Definition of Professional Profiles Design & Review Process and AM Sectoral Framework to Sustain and Feed the AM Qualification System

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Contents

Executive Summary

The Sector Skills Strategy in Additive Manufacturing Project (SAM) tackles the current European need for of developing an effective system to identify and anticipate the right skills for Additive Manufacturing (AM) sector demands, in response to increasing labour market needs.

Work package 3 (WP 3), is composed of three deliverables (Figure 1) that focus on specific fields, thus contributing to the definition of a methodology for designing and revising professional profiles and developing skills adopted within the SAM project. The methodology is based on three pillars: firstly, the methodological approach for the design and review of learning pathways (qualification guidelines) based on the existing and/or emerging professional profiles in the AM sector; secondly, the operational tools for implementing the methodology; and thirdly, a practical guide on existing contexts and tools for implementing the qualifications guidelines.

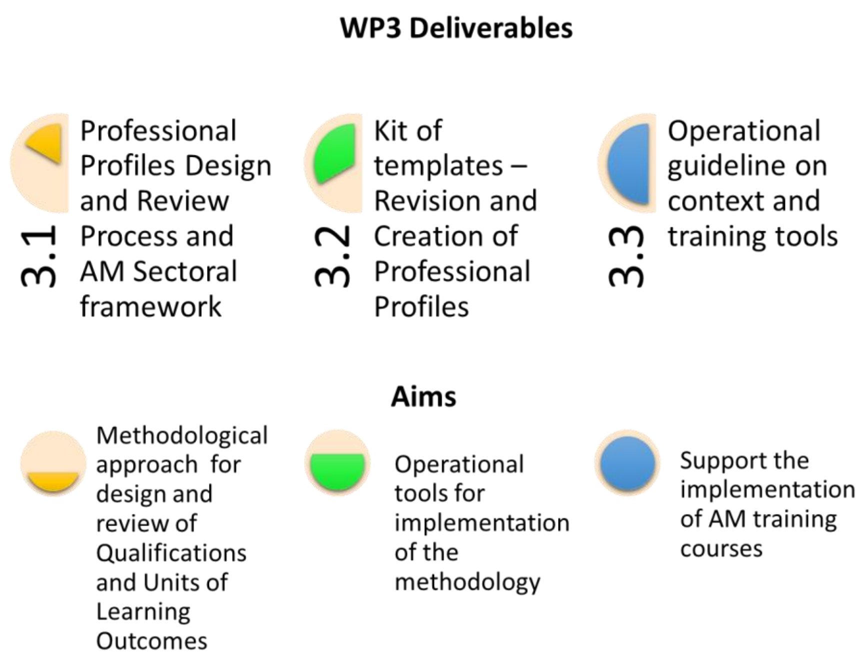


Figure 1- WP3 Deliverables overview

This document consists of Part 1 of the methodology for designing and revising professional profiles and developing skills, and it specifies the methodological approach for developing and revising qualifications in the Additive Manufacturing sector.

It was developed based on a literature review on the current methodologies for the definition and revision of professional profiles, which gave useful insight on how to structure the SAM methodology. It also considers the AM sectoral framework which defines the proficiency levels that need to be considered in the design or review of qualifications. In alignment with other already established EU frameworks such as the European Qualification Framework (EQF), the Digital Competence Framework 2.0 (DigComp), and the Entrepreneurship Competence Framework (EntreComp).

1. SAM Methodology for designing and reviewing professional profiles and skills development in AM

1.1 Methodological Principals

A critical literature review (Appendix C) on theoretical and empirical Competency Models developed for different sectors and professional contexts has been conducted to collect useful insights for SAM methodology.

As a starting point, SAM methodology leverages the EWF sectoral approach for the design and review of Qualifications in the Welding, Joining, and Cutting sector, developed in the RAINBOW project; nevertheless, it goes beyond it by adding a processual approach for the AM sector.

In order to capture the wide range of current and future occupations directly involved in the AM sector, an **overarching processual model** is necessary to map not only all the professional profiles within the AM sector, but also all the skills demand in other occupations that are related to AM. For this, we specifically consider IDEF0 (Icam DEFinition for Function Modelling) model to build up process and activities models, interlinked with EWF´s methodology for the design of Qualifications that is structured into a top-down approach where, based on the definition of a professional profile, the mapping of the major job functions and related activities leads to the development of Competence Units with the description of Learning Outcomes, in terms of Knowledge and Skills, to guarantee that the learners are fully competent for specific job requirements. This process is exemplified in Appendix B.

As EWF's methodology and IDEF0 model, SAM's approach is based on the principles of functional analysis to define the occupational competencies and in setting boundaries between different occupations within the International Additive Manufacturing Qualification System (IAMQS).

1.2 SAM Methodology main principals

SAM methodology for the design and review of professional profiles and skills development in the AM sector (SAM Methodology) is built upon three main principles:

- **A process approach**: Designing and reviewing a professional profile consist of procedural steps that are associated in a consistent way. It means completing each activity is a prerequisite for proceeding to the next one. Establishing a clear job process, for example in revising an existing professional profile, is essential before starting to define job activities.
- **Analysis of similar situations rather than starting from scratch:** The focus is on revising/creating activities based on existing ones. It includes studying the current professional profiles associated with other technologies, in other sectors, and for different roles. It helps to revise/create activities based on those that have already been designed in similar situations.
- **The origin of skill gaps**: Since any development and revision of professional profiles is due to a specific skill gap, the origin of that gap may govern how to design professional profiles and skills development programs. Classification of its origin and basis, therefore, has been considered in the proposed methodology. ***The classification of skills gaps gives orientation on the application of the similarity approach so that the several procedures and rules will be described to conduct professional profiles design according to the type of the skill gap.***

In order to apply the proposed **similarity-based approach**, the concept and term of the professional profile are structured as shown in Figure 2. The process describes a logical connection of all job activities with the identification of input/output/resource/constraint for every individual activity. It gives a holistic view of how activities are interrelated considering their input/output. A professional profile refers to a general description of the professional occupation that includes a set of job functions and job activities. Job function describes a set of functional actions to achieve the main objectives of the profession, and finally every job function includes a set of job activities necessary to complete that job function.

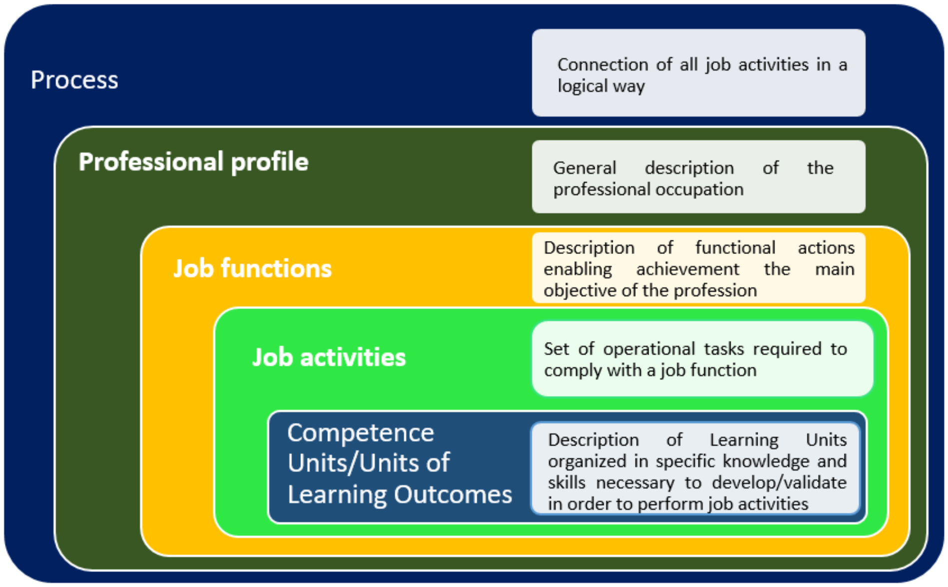


Figure 2- Definition of terms related to a professional profile

Looking into the definitions given in the above figure, a professional profile can be defined/updated according to two sets of details: the first concerns the operationalization work in terms of revising/creating job functions and job activities; then the second identifies and describes the related learning outcomes organizing them in Units of Learning Outcomes.

