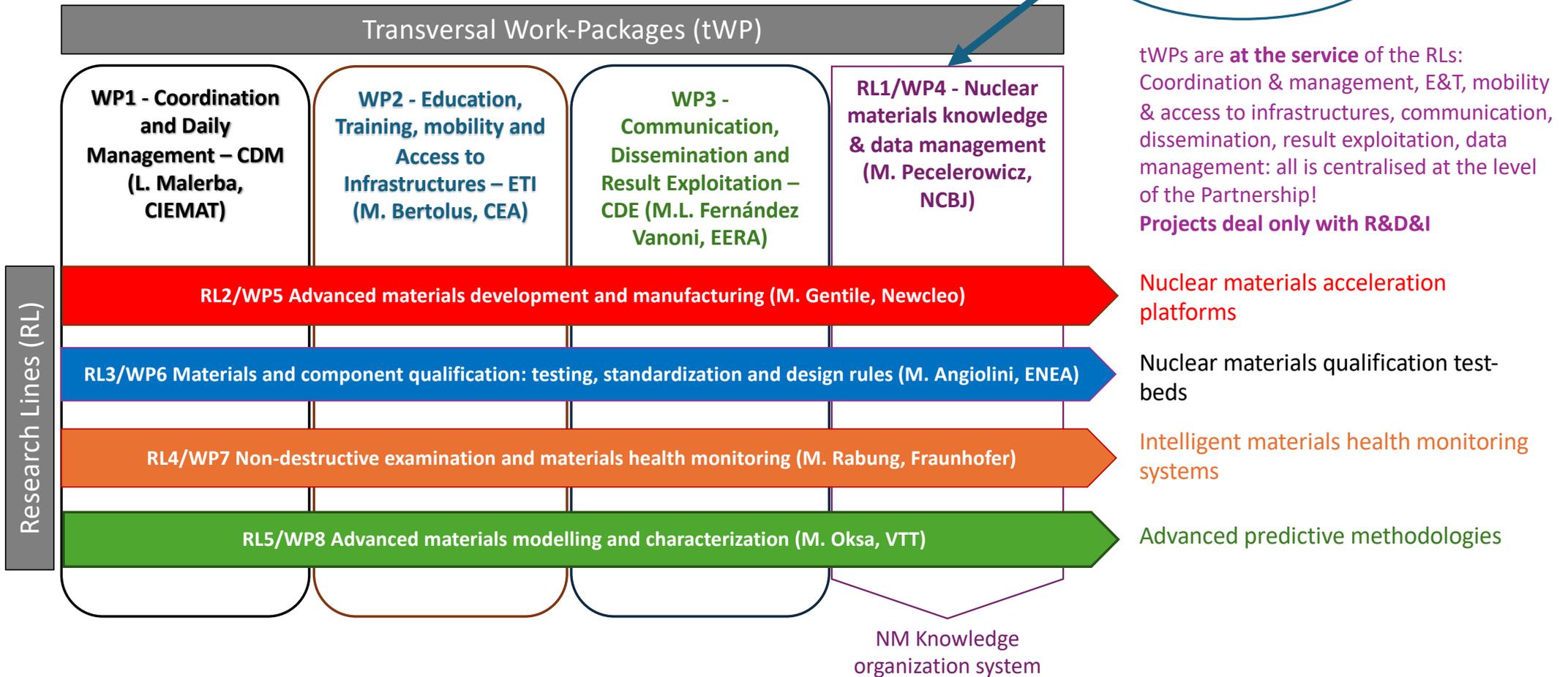
With EERA, SNETP and ENEN, as well as JRC → **20 beneficiaries** (and as many affiliated entities)

The list of AEs & TPs will grow

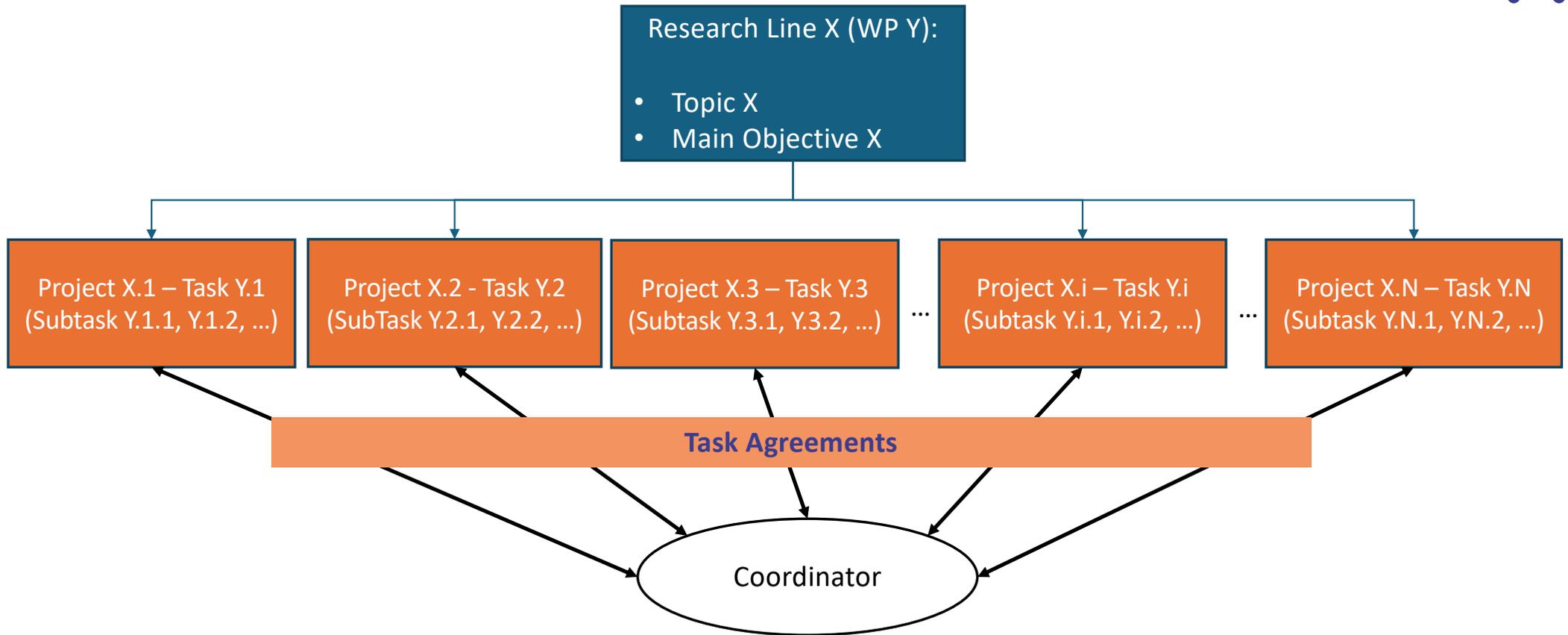
The involvement of platforms (EERA, ENEN, SNETP) is a crucial asset!

CONNECT-NM work-package breakdown: centralisation and devolution

“Transversal Research Line”!



Research lines are project containers



Projects will be selected via **open call(s)**: transparent and effective mechanism to define priorities, matching top-down scope and expectations (RLs, SOs, final products) with bottom-up interests of consortia (nuclear systems and relevant materials). However, (small) **pre-selected** preparatory **projects** have been defined that will start from the beginning of CONNECT-NM.

A few words about money

- Current total budget: **36.36 M€**
- Current Euratom contribution: **20 M€ (55%)**
- Reimbursement rates (applied by decision of the consortium / EC contribution is strictly 55%):

Type of activity	Type of organisation	Funding rate
Non-R&D&I	Association, University, SME	100%
	All others	70%
R&D&I (projects)	Any type of organization	50%

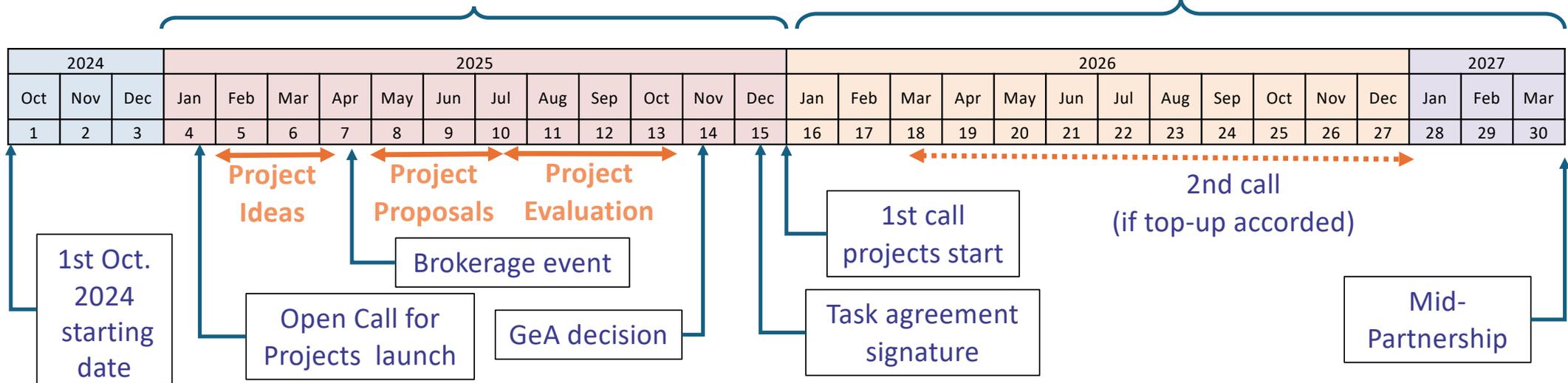
- Total cost of 5 year long “transversal” activities (incl. indirect): 6.21 M€ (Euratom contribution: 4.36 M€)
- Total cost of ~1 year long pre-selected projects (incl. indirect): 2.24 M€ (Euratom contribution: 1.12 M€)
- **Total available for call-selected projects (incl. indirect): 27 M€ (EC contribution: 13.5 M€)**
- **Max. contribution per Project: 900 k€(EC)/Project (target: min. 15 Projects funded)**



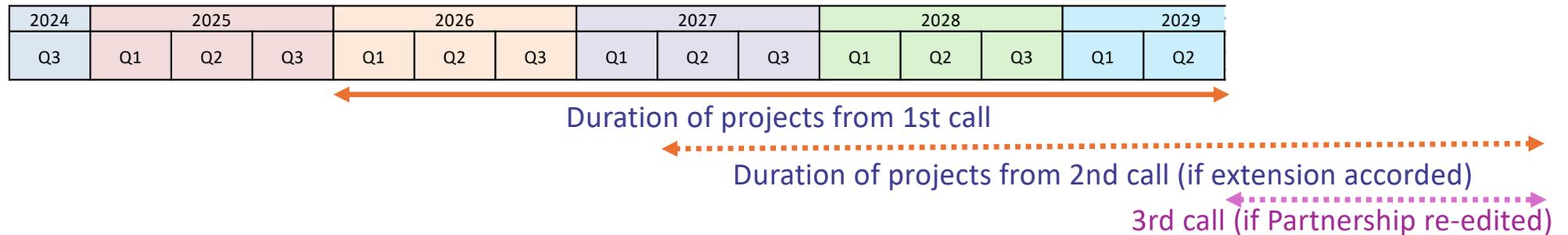
Partnership's timeline

Preparation Euratom FP extension and WP 2026-27

Euratom WP 2026-2027
Top-up funding accorded?



