The NUCOBAM Project – WP1

Additive Manufacturing qualification in the Nuclear industry

INNUMAT meeting, 16th November 2023

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NUclear COmponents Based on Additive Manufacturing

NUCOBAM

grant agreement

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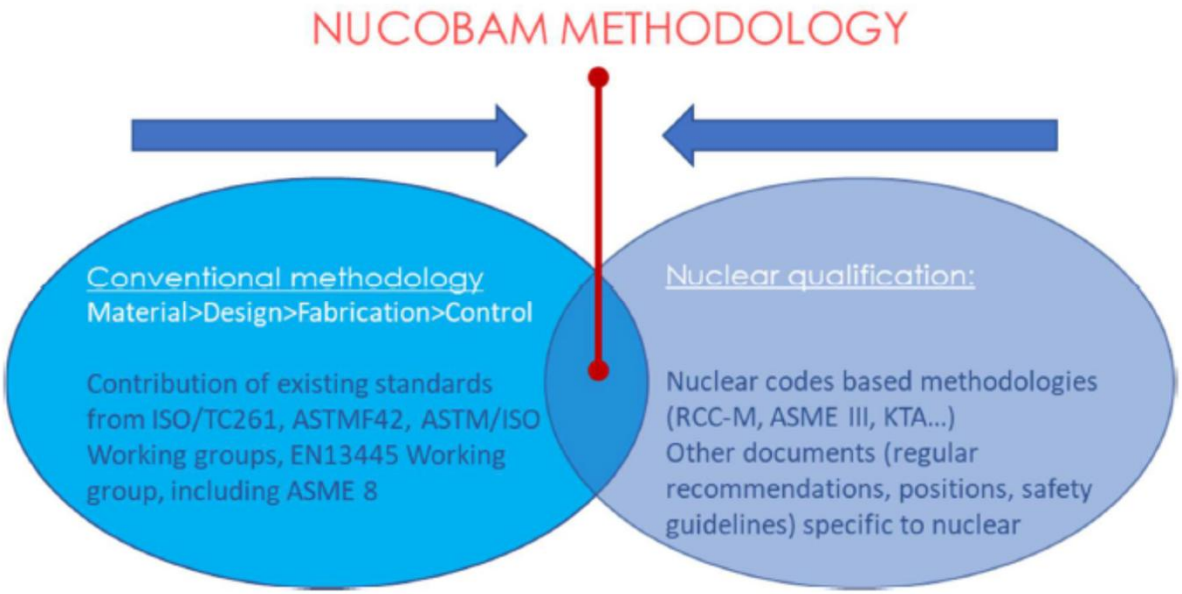
Overall Project Goal

- Establish a qualification methodology for nuclear components to be proposed for standardization and to be forwarded to nuclear design code committees