On the other hand, the SAM methodology considers three different types of pillars (inputs) for the definition of a professional profile, as shown in Figure 3. The first pillar refers to the professional role. The role of a professional may vary due to different activities required at different stages in the product lifecycle. For example, an operator in the post-processing stage is assigned some tasks and responsibilities, which are not necessary for an operator in the pre-processing stage and vice versa. Another example, an engineer in the pre-processing stage is assigned some tasks and responsibilities, which are different from what an operator is expected to perform in the same stage. The second pillar addresses technological processes; obviously, professional profiles are not the same for different technologies; for example, Binder Jetting and Direct Energy Deposition technologies are characterized by their own specific performances, standards, etc. The professional profile for each technology, therefore, needs to match its features and characteristics. Regarding the next pillar: Material, professional profiles might be different based on the different materials used in the AM process.

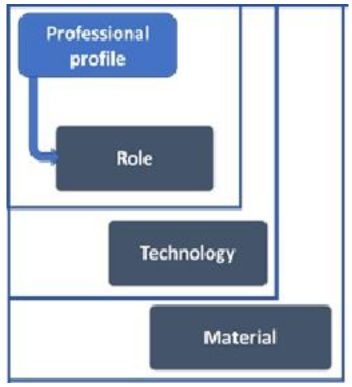


Figure 3- Four pillars (inputs) for the definition of the professional profile in SAM methodology

Figure 4 resumes the SAM Methodology process approach. In a whole view, it has been divided into three phases. The procedure begins with a Starting phase indicated by the blue box. Then it is the Data Resource phase, including four blue boxes embedded by the blue dashed-lined box. Finally, the third step defines the Revision and Creation of the professional profile process, indicated respectively by green and orange boxes.

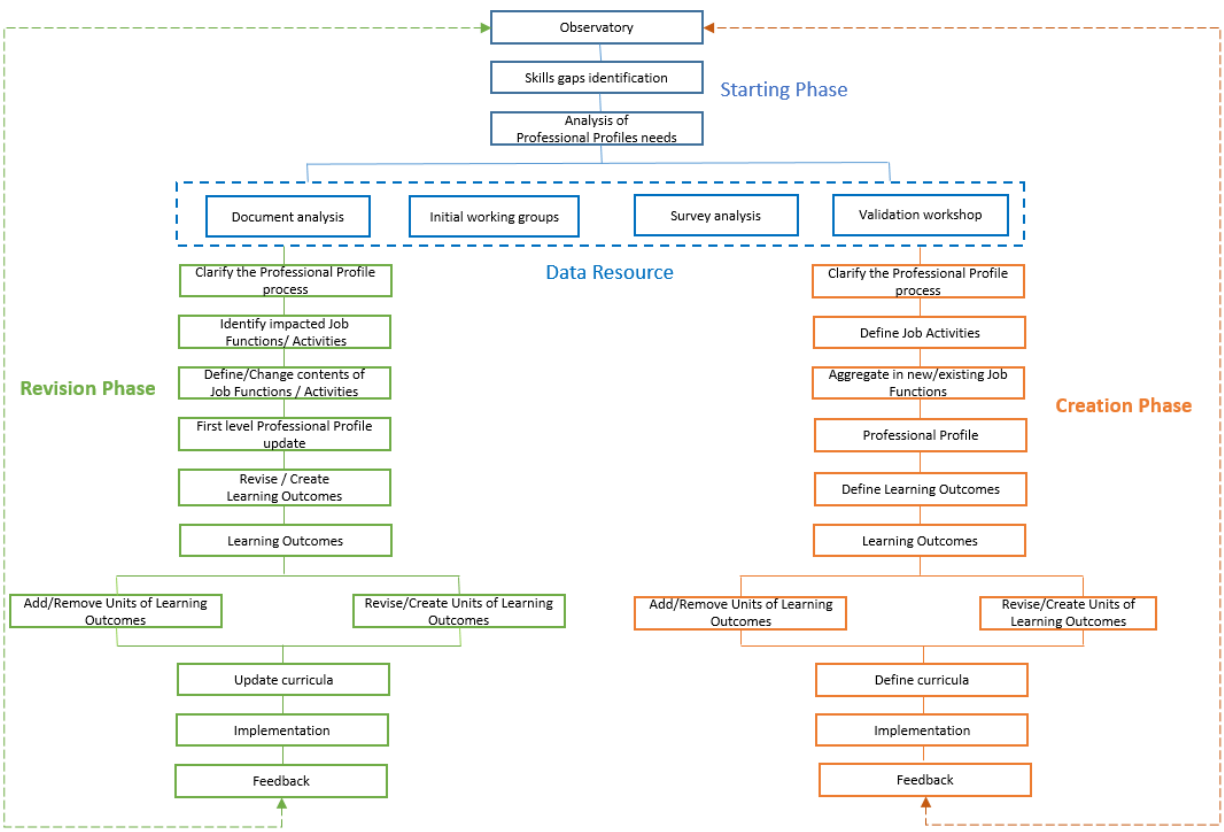


Figure 4- Global (generic) flowchart for designing and reviewing professional profile in AM

Similarity approach for the design and review of professional profiles

SAM methodology procedure for **skills gaps causes classification** begins with collecting inputs from SAM's Forecast Methodology; Assessment of current and future skills in AM implemented by the AM Observatory and identifying the skills gap. It is necessary to indicate the origin of the gap, based on of the classification shown in figure 5:

Skill Gap Origin				
Technological process		Material		Qualification
New technological process	Advancement in technological process	New material	Being updated in use	Systematic review

Figure 5 – Classification of origin of the skill gaps

- **New technological process:** An emerging or new technology in an AM process will likely lead to the development of new methods and tools. In that case, some professional profiles need to be updated, perhaps new ones need to be created, according to the new skills and competencies associated with these new methods and tools. The effectiveness of any new technological process, therefore, depends on how well these skill gaps are detected and then on how well they are considered in the process of reviewing and designing professional profiles.

- **Advancement technological process:** Sometimes, making progress in an existing technology leads to some changes in the AM process. As mentioned above, analysis of which occupations are affected and how they are affected is key to enabling the detection of new employer-required skills, competencies, and professional profiles. These revisions help to shape any potential shortcomings both for employers and the profiles.

- **New material:** The discovery of new material with new characteristics and functionalities will likely affect the AM process. In that case, identification of any changes that take place in this process allows for recognizing what activities in the AM process are affected. It enables us to detect what skills and competencies are missing in the existing professional profiles.

- **Being updated an in-use material:** Sometimes, updating an in-use material causes some changes in an AM process. Being aware of these changes affects what employees and workers need to do in their jobs, and should be considered when reviewing and designing professional profiles.

- **Gaps in existing qualifications:** Sometimes, an existing professional profile suffers from some shortcomings in the provided learning outcomes and curriculum. It usually appears through feedback coming from various sources, such as new European policies, standardization requirements, surveys, companies, VET providers, trainers/teachers, pedagogical experts, and learners, which are disclosing weak points and gaps throughout the learning and training process. In this case, reviewing professional profiles is necessary to resolve any inadequacy.

For all origins of skills gaps, particular attention is given to the following aspects, since they have a direct impact on specific job roles and/or activities within AM professional profiles, but particularly on the development/review of Competence Units/Units of Learning Outcomes:

- <u>New AM applications in a sector that already uses an AM process:</u> Sometimes, in the sectors where AM processes and technologies have been already established, new opportunities arise, in terms of extending current products or producing new ones. In this situation, the identification of missing skills and competencies is essential for designing or reviewing professional profiles.

- Applying existing AM in a new sector: Where a new sector chooses to adopt an AM process then an opportunity may arise whereby professional profiles can be updated. Such changes in the AM process might alter professional structures and, consequently, employees and workers need to be prepared with new skills and competencies for their jobs. Thus, reviewing and designing professional profiles is necessary to resolve these shortcomings and to prepare/adapt qualified people.