Longer term planning



Next Framework Programme

Thank you!

lorenzo.malerba@ciemat.es



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Call 2025: Eligibility, Process Overview, and Guidance for Phase 1 Applications

M. Bertolus, CEA

2025 Call Infoday, Online meeting, January 28, 2025



This project has received funding from the Euratom Research and Training Programme under Grant Agreement No. 101165375

Content of Presentation



- Eligibility
- Submission and selection: overview of the process
- Guidance for Phase 1 Applications





Eligibility

Consortium and Project Participants



- Project consortia must be formed by a minimum of **three independent legal entities from two different EU Member States or countries associated with the Euratom Research and Training Programme**
- **The call is open to research partners from all over the world**, excluding only persons, groups and entities subject to EU financial administrative sanction or are in an exclusion situation
- Organisations from countries not associated with Euratom are not eligible to receive funding from the EC
- **Participants can be Beneficiaries, Affiliated Entities or Associated Partners** already part of the CONNECT-NM Consortium, or organisations not currently in the Partnership but can qualify as one of these categories, **or Third Parties**
- The inclusion of at least one end-user (industry, TSO, regulator...) in the Project Consortium is highly recommended
- Better gender-balanced Projects will be ranked better in case of equal scoring



Project Leading Organisation and Project Leader



- The **Project Leading Organisation must be a Beneficiary or an Affiliated Entity**, current consortium member (preferably) or that can be included in the Consortium with this status, via the post-call amendment of the GrA
- A permanent employee of the project leading organisation shall be appointed as **Project Leader (PL)**
- The PL will be the contact person for any communication that concerns the Project idea / Project proposal and will be responsible for submitting the proposal according to the procedures
- The PL will also act as intermediary between the Project Consortium and the Executive Board of CONNECT-NM, especially with the Coordinator and the Leader of the Research Line to which the Project belongs, as well as the Management Support Office (MSO) of CONNECT-NM



Project Proposal Objective and Scope



- The activities of the Project Proposal shall be aligned with the **Strategic Research Agenda and the materials ID cards produced in ORIENT-NM**, on which the Open Call Work-Programme is based
- It should contribute to the **specific objective of at least one research line of CONNECT-NM** and to realise the final product of this RL

#	Research line	Specific objective	Final product
1	Knowledge and Data Management	To create the conditions for nuclear materials data to be correctly collected and stored, so as to be fruitfully analysed and used	Nuclear materials knowledge organisation system
2	Advanced materials development and manufacturing	To reduce drastically the time required to improve, develop, and even discover new or advanced nuclear materials and elaborate advanced manufacturing processes	Nuclear materials acceleration platforms and advanced manufacturing processes
3	Materials and component qualification: testing, standardization and design rules	To accelerate the qualification of nuclear materials for safe operation	Nuclear materials qualification test-beds for accelerated qualification
4	Non-destructive examination and materials health monitoring	To enable safer and more efficient management of the lifetime of nuclear components	Intelligent materials health monitoring systems
5	Advanced materials modelling and characterization	To improve the capability of prediction of the behaviour of nuclear materials in operation	Advanced predictive methodologies

Materials / Materials' Issues



- Proposals should focus on material(s) or materials' issues of demonstrated interest for current or future generation nuclear fission power plants, without restrictions on the type of nuclear fission system
- The activities of the Project Proposal shall concern nuclear materials belonging to (at least one of) the four categories considered in CONNECT-NM



- The materials and nuclear systems selected in the Project proposal will correspond to a case study to which the research line methodology is applied
- The proposal should set up a sufficiently generalizable methodology that should be extendable to applications to other materials

Funding Rate and Financial Provisions



- **The funding rate of Projects in CONNECT-NM is 50% of the eligible costs claimed**
- Complement is needed from national, regional or institutional funding
- Project consortia or specific partners in consortia may decide to receive less than this amount
- **The maximum amount of EC grant per project is 900 k€**
- Proposers can ask for a higher amount, which might be accorded if the quality of the proposal is outstanding and if it is compatible with the financial possibilities of the Partnership
- The budget of this call of CONNECT-NM is 13.500.000 € (EC contribution)



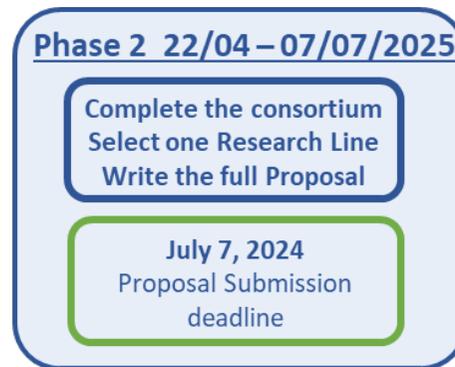
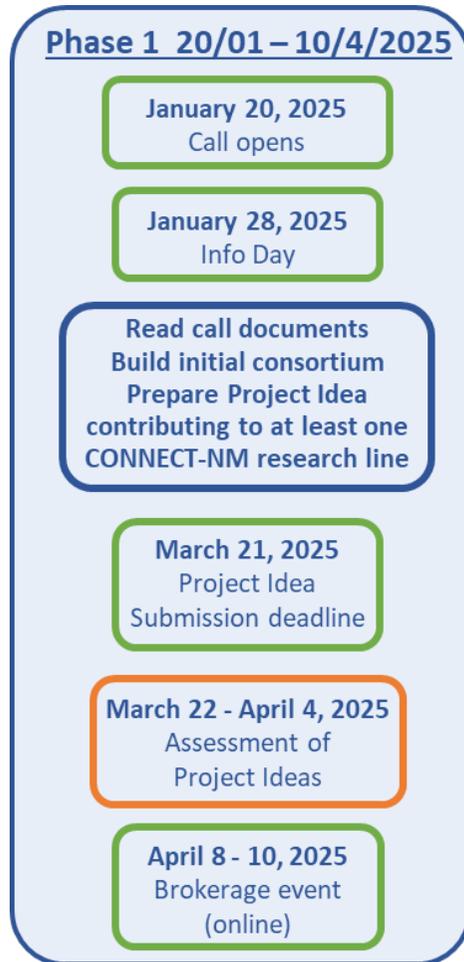
A network diagram background consisting of a grid of interconnected nodes and lines. The nodes are represented by circles of varying shades of orange and brown, connected by thin, light-colored lines. The overall color scheme transitions from a light orange on the left to a dark blue on the right.

Submission and selection: overview of the process

Schematics of Proposal Submission and Evaluation



The proposal submission procedure will occur in two phases





Documents available

- **Open Call Announcement:** short document announcing the call and summarizing the participation conditions
- **Open Call Work-Programme:** document that explains the topics on which Project proposals can be presented within each research line (RL), including objectives, scope, expected output and outcome, expected impact
- **Open Call guide for proposers:** schematic document with practical information about how to submit a proposal
- **Project Idea Template** template (Word and RTF format) to be used to submit Project Ideas in the first phase of the submission procedure
- **Project Proposal Template:** template to be used to submit full Project Proposals in the second phase of the procedure
- **Open Call Procedures:** reference document that describes in detail the procedures applied in the various steps of the Open Call for Projects
- **CONNECT-NM Project Proposal Evaluation Criteria and Scoring System:** version for proposers (information purposes)

All these documents will become progressively available in the [“Call-for-project-documents” directory](#) of the CONNECT-NM website

A network diagram background consisting of a grid of interconnected nodes and lines. The nodes are represented by circles of varying shades of orange and brown, connected by thin, light-colored lines. The overall color scheme transitions from a light orange on the left to a dark blue on the right.

Guidance for Phase 1 Applications

Preparation of a Project Idea



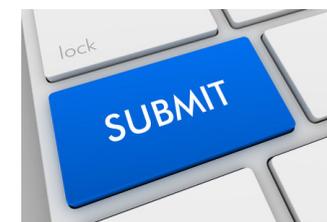
- Read the Open Call documents and strategic research agenda of the Partnership
- After having read the sections “Project requirements per Research Line” of the Open Call Work Programme, select up to three research lines to which your Project idea will be contributing
- **Build an initial consortium**
- **Prepare your Project Idea with your consortium using the Project Idea template provided**
- Proposers using generative artificial intelligence (AI) tools for the proposal preparation are fully responsible for the content of the proposal and must indicate which AI tools were used and how they were utilized



Submission of a Project Idea



- Send an email to the Management Support Office (MSO) of CONNECT-NM (info@connect-nm.eu) to inform of your intention of submitting a Project Idea, indicating the name (acronym) and prospective title of your Project Idea
- The MSO will create a folder with the name of your Project Idea in the directory dedicated to the 1st submission phase of the restricted area of CONNECT-NM website
- This folder will be accessible to the Project Idea Leader in writing mode until the Project Idea submission deadline
- **Submit your project idea by March 21, 2025, at 23.59 (CET) by uploading an electronically signed pdf file of your Project idea in the Project Idea folder**
- Submission via the CONNECT-NM repository is mandatory, applications sent by email, post or any other channels will not be accepted
- Consider that the CONNECT-NM website may be overloaded close to the deadline so upload the final version of the Project Idea enough in advance to respect the deadline



Assessment of the Project Ideas



- The CONNECT-NM Executive Board will assess the consistency of the Project Ideas with the call content and with predefined general eligibility criteria, including national eligibility checks and overlaps with other proposals

On a case-by-case basis, evaluators that may have conflicts of interest will be excluded from the specific discussion of that Project Idea

- Non-binding advice of proposal merging or modification, as well on which Research Line to choose, will be given
- Some proposals may receive the non-binding recommendation not to proceed to the second phase so that the Project Proposals from the 2nd phase are all eligible and competitive and overall cover the various Research Lines and materials of interest in a balanced way