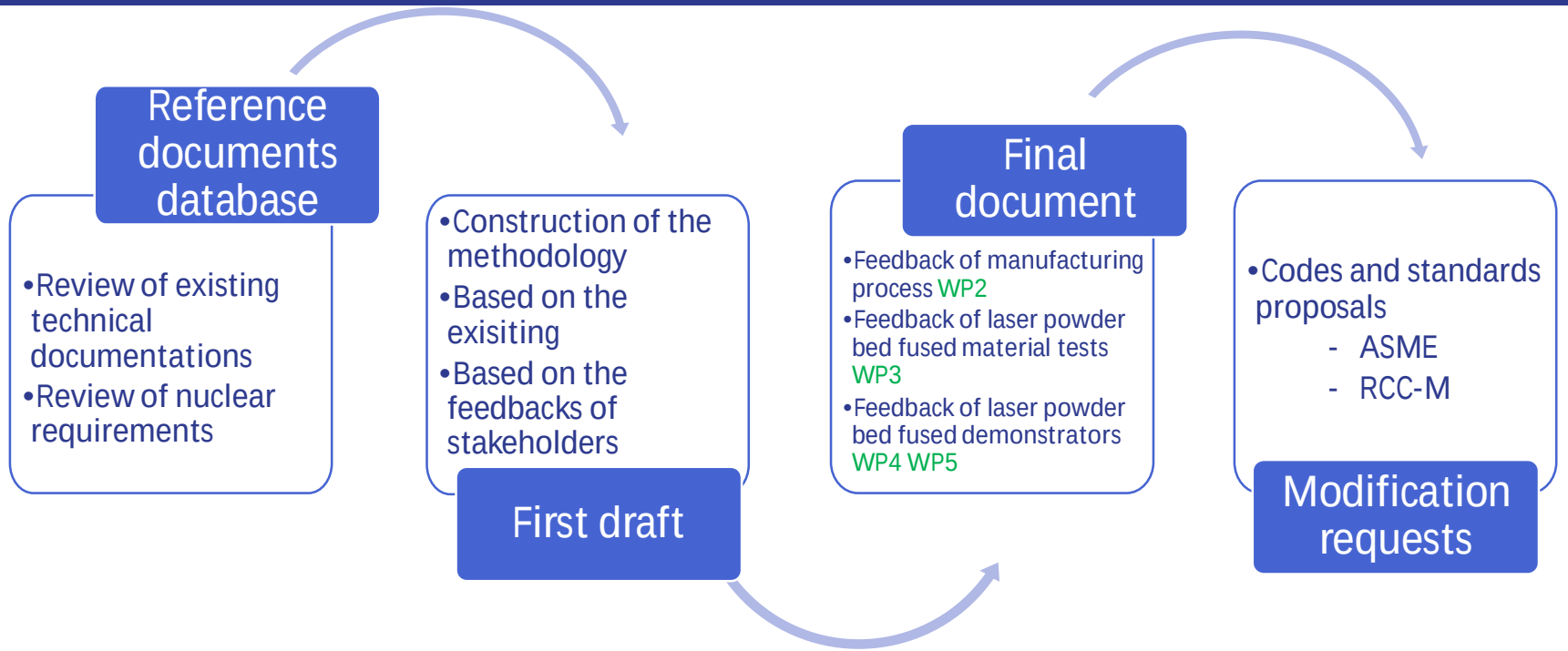


Principles and stakeholders - WP1

- Focus on establishment of a qualification methodology for AM components
- Reviewing the existing standards and qualification processes
- Implementation of specific nuclear requirements
- Text to be proposed to nuclear design codes and standards

framatome, cea, VTT, ENGIE Laborelec, EDF, The University Of Sheffield., NAVAL GROUP, Joint Research Centre JRC, IRSN INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE, TRACTEBEL ENGIE