- Extended stage in the product lifecycle: AM process may change the structure of the product lifecycle. Adding a new stage to the existing lifecycle requires new activities, and consequently, employees and workers will need new skills and competencies to perform these activities. Thus, reviewing and designing professional profiles is necessary to address these missing skills.

- Sustainability (Lifecycle Assessment needs): Concerns about sustainability assurance activities in manufacturing is a promising approach and AM is not an exception. Thus, green skills present themselves splendidly to minimize environmental impacts and promote Circular Economy principles throughout the entire AM process chain. Lifecycle Assessment is, therefore, part of those green skills that make a sustainable AM process and are able to foster a Circular Economy approach to it. Subsequently, professional profiles (and qualifications) need to be reviewed so that employees are prepared and qualified with those skills.

1.3 Data sources and development loops for design and review of professional profiles and Units of Learning Outcomes

A set of accurate data is necessary to perform each step of the design and review of professional profiles shown in Figure 6. This section describes a process of data collection to be followed by the responsible(s) for designing and reviewing the professional profiles as well as the several development loops for conducting the design and review of professional profiles and Units of Learning Outcomes.

Data sources

Identifying and classifying reliable resources to extract relevant data addressing the identified gap(s) is a key aspect of both developing and reviewing professional profiles. Performing literature reviews, analysing related reports and documents, indicating reference groups and experts are more known actions to identify sources of documents and data. For instance, when the origin of the skills gap is a new technological process, then the focus will be on analysing those in-use technologies that are very similar to the new one. Accordingly, documentation of data sources would involve activities such as making a list of similar technologies with their specific characteristics and functionalities, identifying those sectors that these technologies have been established on, and listing experts with a strong background in the deployment and implementation of these technologies. The main sources providing relevant inputs for the development loops are:

Internal data sources:

This consists of data resources that come from the SAM activities including:

- Reports on skills needs and gaps developed by the AM Observatory
- Feedback reports from the implementation of IAMQS Qualifications
- Outcomes from IAMQC and IAMIC Working Groups sessions

External data sources:

This consists of data resources that comes from out of the SAM including:

- Reports/Outcomes from Validation Workshops/sessions with AM Experts
- General reports on technology and/or materials
- General reports or guidelines on European skills policies

Development loops

Within the development loops, shown in Figure 6, we consider both players and the flow of developments:

- **AM Observatory Team**: establishes links between the different actors, providing all the required data (internal and external resources) for implementing Working sessions and Validation Workshops.
- **Education Working Groups:** propose new/review of qualifications/CU, based on the analysis of internal and external resources.
- **IAMQC**: validates proposals, facilitated by the Working Group Chairman.
- **Experts**: Members of the **Education Working Groups** and the **Industry Advisory Group**. We distinguish four types of experts: researchers, engineers and high-level expertise operators, executive management, and operational managers. Depending on the type of knowledge to be collected or discussed, the target working groups are then defined.
- **Working session(s)**: are composed by the experts of a specific Education Working Group that conducts analysis and development sessions, facilitated by the Working Group Chairman. For example, if the session aims to perform "identify impacted Job Functions/Activities", where the origin of the skill gap is emerging from a new technological process, then the expectation is to create a classification of activities in three parts: activities in need to be revised, those which need to be redundant, and new ones that need to be created.
- **Validation Workshop(s)**: The proposals are evaluated in the validation Workshops to assure that the designed professional profile covers the identified gaps. If the designed professional profile can't fulfil the validation criteria, then it will be sent back to uptake the necessary revisions. There is an optional validation workshop whereby the validation process needs to be carried out in two separate sessions/workshops, after a new revision of the profile.

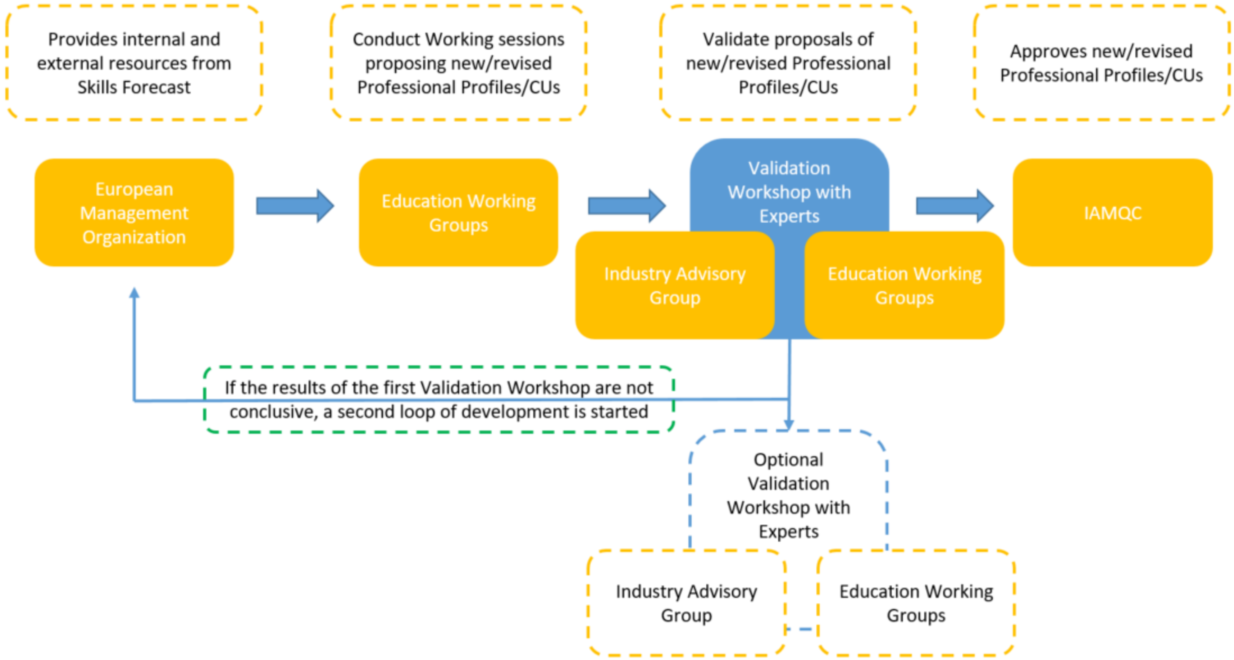


Figure 6- A schematic of development loops

2. Description of Revision/Creation of professional profile

To have a better understanding of how to revise and create a professional profile, this section breaks down the whole process into its subsequent steps. The main objectives in the professional profile design are, initially, the definition of the professional profile in terms of related job functions/activities, followed by the identification of units of learning outcomes in the associated curriculum.