Brokerage Event



- A Brokerage Event will take place online between April 8 and 10, 2025 to facilitate networking
- The exact dates and times will be communicated when the number of Project Ideas likely to be submitted is known
- At this event, the Project leaders will present their Project Idea, stressing the capacities required to achieve the relevant objectives (without necessarily discussing aspects that the consortium may prefer to keep confidential) and exchange with CONNECT-NM management, research line coordinators and advisors, as well as potential participants
- Other participants will briefly describe their competencies and capabilities to contribute to the CONNECT-NM Research Lines and to the Project Proposals that will be developed from the Project Ideas

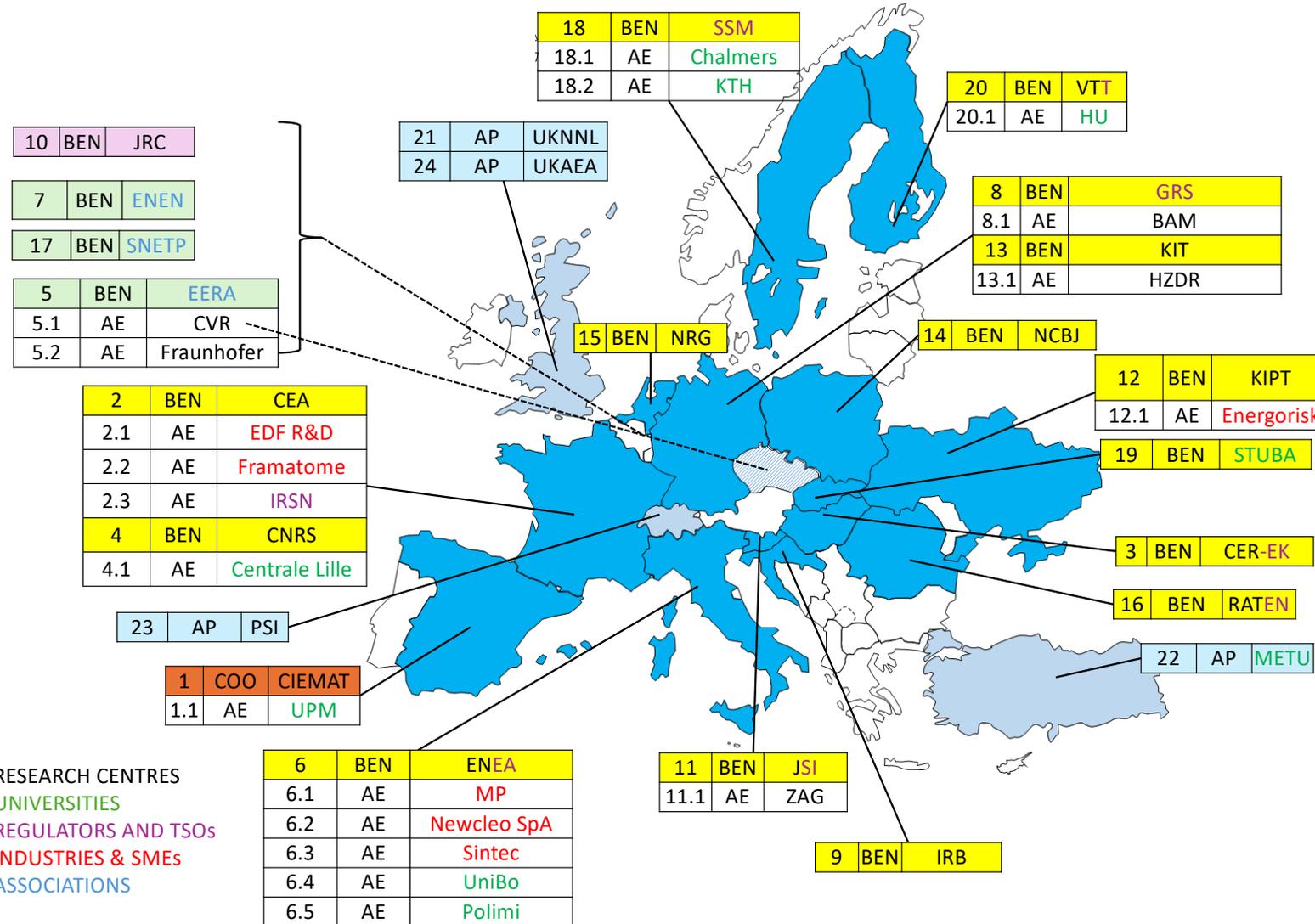


Thank you!



This project has received funding from the Euratom Research and Training Programme under Grant Agreement No. 101165375

Current Consortium members



In total **18 countries** are represented: 14 through beneficiaries, 3 as associated partners, 1 as affiliated entity.

With EERA, SNETP and ENEN, as well as JRC → **20 beneficiaries** (and as many affiliated entities)

The list of AEs & TPs will grow

The involvement of platforms (EERA, ENEN, SNETP) is a crucial asset!

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General Q&A session



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Research Line 1: Nuclear Data and Knowledge Management

Michał Pecelerowicz, IT Specialist, WP4-RL1 Leader

Infoday, online, 28.01.2025



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Table of contents

- **The scope and objectives of the RL1**

- Challenges & goals – data complexity, fragmentation, dispersal
- Structured framework – Nuclear Materials Knowledge Organization System (NM-KOS)
- Semantic Web Technologies

- **The expected results from the projects**

- Creation, extension, population of nuclear materials databases
- Development of interfaces (data upload, extraction, use, analysis)
- Development of dedicated domain ontology

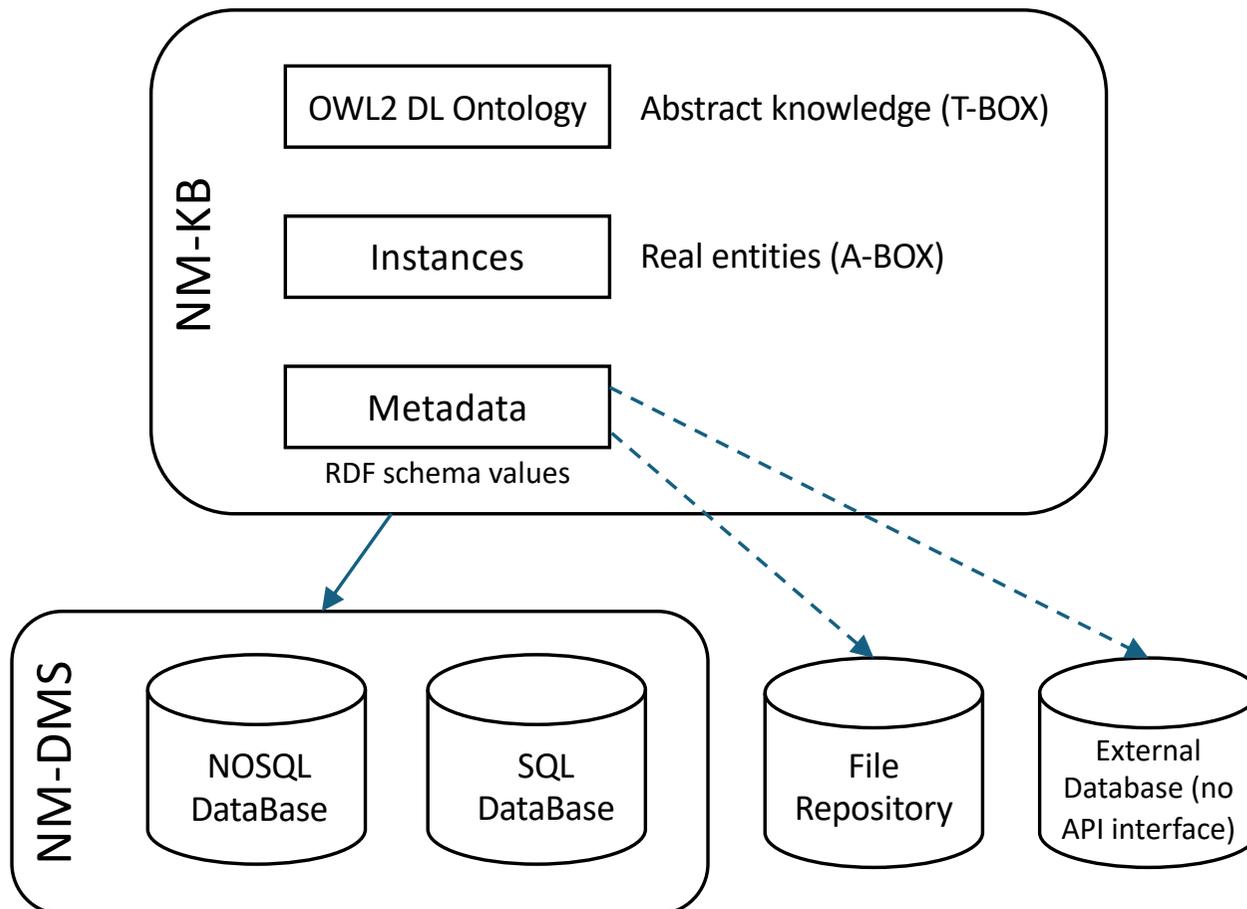
- **The expected outcome and impact**

- Single Open Knowledge Framework
- Acceleration of innovation in the nuclear materials field
- Improving FAIR
- Collaborative network among stakeholders

The scope and objectives – challenges & goals

- **Data complexity and diversity** (*interdisciplinary–multiple disciplines; dependence on data; complex datasets; different scales, formats; experiments, simulations, sensor readings*)
 - **Low data interoperability** (*different disciplines, terminologies, methodologies, formats; lack of standardization-limited data integration; hindered data utilization, interdisciplinary collaboration*)
 - **Data dispersal** (*scattered locations, fragmentation; no centralized view – limited collaboration, cross-disciplinary research*)
 - **Usability barriers** (*numerous systems, steep learning curve*)
-
- Complying with the **FAIR** principles
 - Leveraging **modern technologies** (automatic retrieval, reasoning, AI)
 - Facilitating **faster innovations, ideas discovery; exploitation of existing knowledge**, ultimately promoting the **paradigm shift – from observe&qualify to design&control**.