Establish qualification methodology - WP1



1. Identification and review of the relevant guideline

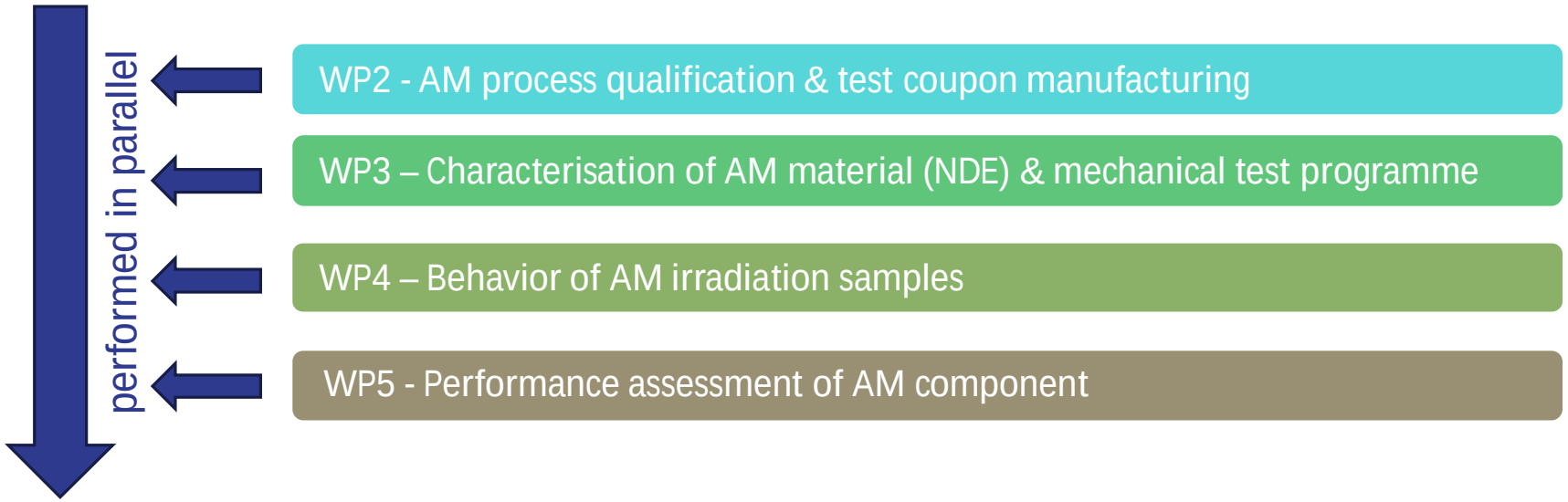
2. First draft methodology

3. Completion of methodology

4. Conversion of the methodology in a standardised text

Establish qualification methodology - WP1

Draft methodology – completed



Final Methodology ready for submission to NC&S committees (WP1) – sept 2024

1. Identification and review of the relevant guidelines

T1.1

- Large variety of applicable guidance, covering all aspects of AM:
  - component design,
  - handling & characterization of metallic powders,
  - AM process itself & its qualification,
  - Post-heat treatment,
  - Documentation,
  - ...

- Relevant standards:
  - EN ISO ASTM 52900 standards family,
  - AMS standards (7002, 7003),
  - Various ASTM standards (e.g. ASTM F3184),
  - AWS D20.11D20.1M,
  - ...

1. Identification and review of the relevant guidelines

T1.1

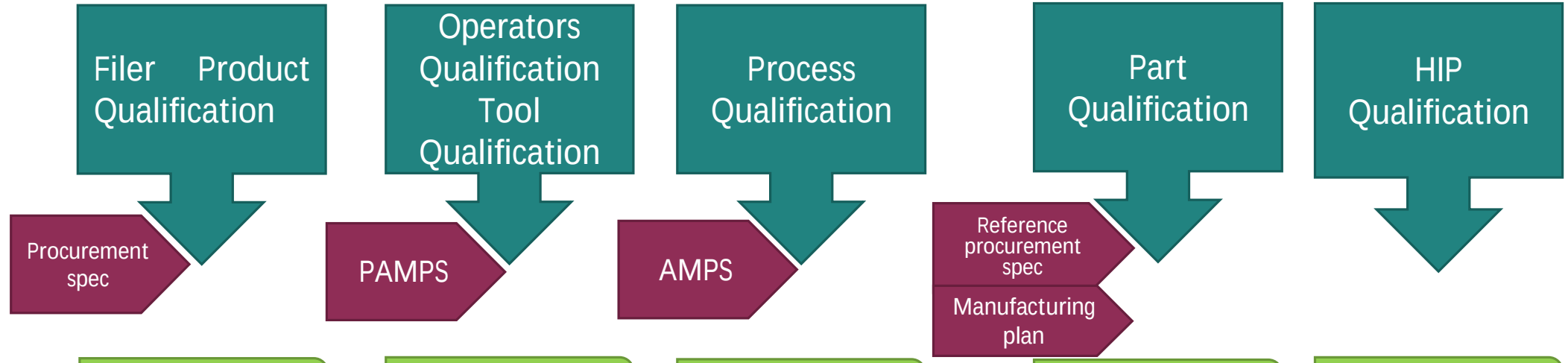
- Lead: JRC, Oliver Martin

- Task completed:
  Complete list of applicable & relevant standards & guidance docs issued on 1st March 2021 (NUCOBAM_WP1.1_standards_guidance_list_v10.xlsx)
  And a short report briefly summarizing the identified relevant standards & guidance docs (NUCOBAM WP1 T1.1_v2.docx).