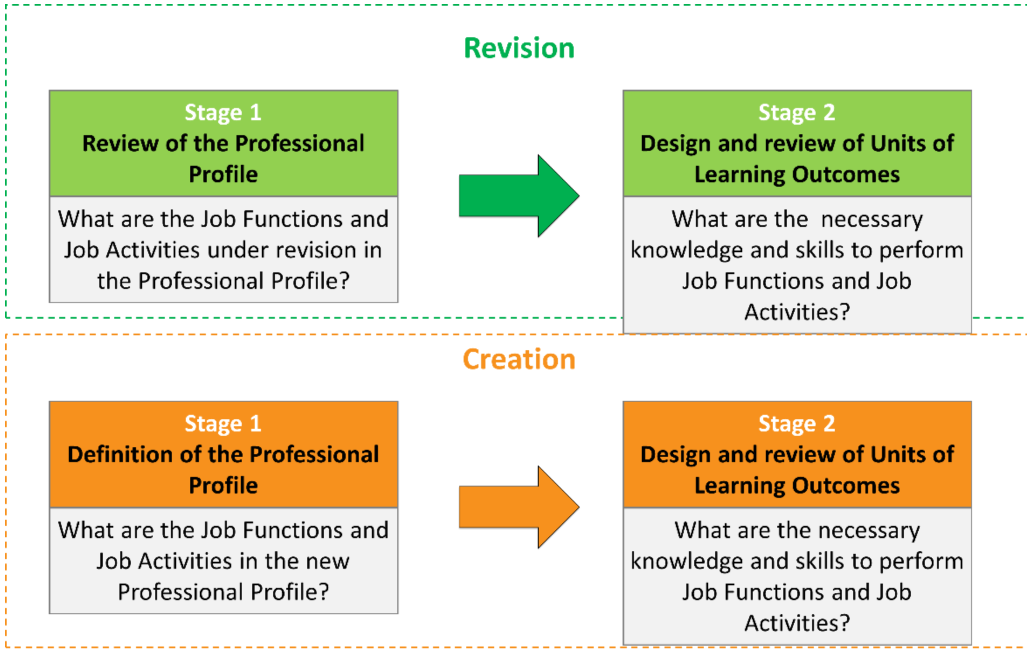


Figure 7 – Stages for revision/creation professional profile

2.1 Design and revision of professional profile

In below, we present what is foreseen in each step and it is explained which and how data sources are used in these steps. This process is applicable for all types of skills gaps and follows the logic presented in Figure 7, but for better clarification, it considers a new technological process as the drive for a new skills gap. A schematic view of the whole process of revision/creation of professional profile is shown in Appendix A. Moreover, a practical example in Appendix B demonstrates the design of a professional profile and the identification of learning outcomes in a real scenario.

Templates for the application of the methodology are provided in the D3.2 Kit of templates – Revision and Creation of Professional Profiles

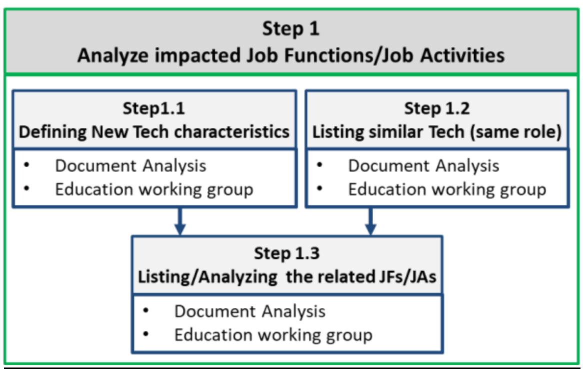
Re-definition of a Professional Profile (PP)

Stage 1
Review of the Professional Profile

What are the Job Functions and Job Activities under revision in the Professional Profile?

The following steps will be the guiding principles for reviewing Professional Profiles:

<u>Step 1: Analyse impacted job activities/function</u>



a) <u>Characteristics of new/updated technological process</u>

Key *questions:*

- What are the characteristics of the (new/updated) technological process/material?
- Are there any similarities with other technologies/materials?
- For which AM professionals is the (new/update in) the technology/material relevant?

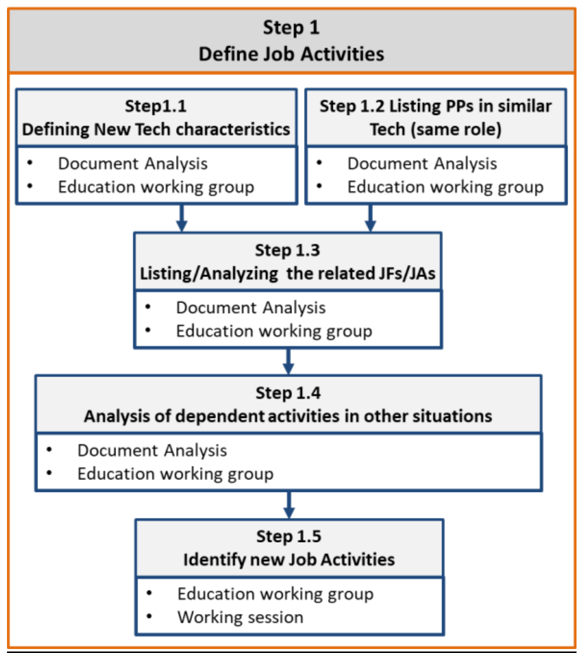
Definition of the Professional Profile

Stage 1
Definition of the Professional Profile

What are the Job Functions and Job Activities in the new Professional Profile?

The following steps will be the guiding principles for defining new Professional Profiles:

<u>Step 1: Define job functions and job activities</u>

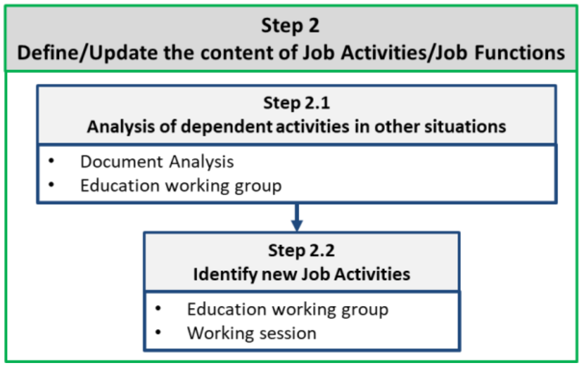


a) <u>Characteristics of new/updated technological process</u>

Key *questions:*

- What are the characteristics of the (new/updated) technological process/material?
- Are there any similarities with other technologies/materials?
- For which AM professionals is the (new/update in) the technology/material relevant?

Step 2: Define/update job activities/functions

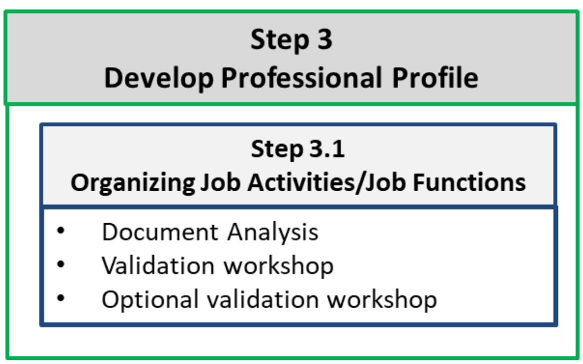


b) Updates in existing Professional Profiles

Key questions:

- Which job activities/functions need to be kept as they are?
- Which job activities/functions need to be revised?
- Which job activities/functions need to be removed?

Step 3: Develop Professional Profile

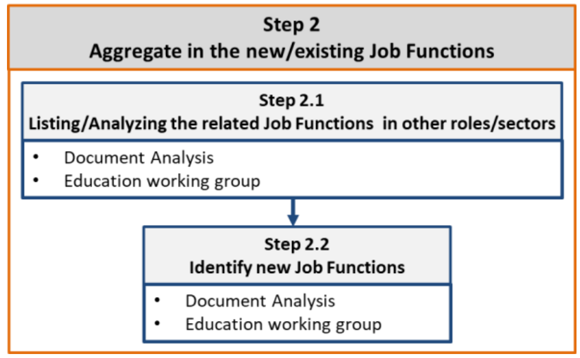


c) List of new job functions/activities

Key questions:

- What new job functions and activities are required?
- Are these job functions and activities similar to other professional profile(s)?

Step 2: Aggregate new/existing job functions



b) Similarities with existing Professional Profiles

Key questions:

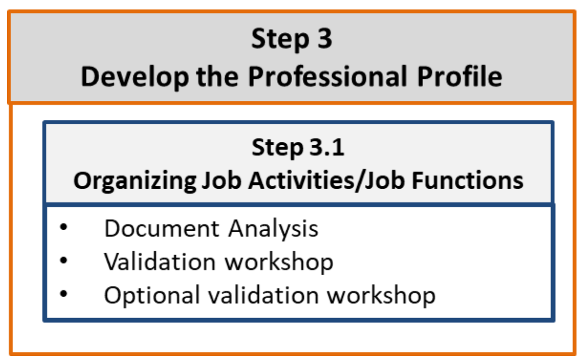
- Which job functions/activities are common to other existing professional profiles?

c) New job functions/activities

Key questions:

- What new job functions and activities are required?

Step 3: Develop Professional Profile



d) New Professional Profile

Key questions:

- What is the general description of this professional profile concerning its main tasks and responsibilities?
- What is the required previous knowledge (academic background) and/or experience in the field to attend the qualification course?
- What level of complexity and depth should be achieved in terms of knowledge, skills,

	autonomy and responsibility at the end of a qualification process?