The scope and objectives – data & knowledge framework



- **NM-KOS** (Semantic technologies, industry-ready software, 2-layered system)
- **NM-DMS** (Stores actual data; project activities, external databases; SQL, NOSQL)
- **NM-KB** (Graph database to store abstract knowledge – metadata, domain entities, mappings. Ontologies to define relationships)
- **KB integrates with DMS** (contextual insights, ontology-based search and retrieval)

The scope and objectives – data & knowledge framework



Two layer architecture advantages:

- Separation of the data layer from the semantic layer – modularity, flexibility, reduced dependency; easier for future expansions.
- Enhanced usability – user friendly, focus only on the DMS; semantic-based tools, complex relationships in the data.

Expected Results

- **Projects are expected to contribute to the construction of both layers of the NM-KOS.**
- **Projects are expected to encompass the following levels:**
 - Creation/extension/population of databases for NM in specific domains (experimental, modeling); Demonstrating strong commitment from the data-generating entities.
 - Development of user-friendly interfaces for data upload, extraction, use, and analysis; suitable data formats (Excel, CSV templates, JSON schemas) – to facilitate uploading/retrieval by end users. Documentation of data entries with references to authoritative sources (e.g., ISO, IAEA standards) – for clear interpretation of data, support of semantically robust database development. Data quality assessment criteria.
 - Development of a dedicated domain ontology and specific application ontologies for each database, based on the documentation provided with each dataset – consistent with the guidelines provided in the documentation of the RL1 PSP – *NM-KB documentation and implementation*, and based on the same EMMO ontological framework. Semantic ontology layer on top of the databases (e.g. Ontop + SQL database) to provide a SPARQL endpoint based on the domain and application ontologies.

Expected Results (2)

- Each project should provide Data Management system for the relevant domains (with a KB layer – SPARQL endpoint).
- Projects should work toward creating a federated data space with a virtualized SPARQL endpoint (unified querying across diverse sources).
- NM-DMS should use technologies compatible with graph database virtualization interfaces (e.g. ENTENTE, JRC's MatDB).
- Projects should leverage the latest advances in ontology development (EMMO), and follow guidelines provided by EMMC and EMCC.
- Relevant documentation by IAEA:
https://www-pub.iaea.org/MTCD/Publications/PDF/P1899_web.pdf
- Connection of the Project proposals with Projects of other RLs is appreciated.



Expected outcome and impact

- **Contribution to the creation of a single open knowledge framework for the European NM domain, with a common access to NM databases (linking data from diverse sources and ensuring data quality control).**
- **The framework should provide a fast access to well-structured and semantically enriched data.**
- **Acceleration innovation in the nuclear field (reduction of the time needed to introduce new materials for specific nuclear applications).**
- **Increasing the number and availability of FAIR nuclear materials databases (withing specific domains, and expanding the number of domains)**
- **Contribution to establishing a collaborative network among stakeholders within nuclear materials modeling.**

Thank you!

Michal.Pecelerowicz@ncbj.gov.pl



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Coffee Break
We are back
at 11.40





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Research Line 2

Advanced Materials Development and Manufacturing

Marialuisa Gentile – *newcleo* Senior Materials Scientist / RL2 Leader

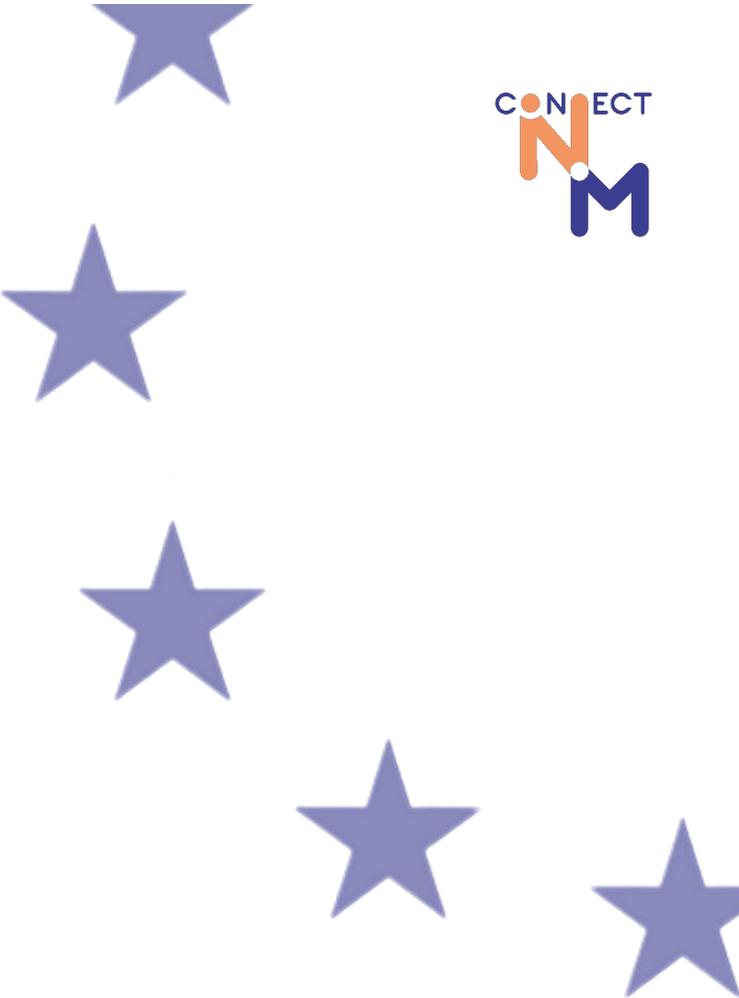
Infoday, January 28th 2025



This project has received funding from the Euratom Research and Training Programme under Grant Agreement No. 101165375

Table of contents

- 1. Research Line 2 Overview**
 - Research Approach
 - Materials Acceleration Platforms
- 2. Scope and Objectives**
 - RL2 Focus
 - Research Priorities
- 3. Expected Results**
 - Final Goal and Challenges
 - Key activities and results
- 4. Expected Outcome and Impact**



Research Line 2: Overview

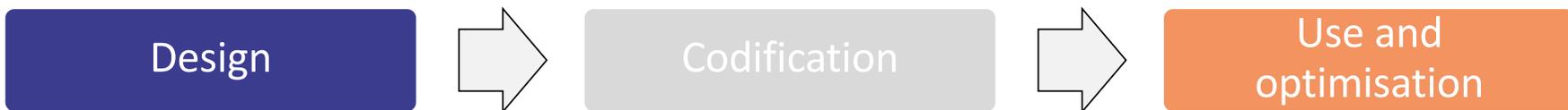


TRIAL AND ERROR APPROACH



PARADIGM SHIFT

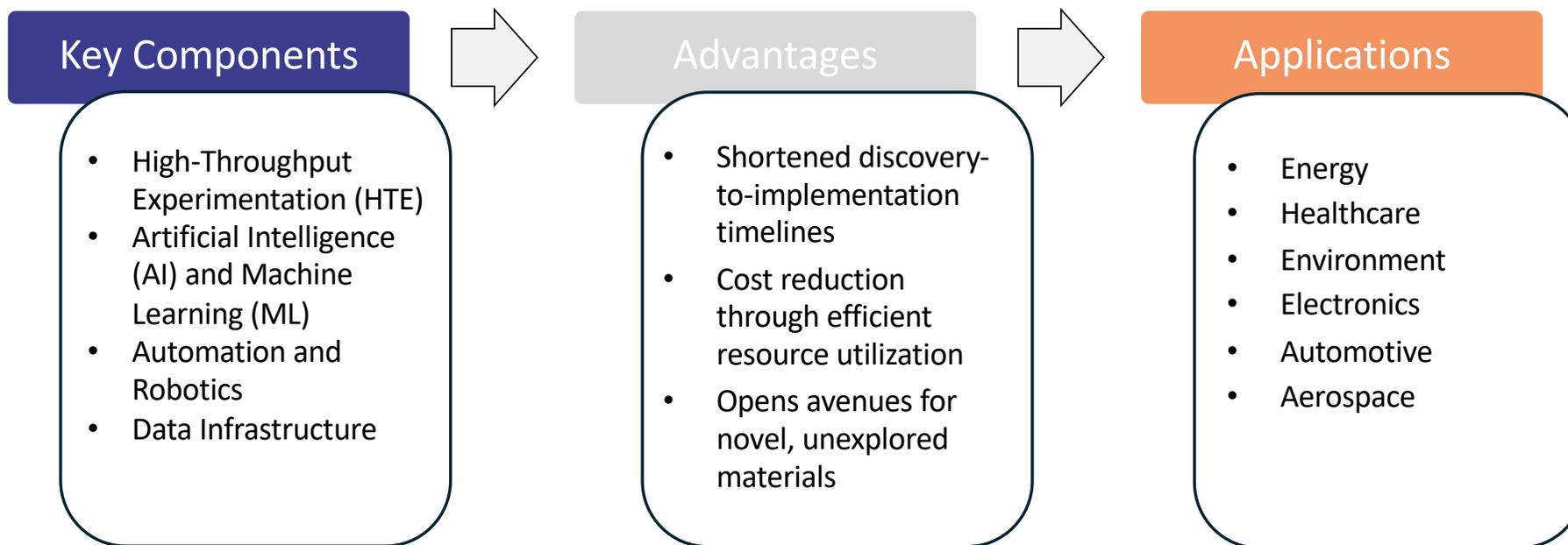
DESIGN AND CONTROL



Research Line 2: Overview

Materials Acceleration Platforms (MAPs)

Materials Acceleration Platforms (MAPs) integrate high-throughput experimentation, artificial intelligence, and automation to transform materials discovery and development



Research Line 2: Scope and Objectives

Research Line 2

Expedite market readiness of nuclear materials through innovation.

Focus

- Development of nuclear materials and advanced manufacturing platforms (n-MAPs).
- Accelerate market readiness of materials through experimental methods and AI tools.

Key Areas

- Application of innovative manufacturing methods.
- Optimization of testing procedures.
- Use of advanced characterization techniques.
- Development of predictive methodologies for long-term behavior.

Research Line 2: Scope and Objectives

Research Priorities

Advancing Low TRL Materials:

Elevate materials from low Technology Readiness Levels (TRL) to near-qualified solutions

Innovative Material Discovery for:

- Structural components
- Core components
- Advanced fuel elements (e.g., accident-tolerant fuels)
- Concrete structures for diverse nuclear technologies

Emphasis:

Materials screening & standardization using machine learning and AI-driven models.

Research Line 2: Expected Results

Final Goal

Developing a Nuclear Material Acceleration Platform (n-MAP)

Adapting MAP concepts for nuclear-specific needs and extending non-nuclear MAP frameworks where applicable.