- Contributors:

2. AM Qualification steps overview

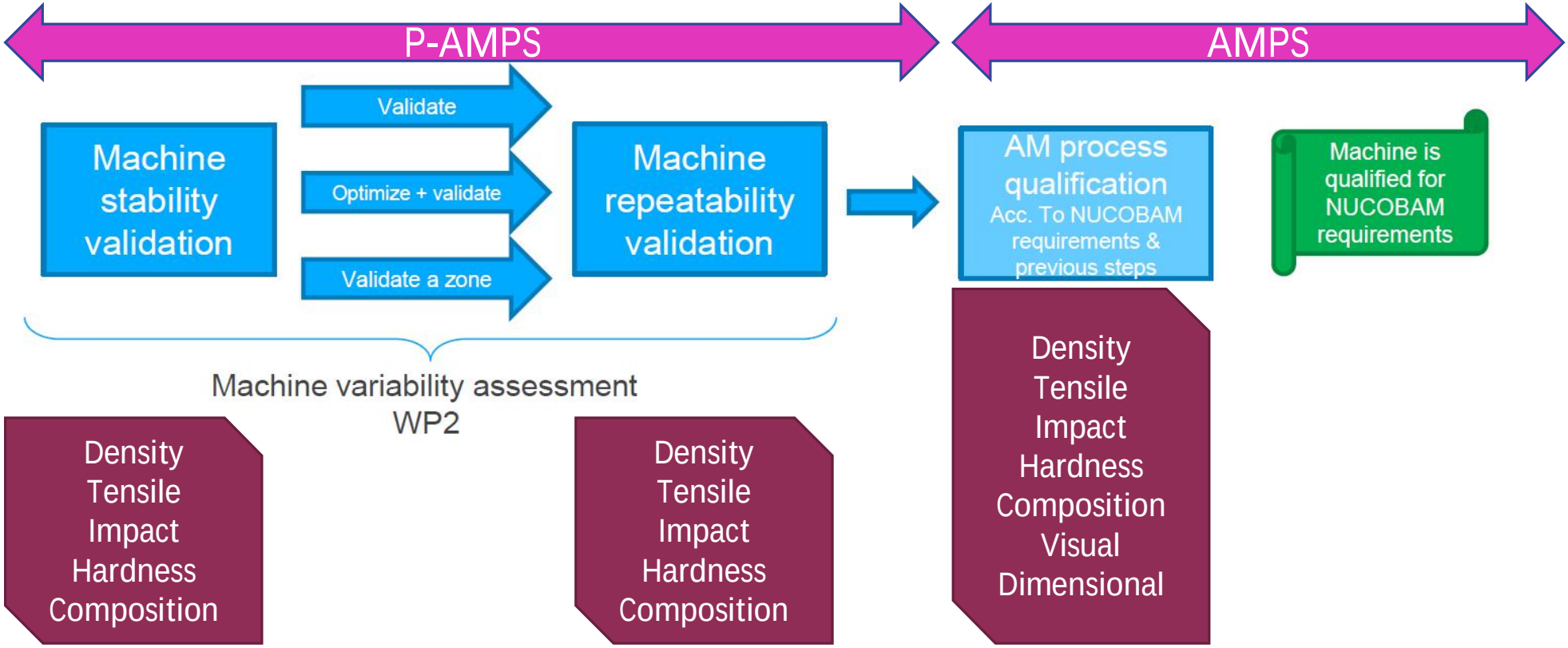
T1.2



Powder	Machine	Qualification component	Production component	Heat treatment
Acceptance of filler materials • Chemical composition • Mechanical properties • Acceptance tests	Operator Certificate Tool Certificate	Technical qualification report Caracterization Acceptance tests	Acceptance tests	Acceptance tests

2. Detail of machine/process qualification

T1.2



2. First draft methodology

T1.2

Qualification methodology

0. Preliminary note
1. General (scope, quality and personnel qualification)
2. Terminology
3. Documentation
4. Powder procurement
5. Qualification of the AM process
6. Manufacturing of the component & test specimens
7. Heat treatments
8. Inspections and tests
9. Post-processing of printed parts
10. Examination
11. Design
12. Pressure and functional testing requirements

References and actions for each chapter:

- Related standards, reference of the information
  - For chapter 8 (tests/inspections) & 10 (examinations) specific references for RCC-M/ISO
- Action to be undertaken for improvements
- Pending comments
- Proposed answers

2. First draft of methodology

T1.2

- Lead: Tractebel, Gilles Theunis
- Issued 01/06/2021 draft methodology word document + references and actions Excel
- Contributors:

3. Completion of Methodology

topics	Questions/proposal	WP feedback expected
Operator qualification	Establish a first list of operator competencies	WP2
Density	Proposal to have a quantitative measurement to try to announce a qualitative relation between density and mechanical properties	WP3
Intergranular corrosion	The selected method (EN ISO 3651-2 method A) is different from ASME or RCC-M methods identified in D1.2.	WP3
Chemical properties	Standards used? Equivalences? Different requirements powder/metal?	WP2 WP3 WP5
Creep, low cycle fatigue, SCC & Fracture toughness	Input for material characterisation depends on WP3	WP3
Tensile	The WP1 proposal is to keep the criteria topic as open point, waiting for the WP3 tests results	WP3
Hardness	Method limits to Vickers. Which criteria?	WP3
Toughness	Share ASME Values for Toughness with Framatome for discussion	WP1 & WP3
Examinations	WP1 proposal to collect existing methods and criteria but asks for a dedicated meeting. Obtention of development in TC 261.	All WP

3. Completion of Methodology

T1.3

topics	Questions/proposal	WP feedback expected
Operator qualification	Establish a first list of operator competencies	Done
Density	Proposal to have a quantitative measurement to try to announce a qualitative relation between density and mechanical properties	WP3
Intergranular corrosion	The selected method (EN ISO 3651-2 method A) is different from ASME or RCC-M methods identified in D1.2.	WP3
Chemical properties	Standards used? Equivalences? Different requirements powder/metal?	WP2 WP3 WP5
Creep, low cycle fatigue, SCC & Fracture toughness	Input for material characterisation depends on WP3	WP3
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Toughness	Share ASME Values for Toughness with Framatome for discussion	WP1 & WP3
Examinations	WP1 proposal to collect existing methods and criteria but asks for a dedicated meeting. Obtention of development in TC 261.	All WP

3. Completion of Methodology

T1.3

- Lead: CEA, Cécile Petesch
- Working document : D1_3_Final_methodology_v2
- Main evolutions compared to draft methodology:
  - New organization for annexes: Annex A dedicated to regulation
  - Some contents still must be validated
- Still to be done: alignment of the text on the WP2, WP3, WP4 and WP5 results
- Contributors:

4. Conversion of the methodology in a standardised text

T1.4

STANDARDS LPBF/316L

Methodology

chapters:

Preliminary note
1. General (scope, quality and personnel qualification)
2. Terminology
3. Documentation
4. Powder procurement
5. Qualification of the AM process
6. Manufacturing of the component & test specimens
7. Heat treatments
8. Inspections and tests
9. Post-processing of printed parts
10. Examination
11. Design
12. Pressure and functional testing requirements
13. Demonstration of weldability

ASME CC

1. Scope
2. A.M code/standard
3. POWDER REQUIREMENTS/powder procurement
   a. Powder manufacturer Qualification
4. QUALIFICATION OF THE AM PROCESS
   a. Design
   b. Procedure specification
   c. Procedure qualification (platform?)
      i. Stability
      ii. Repeatability
      iii. In-process monitoring
   d. Qualification testing of AM manufacturing components
5. MATERIALS
6. MANUFACTURING OF THE COMPONENTS & TEST SPECIMEN
7. HEAT TREATMENTS / THERMAL TREATMENT
8. CHEMICAL COMPOSITION – TESTING
9. MECHANICAL PROPERTIES TESTING
   a. Inspection + tests
   b. Metallurgical evaluation
10. POST PROCESSING OF PRINTED PARTS
11. EXAMINATION
12. QUALITY PROGRAMS
13. RECORDS
14. DEFINITIONS

RCC-M RPP

GUIDELINE:
M 116 SPECIFIC USE OF A NON-REFERENCED MANUFACTURING PROCESS

Manufacturing processes not referenced by the RCC-M can exceptionally be proposed by the Manufacturer, for a particular application. In these conditions, and prior to the procurement of the materials, the Manufacturer must submit the following items to the Contractor for approval:

a) A procurement specification; for this purpose, it shall most frequently use a similar existing Reference Technical Specification, or a compatible standard, stating the options systematically adopted

b) A first part qualification, according to the principle described in M 140

c) A document package justifying the use of the grade for the targeted application. This document package shall include at least the following items:
- References to the existing standards and technical specifications
- The data needed for design
- Evidence that the material obtained by this new manufacturing process is suitable to be employed for the targeted application
- Evidence that the acceptance (destructive and non-destructive tests) is appropriate for the inspections of the products resulting from this new manufacturing process
- Performance under the service conditions, for the targeted application
- Experience feedback: status for similar applications.