2.2 Design and review of Units of Learning Outcomes

After defining the elements of a professional profile, job functions and related job activities, the next step is to identify Units of Learning outcomes. This step follows the EWF (European Welding Federation) approach for classification of Units of Learning Outcomes/Competence Units (CUs) in two types: Cross-cutting or Functional. Cross-cutting CUs refer to those in which learning outcomes are not directly linked with one specific job function, given that the knowledge and skills will be mobilized in several job functions and activities. For Functional CUs, learning outcomes will be directly linked with at least one job function and the knowledge and skills will be directly linked with specific job functions and related activities.

Templates for the application of the methodology are provided in D3.2Kit of templates – Revision and Creation of Professional Profiles.

Re-definition of a Professional Profile (PP)

Stage 2
Design and review of Units of Learning Outcomes

What are the necessary knowledge and skills to perform Job Functions and Job Activities?

The following steps will be the guiding principles for reviewing/defining new Competence Units/Units of Learning Outcomes:

<u>Step 4: Define/revise Learning Outcomes</u>

Step 4
Define/Revise Learning Outcomes

Step 4.1
Relevant Learning Outcomes for Professional Profile
- Document Analysis
- Education working group

Step 4.2
Updates in existing Learning Outcomes
- Document Analysis
- Education working group

Step 4.3
Identify new learning outcomes
- Document Analysis
- Education working group
- Working session

a) Updates in existing Learning Outcomes

Key questions:
- What Competence Units/Units of Learning Outcomes need to be updated?

b) New Competence Units/Units of Learning Outcomes

Definition of the Professional Profile

Stage 2
Design and review of Units of Learning Outcomes

What are the necessary knowledge and skills to perform Job Functions and Job Activities?

The following steps will be the guiding principles for reviewing/defining new Competence Units/Units of Learning Outcomes:

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Step 4.2
Updates in existing Learning Outcomes
- Document Analysis
- Education working group

Step 4.3
Identify new learning outcomes
- Document Analysis
- Education working group
- Working session

a) Similarities with existing Competence Units/Units of Learning Outcomes

Key questions:
- What existing Competence Units/Units of Learning Outcomes directly contribute for the Professional Profile qualification?

Key questions:

- What new Competence Units/Units of Learning Outcomes are required?

Step 5: Definition of the Units of Learning Outcomes

Step 5
Definition of the Units of the Learning Outcomes

Step 5.1
Organizing the identified learning outcomes

- Document Analysis
- Validation workshop
- Optional validation workshop

c) Full list of Competence Units/Units of Learning outcomes

b) Updates in existing Learning Outcomes

Key questions:

- In case already existing Competence Units/Units of Learning Outcomes require an update, what needs to be changed?

c) New Competence Units/Units of Learning Outcomes

Key questions:

- What new Competence Units/Units of Learning Outcomes are required?

Step 5: Definition of the Units of Learning Outcomes

Step 5
Definition of the Units of the Learning Outcomes

Step 5.1
Organizing the identified learning outcomes

- Document analysis
- Validation workshop
- Optional validation workshop

d) Full list of Competence Units/Units of Learning outcomes

An application example is given in appendixes A and B

3. Alignment between AM Framework, EWF Sectoral Framework, Digital Competence Framework and Entrepreneurship Competence Framework

In order to align the Additive Manufacturing (AM) Qualification System Framework with the European Digital Competence for Citizens Framework (DigComp) and the Entrepreneurship Competence Framework (EntreComp), the methodology matched the Learning Outcomes generic descriptors and the EQF levels.

The starting point was the **EWF Qualifications System Framework**, which is a generic description of qualifications for both Welding and AM fields. This sectoral framework contains six levels of proficiency associated to each qualification /CU (Basic, Elementary, Independent, Specialized, Advanced and Expert), and a general descriptor defined in terms of knowledge, skills, autonomy, and responsibility (Appendix D).

The **Digital Competence Framework for Citizens** (DigComp) is meant to serve as a tool to improve citizens' digital skills and it has five dimensions:

Dimension 1: Competence areas identified to be part of digital competence.
Dimension 2: Competence descriptors and titles that are pertinent to each area.
Dimension 3: Proficiency levels for each competence.
Dimension 4: Knowledge, skills and attitudes applicable to each competence.
Dimension 5: Examples of use, on the applicability of the competence to different purposes.

DigComp defines eight proficiency levels for each of the 21 competences identified in the five competence areas, and these proficiency levels support the development of learning and teaching materials, as well as the design of instruments for assessing the competences' development in learners.

Competence area 1: Information and data literacy
- 1.1 Browsing, searching, filtering data, information and digital content
- 1.2 Evaluating data, information and digital content
- 1.3 Managing data, information and digital content

Competence area 2: Communication and collaboration
- 2.1 Interacting through digital technologies
- 2.2 Sharing through digital technologies
- 2.3 Engaging in citizenship through digital technologies
- 2.4 Collaborating through digital technologies
- 2.5 Netiquette
- 2.6 Managing digital identity

Competence area 3: Digital content creation
- 3.1 Developing digital content
- 3.2 Integrating and re-elaborating digital content
- 3.3 Copyright and licences
- 3.4 Programming

Competence area 4: Safety
- 4.1 Protecting devices
- 4.2 Protecting personal data and privacy
- 4.3 Protecting health and well-being
- 4.4 Protecting the environment

Competence area 5: Problem solving
- 5.1 Solving technical problems
- 5.2 Identifying needs and technological responses
- 5.3 Creatively using digital technologies
- 5.4 Identifying digital competence gaps

Each level description contains knowledge, skills, autonomy and responsibility, described in one single descriptor for each level of competence. As referenced by the framework's authors, "each level represents a step up in citizens' acquisition of the competence according to its cognitive challenge, the complexity of the tasks they can handle and their autonomy in completing the task".

If the relationship between digital education and assessment is to be reflected in the IAMQS, the following perspectives on the assessment of digital competences should be considered, based on the approach focused on the publication "Digital Education at School in Europe" (*Eurydice Report, 2019)*:

- Whether digital competences are assessed in the final exam.
- What guidance is provided to teachers and trainers of the system to assess digital competences in the classroom.
- Whether information on digital competences is given on certificates awarded at the end of the qualification/CU.

Research shows that innovations in education usually fail if teachers are not provided with the skills and knowledge needed to implement them in practice. Training trainers/teachers is also a very expensive activity and often much neglected in relation to large-scale initiatives (Pelgrum, 2001). Moreover, as highlighted by Black and William (1998, p. 10) "teachers will not take up ideas that sound attractive, no matter how extensive the research base, if the ideas are presented as general principles that leave the task of translating them into everyday practice entirely up to the teachers". Therefore, an overall approach to including digital competences development in the IAMQS qualifications should be thoroughly discussed and the implications in the qualifications/CUs design or revision should be seriously analysed.

According to the above-mentioned Eurydice Report "Digital Education at School in Europe", in most European countries, the official guidance on the assessment of digital competences in the classroom is limited to learning outcomes. In thirteen national systems, the learning outcomes provided in the curriculum are the only guidance at any education level. Specifications available for teachers to use when assessing students in the classroom are also a valuable source of guidance. If they indicate for the final examinations which competences will be tested, what is expected of learners, what kind of tasks need to be performed and how the tests will be evaluated, teachers can use these as benchmarks for assessing students during the course.

As stated in the EC 2019 report of the high-level expert group on "The Impact of the Digital Transformation on EU Labour Markets", jobs that are anticipated to grow in the next decade will need digital skills because of their characteristics. With technologies such as artificial intelligence or machine learning increasing their presence in the workplace, workers will not only need to acquire new skills but constantly update them.

It is, then, a system quality issue to include elements of the digital transformation in the education and training of the AM work force.