Key Challenges in n-MAP Implementation

- *Irradiation Performance*: Evaluate material performance under irradiation conditions and predict long-term behavior using specific property indicators.
- *Transferability Issues*: Charged particles (ions, protons, electrons) are cheaper and faster than neutron irradiation but face result transferability challenges.
- *Reproducibility*: Tune processes for consistent material and component properties.

Research Line 2: Expected Results – Research Projects

Key Results:

- Application of innovative fabrication and post-fabrication treatment methods
- Optimization of testing procedures to monitor materials properties
- Employment of advanced characterization procedures
- Development of ad hoc predictive methodologies of long-term behaviour of materials
- Identification of proven indicators of long-term materials performance
- Development of standards or guidelines for material irradiation handling aspects of transferability to neutrons or to realistic irradiation conditions.
- Production of scientific data on innovative nuclear materials

Projects should be engaged in two or more key results

Research Line 2: Expected Outcome and Impact

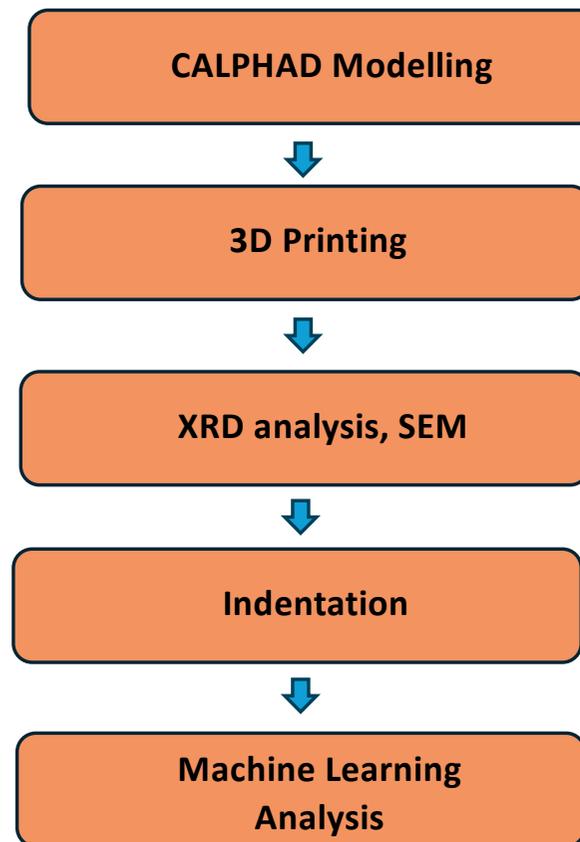
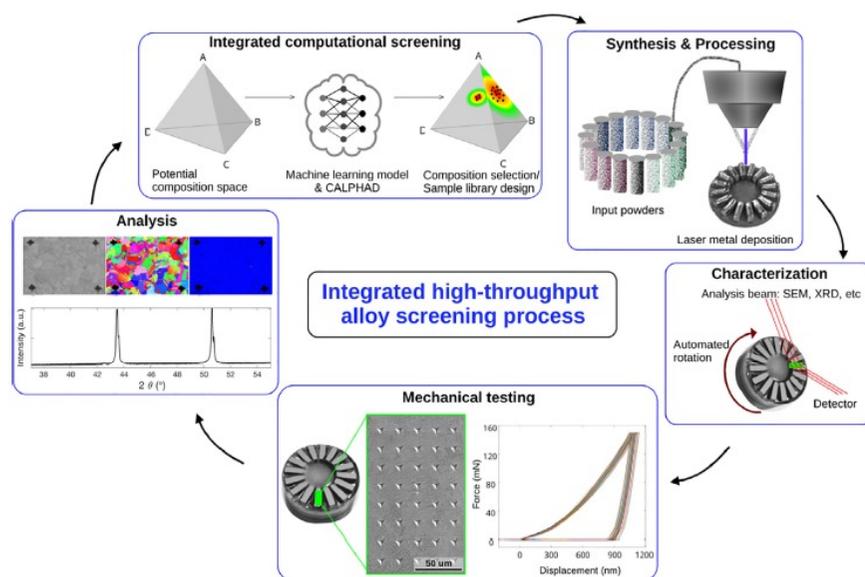
OUTCOME AND IMPACT AREAS OF RESEARCH PROJECTS

Advanced Materials	Advanced Manufacturing	n-MAP
Increase Existing Materials TRL	Process Parameters Optimization	Screening Methodologies
Innovative Materials Development	Materials Design Strategies	Materials Optimization
	Component Manufacturing	New Materials Identification
	Coating Manufacturing	Cost Reduction

Research Line 2: MAP Example

High-throughput rapid experimental alloy development (HT-READ)

Model System: Ni-based Alloy 625



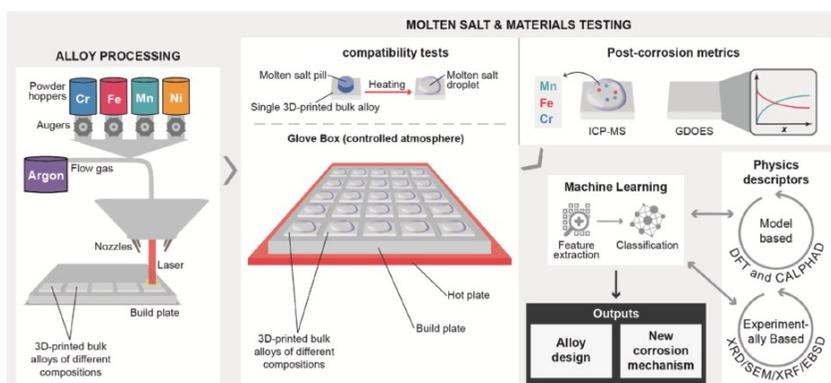
Vecchio, K. S. et al. High-throughput rapid experimental alloy development (HT-READ). *Acta Materialia* 221, 117352 (2021).

Research Line 2: MAP Example

Integrated High-Throughput and Machine Learning Methods to Accelerate Discovery of Molten Salt Corrosion-Resistant Alloys

Additive Manufacturing of Cr-Fe-Mn-Ni Alloys

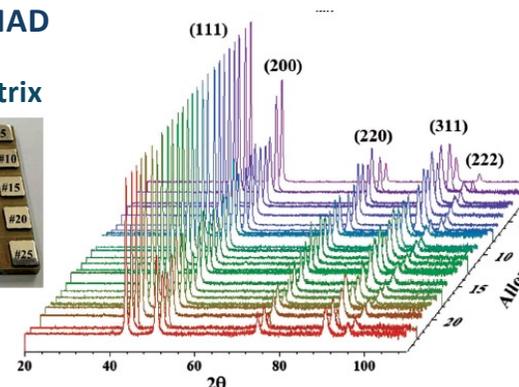
Schematic of the developed HTP and automated methods for corrosion-resistant alloy development



XRD characterization

25 ALLOYS SELECTED
USING CAPHAD

Sample Matrix



Wang, Y. et al, Integrated High-Throughput and Machine Learning Methods to Accelerate Discovery of Molten Salt Corrosion-Resistant Alloys. *Adv. Sci.* 2022, 9, 2200370

Thank you!

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Research Line 3: Materials and Component Qualification: Testing, Standardization and Design Rules

Massimo Angiolini – Senior Scientist, WP6-RL3 Leader

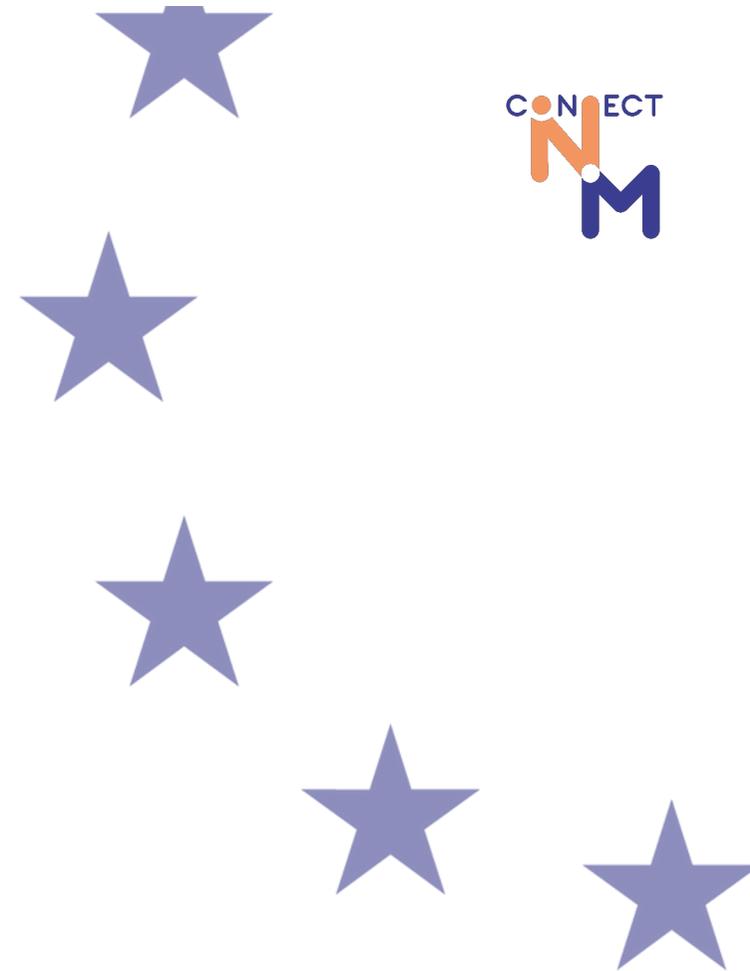
Infoday, online, 28.1.2025



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Table of contents

- **Scope and objectives of Research Line 3**
 - Optimize data harvesting and improve the quality of the data
 - Develop Accelerate Qualification Paths (AQP)
 - Nuclear materials identity cards
- **Expected results**
- **Anticipated outcomes and impacts.**



Scope and objectives

- ✓ **Materials R&D and qualification in nuclear is intrinsically a complex and time-consuming process, largely determined by the testing and irradiation requirements.**
- ✓ **The main bottleneck is the time required for long-lasting qualification tests e.g. creep, corrosion, irradiation and microstructure evolution under conditions representative of operating and incidental situations.**
- ✓ **To exploit the full potentiality of nuclear energy in connection with the energy transition, qualification time needs to be reduced. The focus is in**
 - ✓ **Develop Accelerate Qualification Paths (AQP), minimizing the reliance on long-lasting tests and, in general, experimental data that are difficult to obtain**
 - ✓ **Increasing the number and quality of the information learned from the samples investigated**