M 180 ADDITIVE MANUFACTURED (AM) QUALIFICATION

M 3500 PART PROCUREMENT SPECIFICATION AUSTENITIC STAINLESS STEEL LPBF ADDITIVELY MANUFACTURED VALVE BODIES

4. Conversion of the methodology in a standardised text

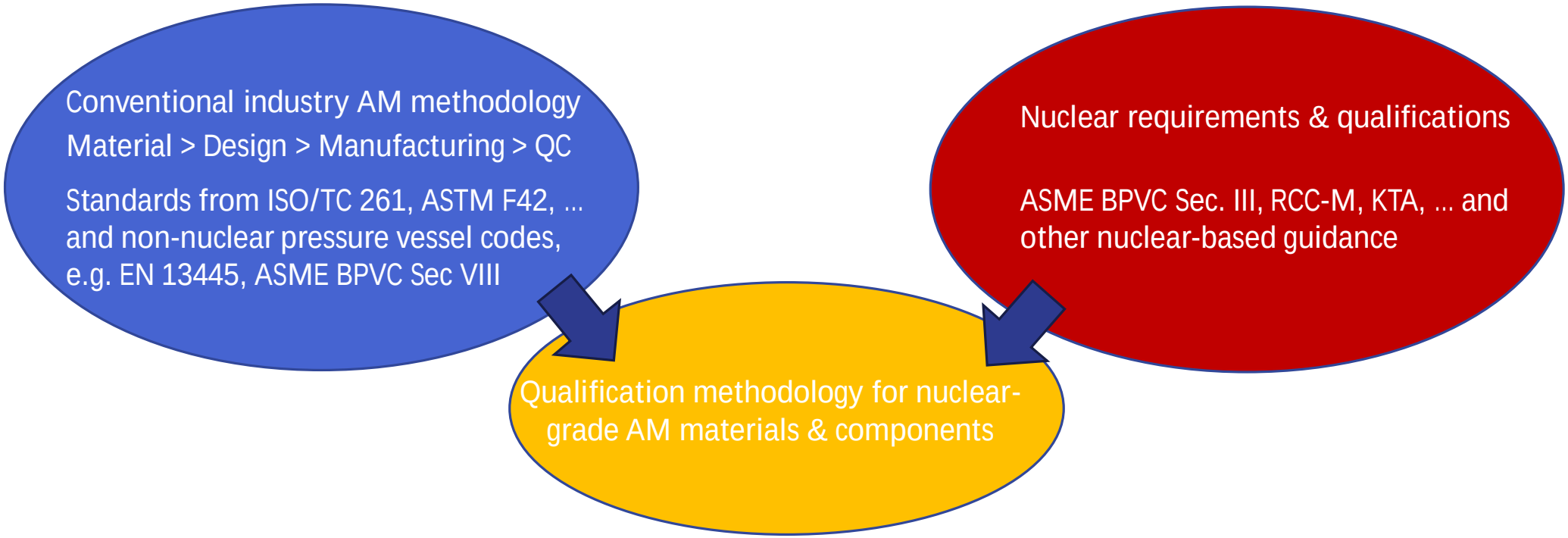
T1.4

- Lead: Tractebel, Roxane Misler
  - Two possible standardization: RCC-M (AFCEN) and ASME BPV (ASME) for the valve core
  - Task result: A document gathering the code evolution proposals should be presented/submitted to standard development organizations (submission not included in NUCOBAM)
  - Potential submission of material to the ASME committee :
  - Potential submission of material to the AFCEN committee :
- Contributors :

Conclusion

- Qualification methodology still open on several points
- Document D1.2 and D1.3 much more complete than only qualification methodology as:
  - It gathers the specific points treated in NUCOBAM
  - It gathers elements of explanations, codes and standards requirements and at least WP2 complements
- The transfer of the methodology report in a modification request for standardization organizations has started
- Work limited to LPBF and 316L, the question of the extension of recommendations is raised

Overall Project Conclusion



NUCOBAM Partners

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