The **Entrepreneurship Competence Framework** (EntreComp) consists of three competence areas, 15 competences, and an 8-level progression model completed with 442 learning outcomes (Annex D). The EntreComp is aimed at establishing a common reference framework for entrepreneurship as a competence to help citizens to develop their ability to actively participate in society, to manage their own lives and careers and to start value-creating initiatives. In this context, entrepreneurship is understood as a transversal key competence applicable by individuals and groups, including existing organizations, across all spheres of life. Entrepreneurship is defined as "when you act upon opportunities and ideas and transform them into value for others." The value that is created can be financial, cultural, or social.

The EntreComp Progression Model provides a reference for the development of proficiency starting from value creation achieved through external support, up to transformative value creation. It consists of four main levels: Foundation, Intermediate, Advanced and Expert. Each level is in turn split into two sub-levels (Annex D).

To know more about EntreComp visit:
https://publications.jrc.ec.europa.eu/repository/bitstream/JRC101581/lfna27939enn.pdf

This analysis is based on general descriptors; it may not be suitable for each specific qualification. For a more accurate and less generic alignment between EntreComp and EWF and IAMQS qualifications, there should be a more comprehensive analysis of the specific Learning Outcomes that can mirror an entrepreneurial attitude in each qualification or even in the way training is delivered, promoting the crucial EntreComp competences development as a way to increase workers readiness to deal with today's society challenges.

3.1 DigiComp and EnterComp frameworks alignment with the Metal AM Process Engineer for PBF-LB

Stakeholders from the Industrial council engaged to classify the relevance of competence areas from DigComp and from EntreComp. The following sections describe the methodological approach used for making the framework alignment for the Metal AM process Engineer for PBF-LB.

3.1.1 Methodological approach

- **Step 1 -** Present the context of the alignment, the DigComp and EnterComp Frameworks (Appendix D) and the selected Professional Profile and Qualification to the Industrial Council
- **Step 2 -** For the selected Professional Profile and Qualification, ask the Industrial Council to **classify the Competence areas from DigiComp and from EnterComp as relevant or not relevant after** showing them the skills that are included in each competence area**.**
- **Step 3 -** For the Competences that were classified as relevant, ask the Industrial Council to **classify the proficiency level of each required skill** (Appendix D) which are Foundation, Intermediate, Advanced and Highly Specialized (Appendix D). At this point, skills that are found not so relevant for the profile can be excluded.
- **Step 4 -** The Qualification Council, through the Working groups, analyse the classification results obtained and **propose a proficiency level for each skill**, supporting it with a justification and underlining keywords if useful. At this point, skills that are found not so relevant to the profile can be excluded. **The analysis of the Professional Profile shall be made based on the expected level of knowledge and skills for that Profile, and not based on the current content of the qualification.**
- **Step 5 - Validate the proficiency level proposed for each Skill** with the industrial council. (During the validation process, the proficiency levels are discussed and agreed, based on the stakeholder's experience and the supporting explanations provided in the proposal submitted for validation).
- **Step 6 -** With the skills proficiency levels defined, and considering the PP description, **compare the Competence level descriptors with the learning outcomes of the qualification.**
- **Step 7 -** For those skills that are not covered by the qualification, or not covered to the desired proficiency level, the assigned working groups of the **Qualification Council will update the qualification**, either by:
    - adding new learning outcomes
    - adjusting existing Los
    - creating additional CUs
    - forcing a learning approach that will integrate the development of those digital skills
- **Step 8 - Submit for approval by the Qualification Council.**

3.1.2 Alignment proposal

DigiComp alignment proposal – This section describes the **digital skills** for the Metal AM Process Engineer PBF-LB

Competence area	**Required Skills** (From the most relevant to less relevant)	**Proficiency** (task complexity, autonomy, cognitive domain)
Information and data literacy	**1 Evaluating data, information and digital content**	**1.Advanced** (The Engineer is the one responsible for assessing the reliability of sources and data in digital environments and to provide it to others. It is not Highly Specialized (HS) because their core role is not

	2 Managing data, information and digital content **3 Browsing, searching and filtering data, information and digital content**	to create solutions to ensure the reliability of information/data in digital environments, rather their collecting the information/data, not others) **2.Advanced** (consensual level among experts) **3.Advanced** (Because the Engineer needs to be able to assess information needs, apply searching strategies the most appropriate data, information and content in digital environments, <u>and explain how to do it</u>.)
Communication and collaboration	**1 Collaborating through digital technologies** **2 Interacting through digital technologies** **3 Sharing through digital technologies** **4 Engaging in citizenship through digital technologies** **5 Managing digital identity** **6 Netiquette**	**1. Advanced** (There is a significant number of experts classifying it as Advanced and Highly Specialized (HS). Advanced, because they are able to use several digital tools and technologies (e.g., Dropbox, SharePoint, Google drive) <u>for collaborative processes</u>, and co-creating data, resources and knowledge; select the most appropriate. Not HS, because it's not the Engineer duty to establish direct links between devices and these digital tools and technologies (IoT). **2. Highly Specialized** (considerable number of experts confirming it) **3. Advanced** (Consensual level among experts) **4. Not Relevant** for the AM Engineer PBF-LB Professional Profile and job activities **5. Not relevant** for the AM Engineer PBF-LB Professional Profile and job activities **6. Not relevant** for the AM Engineer PBF-LB Professional Profile and job activities

Digital content creation	**1 Integrating and re-elaborating digital content**	**1. Intermediate** (Not a core activity of the Engineer, and an Intermediate level already ensures their ability to discuss ways to modify, refine, improve and integrate new content and information to create new and original ones)
	2 Developing digital content	**2. Intermediate** (Not a core activity of the Engineer, and an Intermediate level already ensures their ability to create and edit digital content in different formats)
	3 Copyright and licenses	**3. Intermediate** (Not a core activity of the Engineer, and an Intermediate level already ensures their ability to discuss rules of copyright and licenses that apply to digital information and content)
	4 Programming	**4. Not relevant** for the AM Engineer PBF-LB Professional Profile and job activities
Safety	**1 Protecting health and well-being**	**1. Advanced (digital risks)** Experts are divided among the levels, but there is a significant number identifying HS. Advanced, because the Engineer has the duty to protect himself and others from dangers and health-risks and threats to physical and psychological well-being while using digital technologies and digital environments.
	2 Protecting personal data and privacy	**2. Intermediate** (Because the Engineer is able to discuss ways to use and share personally identifiable information while protecting themselves and others from damages; their responsibility doesn't cover others' personal data sharing/protection)
	3 Protecting the environment	**3. Advanced** (Consensual level among experts)
	4 Protecting devices	**4. Advanced** ((Consensual level among experts)
Problem solving	**1 Identifying needs and technological responses**	**1. Intermediate** (Not Advanced, because it is not the AM Process Engineer Job to assess the needs of others and to decide on the digital environments to use in the company. But it is their responsibility to explain and select the environments for their own needs)
	2 Solving technical problems	**2. Advanced** (Not HS, because the process engineer does not create solutions for technical problems in the machines /devices. But, it is their responsibility to identify the problem and apply different solutions provided by the device manufacturers)
		3. Intermediate (The Engineer is able to discuss their own digital competence gaps and indicate how others

	3 Identifying digital competence gaps **4. Creatively using digital technologies**	can support them, but the Engineer is not a Digital skills assessment expert) **4. Highly Specialized** (Because the Engineer is able to create solutions to solve complex problems with many interactive factors and to innovate when creating processes and products)

F - Foundation / I - Intermediate / A - Advanced / HS – Highly Specialised

EnterComp alignment proposal – This section describes the **Entrepreneurial skills** for the Metal AM Process Engineer PBF-LB