Scope and objectives

Optimize data harvesting and improve the quality of the data

Conventionally, data are produced in different laboratories & facilities with little or no coordination of the work

Data sharing is often done using as data sources scientific journals, conference presentations

Different characterizations protocols & poor alignment of the tools

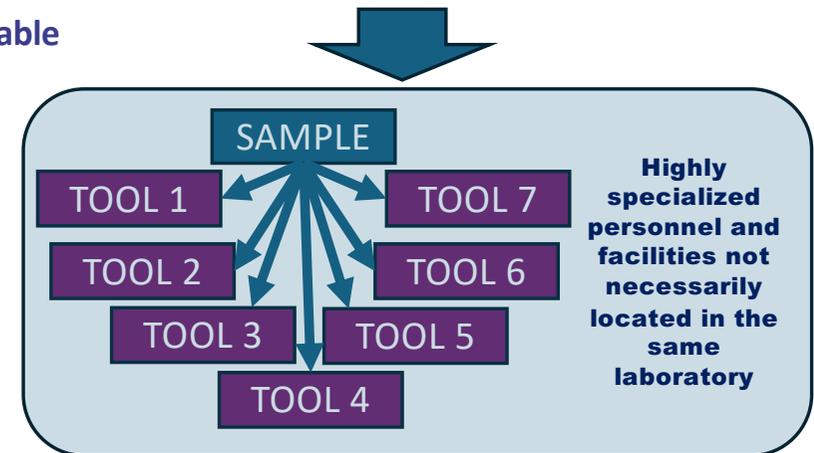
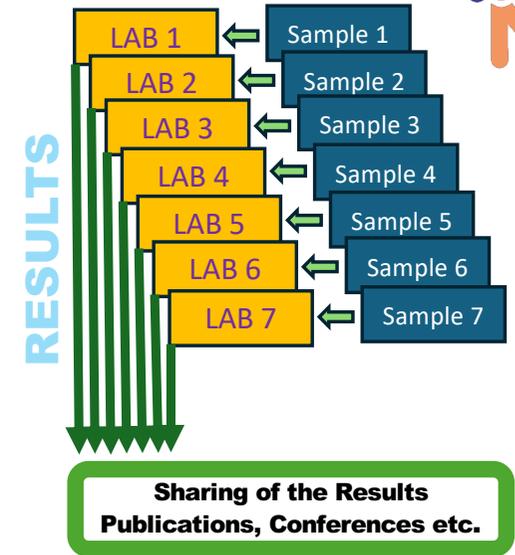
Differences in realizing representative samples and measuring the environmental parameters

Poor usability of the results, waste of resources, redundant or conflicting activities within different teams, poor alignment of the data

Move to a different approach to increase the completeness of the information attainable from the samples investigated: high quality samples are fully characterized in highly specialized facilities connected in a framework under a quality system

- Sample management
- Equipment calibration and maintenance
- Method validation and verification
- Training and competency of the personnel
- Document management and recordkeeping
-

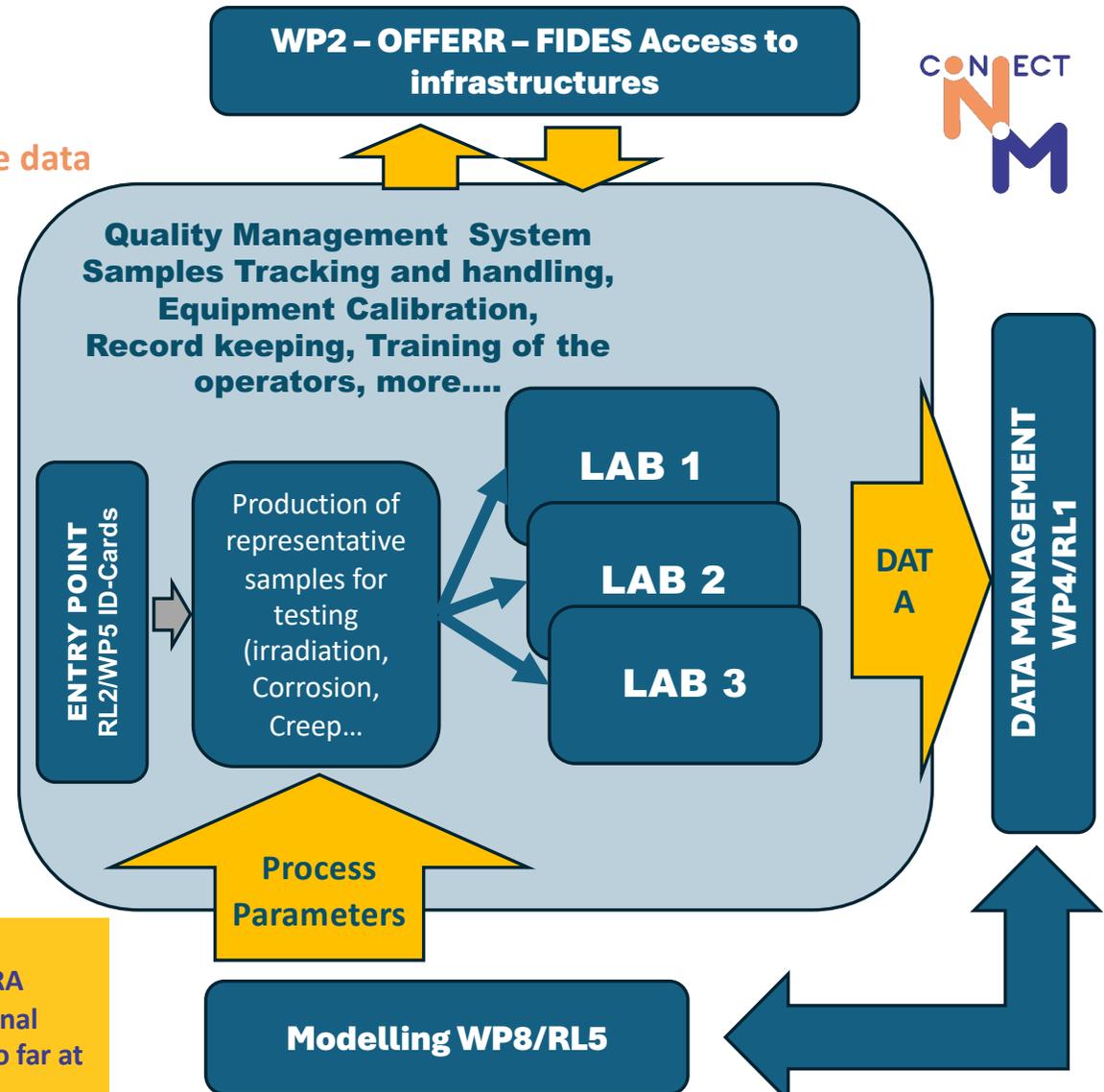
Collect the data are in dedicated databases and ensure their usability with the most complete set of metadata possible



Scope and objectives

Optimize data harvesting and improve the quality of the data

- The implementation of this optimized approach will be a major objective of Research Line 3 and will lead to the integration of infrastructures and facilities located in various European laboratories into a single delocalized entity
- We refer to such networks as Test-Beds (TBs)
- TBs should ideally include various experimental testing and characterization facilities for materials, including irradiation, and be coupled to advanced modelling and data management
- The coordination of infrastructures & skills will be a step forward and will
 - contribute to accelerate materials development and qualification, enabling the research community to do timely adjustments
 - allow effective resources allocation, avoiding redundant or conflicting activities within different teams, inefficiencies, and missed opportunities.

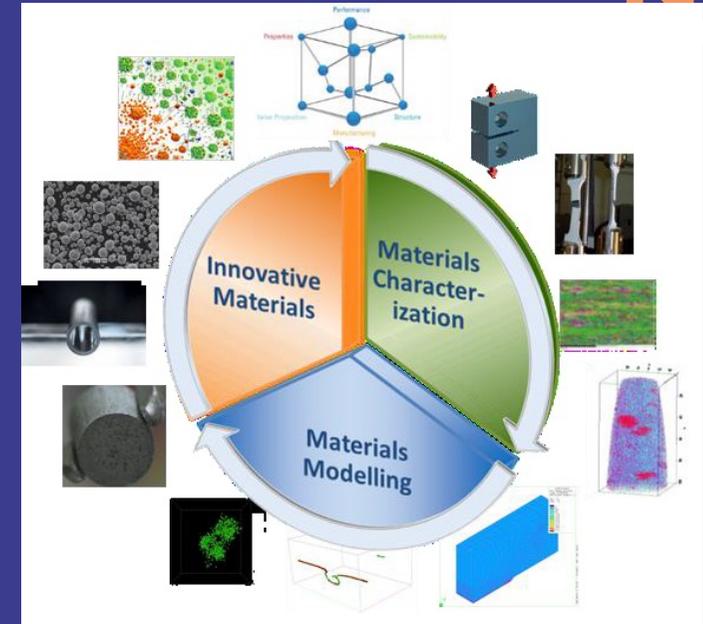


Despite the efforts to maximize complementarities and skill interconnections in the frame of the EURATOM projects, or by the EERA JPNM and SNETP initiatives, the implementation of stable organizational structures as TBs for nuclear materials have never been put in place so far at European level

Scope and objectives

Develop Accelerate Qualification Paths (AQP)

- Accelerated Qualification involves a change of paradigm in qualification from the conventional “observe and qualify” approach to the development and use of new testing procedures to extrapolate the long-term performance of materials and the associated variability from shorter-term experiments
- Little can be done to reduce the time for neutron irradiation, PIE, creep, aging...
- Coupling experimental characterizations and computational techniques and the use of databases provide new opportunities in predicting the performance in service and drive materials qualification



		Typical testing scale	
Proof-of-Performance	TRL 9	Actual system proven through successful operations. Commercial-scale fabrication	
	TRL 8	Actual system completed and qualified through test and demonstration	
	TRL 7	System prototype demonstration in operational conditions	
Proof-of-Principle	TRL 6	System/subsystem model or prototype demonstration in relevant environment	
	TRL 5	Component and/or subsystem validation in relevant conditions	Full scale prototype
	TRL 4	Component/subsystem validation in laboratory environment	Bench scale fabrication
Proof-of-Concept	TRL 3	Proof-of-concept demonstrated at laboratory scale	Laboratory scale
	TRL 2	Technology concepts and options evaluated and/or applications formulated	Optimised coupons fabrication
	TRL 1	Basic principles observed and reported	Sample (gramme quantities) Literature review, basic data acquisition

Scope and objectives

Develop Accelerate Qualification Paths (AQP)

- Accelerated qualification in the TB's will involve using methods to quickly assess the performance, reliability, and durability of materials in view of their deployment in critical applications
- Such approach needs understanding of the key parameters of the process/issue under investigation
 - to produce representative conditions
 - to simulate the long-term effects of environmental factors, irradiation, mechanical stresses
- Indeed, the support of modelling, data mining and a data driven design of experiments allows to reduce the number of long-lasting tests or data that are difficult to be obtained
 - Increase the throughput of the tests
 - Develop &/or apply accelerated tests
- Via
 - Separate effect testing
 - Use of small specimen test techniques
 - Use of ion irradiation to simulate neutrons
 - Accelerated aging
 - More...