Competence area	**Required Skills** (From the most relevant to less relevant)	**Proficiency** (task complexity, autonomy, cognitive domain)
Ideas and Opportunitie s	**1.Spotting Opportunity (Identify needs and challenging opportunities to create value)** **2. Creativity (Develop creative and purposeful ideas/solutions)** **3. Ethical and sustainable thinking (Assess the impact of ideas, opportunities and actions)** **4. Vison (Visualize future scenarios to help guide effort and action)** **5. Valuing Ideas (Recognise the potential of an idea to create value and identify suitable ways to make the most out of it)**	**1. Expert** (Because the Engineer can judge opportunities for creating value and decide whether to follow these up at different levels of the system they are working in). **2. Advanced** (Although the Engineer requires a certain level of creativity, their job-functions do not require an expert level to design or create new products**)** **3. Advanced** (Because it is expected from the Engineer that they can take responsibility for promoting ethical behaviour in their area of influence. They can discuss the impact their organisations have on the environment, and they can analyze the implication of their activity within the boundaries of the system they are working in) **4. Expert (B**ecause the Engineer can plan and develop, alone or with others (designer), alternative scenarios for the process implementation, improvement opportunities, identifying the challenges. **5. Advanced** (Because the Engineer can tell the difference between trademarks, register rights, trade secrets, confidentiality agreement and copyrights; They can breakdown a value chain into its different parts and identify how value is added in each part)

Resources	**1. Self-awareness and self-efficacy (Identify and assess individual and group strength and weaknesses)** **2. Motivation and perseverance (Be resilient under pressure)** **3. Mobilising others (Communicate effectively, negotiate and lead)** **4. Mobilising resources (Gather and manage required resources)** **5. Financial and economic literacy (Develop financial and economic know-how)**	**1. Advanced** (The Engineers have the ability to influence the course of events despite uncertainty, setbacks and temporary failures) **2. Experts** (The Engineer can cope with unexpected changes, setbacks and failures, staying focused despite challenges and making sure that the solutions will develop in a continuous cycle of improvement) **3. Intermediate** (Because the Engineer should lead by example, can persuade others by providing evidence for their arguments, and can communicate imaginative processes solutions.) 4. **Advanced** (Because the Engineer can choose and put in pace effective resource management procedures (life cycle analysis). 5. **Intermediate** (Because the Engineers understand financial and economic concepts and can draw up a budget for an alternative process solution or innovation.
Into Action	**1.Taking the initiative** **2. Coping with uncertainty, ambiguity and risk (Make decisions dealing with uncertainty, ambiguity and risk)** **3. Planning and management (Prioritize, organise and follow up)** **4. Work with others** **5. Learn through experience**	**1. Expert** (Because the Engineer takes responsibility in complex value-creating activities and in seizing new opportunities; The engineer can encourage others to take initiative in solving problems and creating value within the team and organisation). **2. Advanced** (Because the Engineer can put together different points of view and make decision, even when the information is incomplete and the degree of uncertainty is high; Additionally, the Engineer can apply the concept of unfordable losses based on a risk assessment and outline a risk assessment plan). **3. Advanced** (Although requiring an expert level for planning and organizing, and flexibility and adaptability to change) • For defining goals – Advanced • Plan and organize – Expert • Define priorities – Advanced

		• Monitor progress – Advanced • Flexible and adapt to change - Expert **4. Intermediate** (Because the Engineer can combine different contributions, can express ideas assertively, can listen to end users, can share ownership with the members of the team, can create a team of people that can work together in the activity and can establish new relationship to get the support needed to turn ideas into action) **5. Expert** (Because the Engineer can take a team or the organisation to a higher level of performance based on the feedback collected and by learning lessons from achievements and failures; Can identity opportunities for self-improvement in the organisation and can learn from the impact monitoring and evaluation activities designed to track the progress of the activities.)

3.1.3 Consideration and Recommendations

At this stage, this alignment process is a very complex and time-consuming activity .It also requires the involvement of highly specialized educational experts that are familiar the frameworks and have already the experience using it. Moreover, it is important to underline that the above mentioned frameworks have a general scope and address citizens, while there is a need for creating EntreComp and DigComp- aligned frameworks for the specific AM context, with specific AM practical examples to facilitate the interpretation and identification of the most adequate proficiency level associated to a Professional Profile.

3.2 AM systems framework (Generic description for AM professional profiles)

During the implementation of SAM Methodology, a thorough analysis was made between the alignment of the AM framework defined in terms of EQF level descriptors for knowledge, skills, autonomy and responsibility and other relevant frameworks, to confirm its applicability, integration level, added value in terms of compatibility and/or correspondent level assignment.

Table 1. AM Qualification System framework

<table>
<tr><th colspan="3">ADDITIVE MANUFACTURING FRAMEWORK</th><th rowspan="2">EQF Level</th><th colspan="4">Alignment between EQF Levels and other relevant Frameworks</th></tr>
<tr><th>KNOWLEDGE</th><th>SKILLS</th><th>AUTONOMY AND RESPONSIBILITY</th><th>DigComp</th><th colspan="2">EntreComp</th><th>EWF</th></tr>
<tr><td>Knowledge at the most advanced frontier in the field of additive manufacturing and at the interface between other manufacturing fields.</td><td>Highly advanced and specialised skills and techniques, including synthesis and evaluation required to solve critical problems in research and/or innovation applied in additive manufacturing technology.
Extend and redefine existing knowledge or professional practice when applying additive manufacturing processes.</td><td>Demonstrate substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes including research at the forefront of additive manufacturing.</td><td>8</td><td rowspan="2">Highly Specialized</td><td rowspan="2">EXPERT</td><td>8</td><td>NA</td></tr>
<tr><td>Highly specialised and forefront knowledge including original thinking, research and critical assessment of theory, principles and applicability of additive manufacturing processes.</td><td>Highly specialised problem- solving skills including critical and original evaluation, allowing to define or develop the best technical and economical solutions, when applying additive manufacturing processes, in complex and unpredictable conditions</td><td>Manage and transform additive manufacturing processes in a highly complex context.
Fully responsible for the definition and revision of additive manufacturing personnel's tasks.</td><td>7</td><td>7</td><td>EXPERT</td></tr>
<tr><td>Advanced knowledge and critical understanding of the theory, principles and applicability of additive manufacturing processes.</td><td>Advanced problem-solving skills including critical evaluation, allowing to choose the proper technical and economical solutions, when applying additive manufacturing processes, in complex and unpredictable conditions</td><td>Manage the applications of additive manufacturing processes in a highly complex context.
Act autonomously in decision making and definition in the definition of the additive manufacturing personnel's tasks.</td><td>6</td><td rowspan="2">Advanced</td><td rowspan="2">ADVANCED</td><td>6</td><td>ADVANCED</td></tr>
<tr><td>Specialised, factual and theoretical of theory, principles and applicability of additive manufacturing processes</td><td>Specialised range of cognitive and practical skills, allowing to develop solutions or choose the appropriate methods, when applying additive manufacturing processes in common/regular problems.</td><td>Manage and supervise common or standard additive manufacturing processes, in an unpredictable context.
Take responsibility in standard work and supervise additive manufacturing personnel's tasks.</td><td>5</td><td>5</td><td>SPECIALIZED</td></tr>
<tr><td>Factual and broad concepts in the field of additive manufacturing processes.</td><td>Fundamental cognitive and practical skills required to develop proper solutions and</td><td>Self-manage of professional activities and simple standard applications of additive manufacturing processes in predictable</td><td>4</td><td>Intermediate</td><td>ADVANCED</td><td>5</td><td>INDEPENDENT</td></tr>
</table>

ADDITIVE MANUFACTURING FRAMEWORK			EQF Level	Alignment between EQF Levels and other relevant Frameworks			
KNOWLEDGE	SKILLS	AUTONOMY AND RESPONSIBILITY		DigComp	EntreComp		EWF
	application of procedures and tools on simple and specific additive manufacturing problems.	contexts but subject to change. Supervise routine tasks and similar function workers, as well as take responsibility for decision making in basic work.			INTERMEDIATE	4	
Knowledge of facts, principles, processes and general concepts in the field of additive manufacturing.	Basic cognitive and practical skills required to use relevant information in order to carry out tasks and to solve routine problems using simple rules and tools in additive manufacturing applications.	Take responsibility for completion of tasks in additive manufacturing applications. Adapt own behaviour to circumstances in solving problems.	3		INTERMEDIATE	3	NA
					FOUNDATION	2	
Basic factual knowledge in the field of additive manufacturing	Basic range of cognitive and practical skills required to accomplish tasks and solve problems by selecting and applying methods, tools, materials and information in the field of additive manufacturing.	Carry out, under supervision, professional activities in additive manufacturing applications with some autonomy.	2	Basic	FOUNDATION	2	NA
Basic general knowledge in the field of additive manufacturing technology.	Basic skills required to carry out simple tasks related with additive manufacturing.	Perform basic tasks related with additive manufacturing technology under direct supervision in a structured context.	1			1	NA

4. Structuring Qualifications and Units of Learning Outcomes

The application of current methodology results in the publishing of harmonized International Qualification and Competence Units/Units of Learning Outcomes Guidelines (training guidelines), for Additive Manufacturing (AM) Professionals, providing:

Qualifications

- Full description of the professional profile;
- Entry requirements;
- Qualification outcome descriptors;
- Mandatory Competence Units organized in Learning Outcomes.