With the support of modelling to extrapolate the resulting data to operational conditions



Scope and objectives

Develop Accelerate Qualification Paths (AQP)

- This approach in most cases is not suitable for licensing purposes because the regulations are very strict regarding the geometry and size of the samples, the number and time of the tests to be carried out, etc. however can support the development and guide the choice of materials to be licensed
- On specific issues the use of accelerate testing for licensing could not be excluded and for this reason, the introduction of accelerated paths should be assessed in collaboration of the regulatory bodies and their technical support organizations (CEN-WS064, European creep collaborative committee and more...)

Comments or RCC-MRx requirements
<ul style="list-style-type: none"> • Ageing treatment intended to characterise the material, representative of ageing expected in envisaged service conditions. <p>Includes at least:</p> <ul style="list-style-type: none"> • A study of the candidate material's micro structure and of its change during ageing. • Determination of the conventional plastic behaviour. • Determination of the fracture behaviour.
<ul style="list-style-type: none"> • Interruptive creep tests and multiple specimen testing machines are forbidden. • Strain monitoring mandatory during the test by extensometry or optical means. • See RMC 1290 and A3.GEN.31 • $T_{fracture} \geq 500$ h systematically. • $T_{fracture} \geq 10,000$ h per temperature and per heat. • If thermal ageing, $T_{fracture} \geq 30,000$ h for at least 1 test. • $T_{fracture} \geq \frac{1}{5} \times$ life time for at least 1 test • Recommended: ECCC (see Appendix 2). • Recommended: proportional cylindrical specimens with a 10 mm diameter calibrated area.
<ul style="list-style-type: none"> • Programme and tests representative of the envisaged operating conditions (temperature, number of cycles, etc.). • ASTM E2714 specific to the fatigue-creep tests • ASTM E606M and ISO 12106 providing recommendations for the fatigue tests with holding time.



ORIENT - NM
 Organisation of the European
 Research Community on Nuclear
Materials

A Coordination and Support Action in
 Preparation of a Co-Funded European
 Partnership on Nuclear Materials

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 from the Euratom research and
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Start date of project	01/10/2020
Duration	30 months
Reporting period	2 - 01/04/2022 – 31/03/2023

**Work Package 2 – Vision Paper and Strategic Research
 Agenda for an EJP on nuclear materials**

Deliverable D2.1: Nuclear materials identity cards

Author(s) name and affiliation	Marjorie Bertolus, CEA	Massimo Angiolini, ENEA
	Marco Cologna, JRC	Pål Efsing, KTH
	Miguel Ferreira, VTT	Benoit Tanguy, CEA
	+ TAG members indicated in individual cards	
Date of issue	28/04/2022	
Date of final approval	06/05/2022	
Dissemination Level		

PU	Public	X
CO	Confidential, only for partners of the ORIENT-NM Action and the EC	

Nuclear materials identity cards 

- It is difficult to cover every aspect of Nuclear Materials since it is a very broad field encompassing nearly all experimental techniques
- Therefore, it is crucial to define the specific R&D areas and prioritize the issues to be addressed
- The classes of materials that need continued R&D and qualification has been identified by the Technical Advisory Group (TAG) in ORIENT NM
 - Structural metallic materials,**
 - Cladding materials,**
 - Fuels,**
 - Concrete.**
- For each material, the TAG compiled a Material ID card where the issues that need to be addressed have been identified and listed in priority order

Expected results

Projects proposed in this research line are expected to establish characterisation TBs on specific issues and contribute to the development of AQP's by adopting a novel approach resulting from:

- integration of modelling and predictive capabilities and/or non-destructive testing and examination tools in current paths,
- development of new accelerated tests with relevant protocols and/or suitable data harvesting methodologies and management,
- development of protocols for currently non-standardised tests (non-conventional coolants corrosion, small specimen testing...),
- alignment of tests, protocols across participating partners and/ or labs, as well as sharing/exchange of dedicated test material across partners.

The definition and development of AQPs are expected to be carried out with special applications in mind as case-studies (i.e. specific nuclear system and/or material),

For the implementation of AQP's, the proposals must include the cooperation with the regulatory bodies, their technical support organizations and the relevant stakeholders across Europe (e.g., CEN, CENELEC, ETSI, ISO, IEC, ITU, EEEEC, industry), identify the standardization framework, existing standards and the testing plan towards standardization.

- The development of harmonized guidelines, best practices and standards will be considered as pillars, round robin tests to assess the quality of the protocols are advised,

For the correct operation, in application of standardized and accelerated qualification paths, the proposals will necessarily require the implementation of a TB Quality Management System,

Proposal shall implement advanced data analysis and storage: collect data in dedicated shared points for the consultation between the partners. The accessibility and reusability of data produced will be assured by a complete set of metadata in collaboration with WP4 data management,

Proposals should include actions designed to facilitate cooperation with the projects of the other RL's of CONNECT NM and enhance their involvement.

The final output of this effort will be the implementation of stable organizational and legal structure, a single entry-point for specific issues for the accelerated qualification of materials and components, open to any potential customer.

Anticipated outcomes and impacts.



The construction of TBs, by integrating infrastructures, will represent a step forward towards the consolidation of the relevant European research community and will allow effective resource allocation, avoid redundancies, inefficiencies, and missed opportunities.

- “Consolidation of the European research community on nuclear materials”

Within RL3 the interaction with industry, regulators and Technical Support Organisations, will be an integral part of the relevant projects, via workshops, meetings and, eventually via the direct involvement in the RL projects, supporting the work performed.

- “Improve the interaction of the nuclear materials research community with nuclear industry, private companies, European nuclear regulatory bodies and their technical support organisations”.

The definition of AQPs, with the approval of the regulators, by enabling the fast deployment of better performing materials will provide a strong contribution in maintaining and strengthening the level of safety of current and future European nuclear installations.

Standardized and quality controlled experimental procedures and methodologies will increase the reliability of the data, and thus the reliability of the qualification process, with subsequently increased safety.

- “Contribute to maintaining the high level of safety of nuclear installations for current and future fleets, in full compliance with relevant European regulations”.

The TBs will constitute an effective way to coordinate the use of infrastructures for nuclear materials. Their correct operation, in application of standardized and accelerated qualification paths, will necessarily require quality assurance practices to be followed, as well as FAIR data.

Such joint approach will help European players to remain at the forefront of the nuclear materials R&D assuring improved competitiveness of Europe at the world scale, in this dynamic technology domain.

- “Develop scientific knowledge and technological expertise applicable to the nuclear materials domain, including the coordinated use of infrastructures for materials qualification with sustainable quality assurance, and the production of reliable nuclear databases that meet FAIR principles”.

The scope of the action is focussed on the faster exploitation of innovative materials and materials solutions by adopting a method that is in many ways revolutionary for the qualification of materials and components, compared to the conventional ‘observe and qualify’ approach. The implementation of this innovative approach within the RL3 projects will be a game changer fostering the development of new knowledge and skills to shift habits of practice towards sustainable practices within the nuclear industry.

- “Promote a culture of continuous improvement and change of paradigm in materials science, supporting the growth of sustainable practices within the nuclear industry”.

Thank you!

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RL4 - Non-destructive examination and materials health monitoring

Madalina Rabung - WP7L / Senior Lead Business Development Research EU affairs

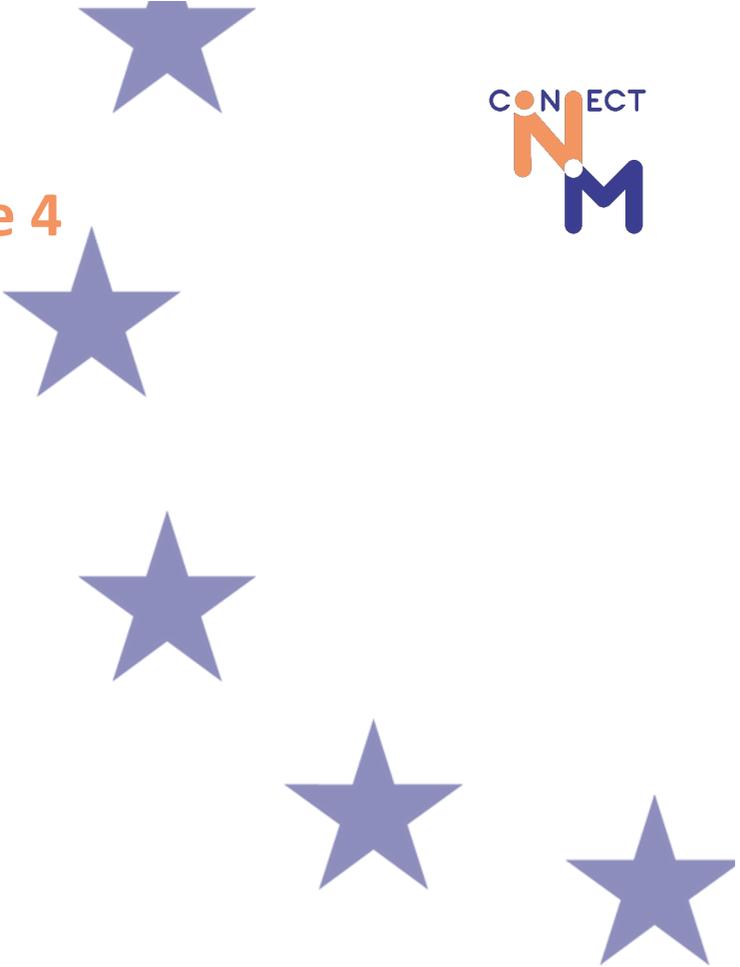
Online, 28th January 2025



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1. The scope and objectives of the Research Line 4
2. The expected results
3. The anticipated outcomes and impacts





1



The scope and objectives of the Research Line 4

Non-Destructive Testing and Evaluation (NDT&E) techniques

- discern and evaluate the progressive alterations in material properties over time, under continuous observation, in situ and in operando conditions
- offer valuable insights without compromising the material's functionality
- facilitates real-time monitoring of materials by employing advanced sensing techniques, such as distributed sensor networks and embedded microsensors
- track and predict material behaviour, thereby ensuring the timely detection of defects, degradation, or other critical changes by analysing of the collected data, facilitated by modern data science approaches (e.g. machine learning)
 - supports maintenance decisions and extends the lifecycle of components across diverse applications.

The scope and objectives of the Research Line 4

RL4 aims to develop **intelligent materials health monitoring systems**

- To evaluate parameters related to the micro- (defect location, density, size) and macro-structural state (mechanical properties) during service.
- considering operational factors (such as temperature and pressure cycles, irradiation parameters, mechanical loading etc.) through continuous inspection.

Twofold objective:

- enhance the accuracy of estimations of the operational lifetime of nuclear power plants,
- facilitate the development and qualification of materials, both by using cognitive sensors.



2



The expected results of the Research Line 4

Projects are expected to develop IMHM systems for NDT&E of operational-induced degradation in materials and components of current nuclear power fleets, as well as to develop materials for next generation reactors, including SMRs.

- Multi-parameter / multi-NDT&E-method-monitoring technologies, which fulfil requirements of NPP operational conditions and support customised maintenance and repair plans
- Cognitive sensors to understand the physical mechanisms affecting material properties in operation
- Sensors deciding which information is relevant by applying enhanced statistical analysis, machine learning algorithms, or artificial intelligence to select relevant data, instead of 'blind' big data analysis and supporting monitoring tools for predictable materials degradation

The expected results of the Research Line 4

Projects are expected to develop IMHM systems for NDT&E of degradation in materials and components of current nuclear power fleets, as well as to develop materials for next generation reactors, including SMRs.

- System to not only monitor the state of individual structures, but also to infer about their interdependencies and, thus, the evolution of the system as a whole by means of advanced data fusion, interrelation of data generated by different NDT&E methods and machine learning-driven decision-making techniques
- Analysis of the fault tolerance of the machine learning-driven decision-making techniques and development of embedded methods for indicating or even for qualifying the reliability of the outputs, as instrumental for human-free operation.
- Development of protocol(s) for training, testing and especially validating machine learning-driven decision making techniques that can increase the transparency of the machine learning applications in safety areas and can serve as a basis for future industrial standards and rules.



3



The anticipated outcomes and impacts

Projects in the RL4 are expected

- To demonstrate their high added value in industrial nuclear applications, in terms of increased safety and cost reduction, in particular for better estimation and management of the operational lifetime of NPPs and their components,
- To provide a feedback/input to models and design rules, which can be in turn improved.
- To contribute to the development of n-MAPs (RL2) and AQPs (RL3).
- To describe how the techniques developed for the operational phase of a specific component could be applied on other phases or even on the whole material/component lifecycle

The anticipated outcomes and impacts

Projects in the RL4 should increase the safety and sustainability, including economic sustainability, of nuclear energy as a whole.

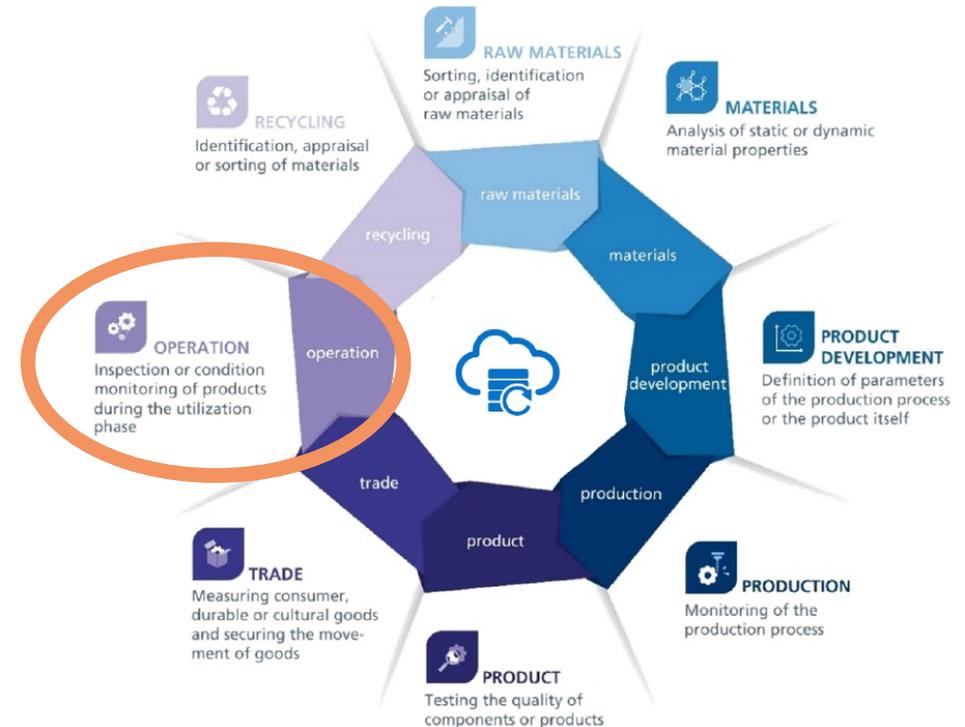
Projects describe pathways to:

- enable the capture of a variety of material properties right from the start of the component development, until its end-of-life.
- reduce maintenance costs, quantifying the reduction compared to the state-of-the-art.
- assess and validate the longevity of materials, components and products through accelerated testing.
- enable the traceability of materials information throughout the value chain to identify the possible origins of defects, thanks to the significant amount of *a priori* knowledge that becomes in this way available before each inspection measurement (including multi-scale modelling of structure, and structure vs. properties correlations).

Examples of projects

Project shall mainly concern the degradation* during the operation phase of nuclear materials belonging to (at least one of) the four categories considered in CONNECT-NM.

Other phase(s) of the material value chain can be considered in addition to the operating phase.



*thermomechanical fatigue, radiation-induced ageing, swelling, creep; corrosion and stress-corrosion cracking/dissolution/erosion in contact with heat-transferring fluids or due to solid-solid contact; creep; various concrete degradations; fuel assemblies degradation etc

Thank you!

Madalina.Rabung@izfp.fraunhofer.de



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Research Line 5: Advanced Materials Modelling and Characterization

Maria Oksa – Senior Scientist, WP8-RL5 Leader

Infoday, online, 28.1.2025



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- **The scope and objectives of the Research Line 5 Advanced Materials Modelling and Characterization**
 - Main objectives
 - Expectations
- **The expected results from the projects in the RL5**
- **The anticipated outcomes and impacts of the projects in the RL5**
- **Linkage to other Research Lines and activities**
- **RL5 Core group**

The scope and objectives

- **The main objective is to improve the capability of advanced predictive methodologies (APM)**
- **To develop physical models coupled to advanced microstructural characterization to achieve high-level understanding and predictive capability of the behaviour of materials under operating reactor conditions, especially radiation effects.**
- **The focus is on boosting the possibilities of multi-scale and multi-physics simulations, taking advantage of modern machine learning as well as experimental examination approaches.**
- **Other expectations:**
 - The methodologies are expected to blend physical and data-driven modelling approaches and to become of direct applicability at industrial level, under increasingly wide ranges of operational conditions.
 - Close collaboration with the other RLs: pursuing the elaboration of design rules, assessment, and test procedures, for both operating and off-normal conditions, feeding fuel performance codes, assisting materials development and discovery, or supporting materials health monitoring.

The expected results

- **To contribute effectively to the development of APMs that blend physics-based and data-driven modelling approaches, in interaction with the use of advanced microstructural, microchemical and micromechanical examination techniques (including non-destructive ones)**
- **Expected activities include:**
 - 1) advancing physics-based models and analytical tools
 - 2) improving bridging between scales
 - 3) utilizing data-sets to discover new solutions through the employment of machine learning
 - 4) executing experiments dedicated to supplying necessary data, enabling the aforementioned activities
- **Aspects valued in the proposals:**
 - Originality in the combination of physics-based and data-driven approaches to boost the predictive capability of the methodology
 - Creativity in the elaboration of novel methodologies
 - Methodologies that simultaneously combine the use of advanced (and fast) characterization, physics-based models and data-driven approaches

The anticipated outcomes and impacts

- Support to n-MAPs (nuclear material acceleration platforms), AQPs (accelerated qualification paths) and IMHM (intelligent materials health monitoring systems) systems
- Taking important steps towards advanced methodologies and engineering tools of direct interest and use for industry and/or regulators
- Boosting the capability of predicting the behaviour of materials in operation and of assessing properties of importance for component lifetime management and safety, by enabling more reliable safety assessments to be carried out.
- Digital technologies to contribute to reduce the number of exposure experiments and subsequent testing required on activated materials, thereby having an important impact on time-to-market and cost reduction
- Pivotal support to the overall safety, efficiency, economy and sustainability of nuclear systems
- Contribution to safe long-term operation of current nuclear power fleets, as well as to develop materials for next generation reactors, including SMRs

Linkage to other Research Lines and activities

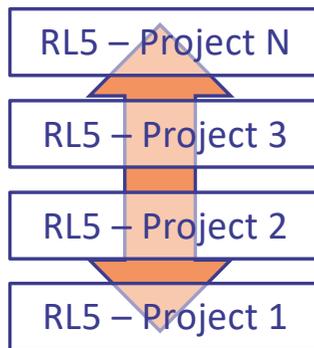
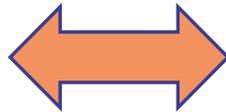


Metallic structural materials – Cladding materials – Fuel materials – Concrete

Physics-based models – ML – Analytical tools – Different scales – Data sets – Dedicated experiments

Other EU projects

National and International Organisations



Advanced predictive methodologies (APM)

- Materials behaviour
- Development of materials

→ Applicability at industrial level

RL1 – Projects 1-N
Knowledge and Data Management

RL2 – Projects 1-N
Materials Development and Manufacturing

RL3 – Projects 1-N
Qualification, Testing, Standardisation and Design

RL4 – Projects 1-N
NDE and Materials Health Monitoring

RL5 Core group

- Maria Oksa, RLL, VTT, Finland

Research Line Advisors:

- Wade Karlsen, VTT, Finland
- Marjorie Bertolus, CEA, France
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Thank you!

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Q&A session on Research Lines



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Closing Remarks

Lorenzo Malerba, CIEMAT, CONNECT-NM Coordinator



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