Competence Units/Units of Learning Outcomes

- Recommended entry requirements;
- Learning Outcomes;
- Specifications for examination;
- Specifications for required equipment and facilities.

4.1 – Routes to Qualification

The International Additive Manufacturing Qualification System (IAMQS) foresees two possible routes for AM Professionals International Diploma awarding: by attending a training course or through the Recognition and validation of Prior Learning (RPL).

4.1.1 Training

Regarding Training Routes, SAM´s D 3.3 Operational guideline on context and training tools, provides detailed references on the training tools applied and the pedagogical approaches used to deploy AM Qualifications/Competence Units.

4.1.2 RPL

Building upon the European harmonised scheme for RPL in the AM sector (CLLAIM project), SAM´s methodology fine-tuned the RPL Scheme and tools (templates for application in D3.2 - Kit of templates – Revision and Creation of Professional Profiles), as presented below:

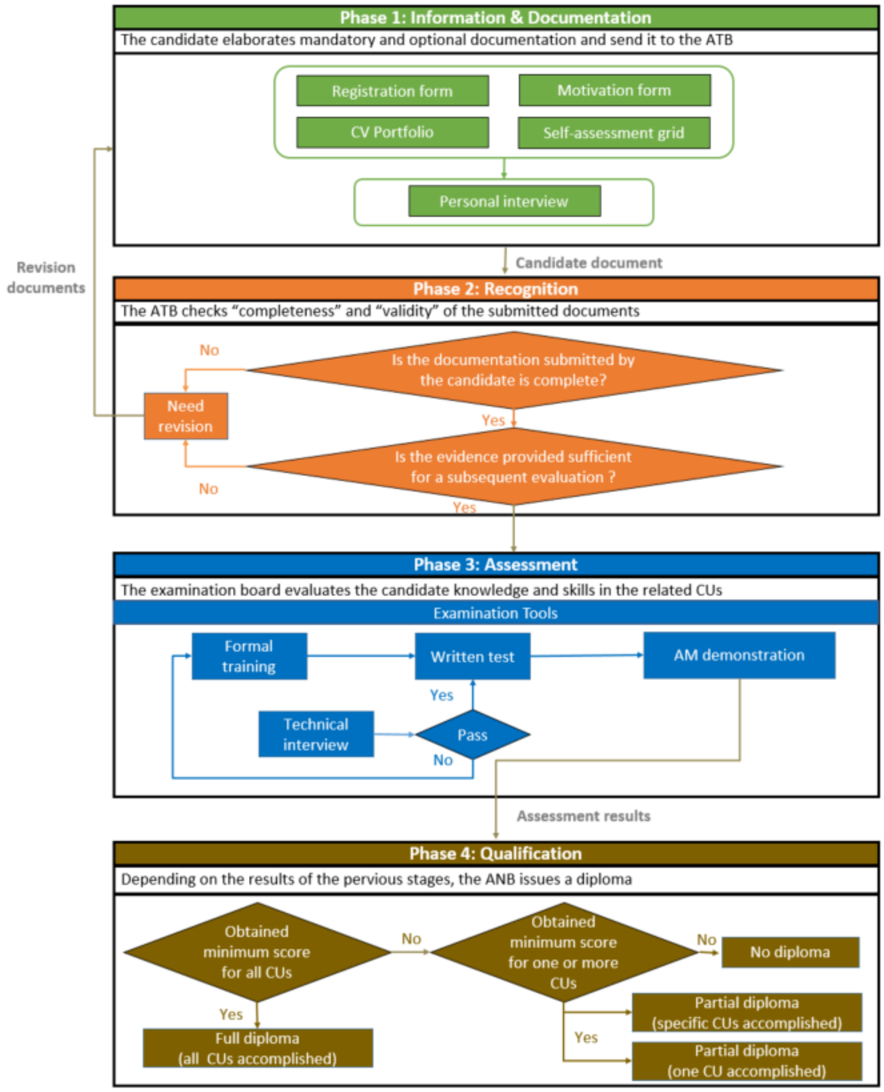

Figure 8 – RPL Scheme and four phases

Phase 1 - Information and Documentation: This phase includes two parts. First, it needs to provide complete information about the whole RPL process, for the AM professional profile that the candidate wants to apply. It is important to ensure the candidate accesses to all necessary information and understands what he/she is expected to do during this process. Then, when ATB makes sure the candidate gets fully aware of the RPL process, he/she will be asked to collect and submit the requested documents to the ATB., If additional information or clarification is required, the candidate will be invited for a personal interview.

Phase 2 - Recognition: In this step, ATB will examine the completeness and validity of the documents and information submitted by the candidate. If during the review process ATB faces any doubt preventing making a conclusion on the fulfilment of the requirements, the process would return to Phase 1, Information and Documentation.

Phase 3 - Assessment: The main aim of this phase is to assess whether the candidate already acquired the Learning Outcomes for the selected AM professional profile. A description of the assessment process and related steps, shown in figure8, are described in below:

- Technical interview: the assessment will start with a structured interview in which the candidate will be asked technical questions referring to the skills identified in the list of Competence Units (CUs) of the selected AM professional profile. The results will be reported for each individual CU, the candidate will pass an interview exam for a specific CU only if he/she gets a minimum score of 50%. Otherwise, the candidate fails in the interview exam; an alternative option would be attending in the Formal training for the CUs he/she failed.
- Written exam: once the candidate successfully passes the technical interview for a particular CU, he/she is allowed to take the written exam for the same CU.
- AM Demonstration: It would be a practical exam by which the candidate is expected to demonstrate the identified skills in a specific CU. Then an assessor will evaluate whether the candidate accomplishes a task referring to a particular skill and considering the given criteria. Like a technical interview, the results will be reported for each individual CU. The candidate will pass an AM demonstration exam for a specific CU only if he/she gets a minimum score of 60%.

Phase 4 – Qualification: According to the performance of the candidate in the Assessment phase, the obtained results will indicate his/her qualification for the selected AM professional profile. This process will lead to the issuance of a diploma by the ANB, under one of the conditions in below:

- Full Diploma: The candidate got the minimum score for every individual CUs - meaning there is no CU in which the candidate did not get a minimum score.
- Partial Diploma: The candidate got the minimum score for some, not all, CUs – meaning there are several CUs in which the candidate did not get a minimum score.
- No Diploma: The candidate did not get the minimum score for every individual CUs – meaning there is no CU in which the candidate got a minimum score.

The templates developed to use at the RPL process are shown and described in the D3.2.

An application example for RPL is given in Appendix E

4.2. Qualification tools

This section provides a brief overview of the ECVET and the ECTC systems and how SAM methodology approaches the assignment of credits/points to Qualifications, contributing for the enhancement of their transparency, recognition, and promotion of mobility of qualified professionals.

4.2.1. European Credit system for Vocational Education and Training

ECVET, the European Credit system for Vocational Education and Training, is a common methodological framework applicable to all EQF (European Qualifications Framework) enabling the transfer, accumulation, and recognition of the learning outcomes completed by students who are planning to achieve a qualification in vocational education and training. The system is based on units of learning outcomes as part of qualifications that can be assessed and validated, enabling the recognition and transfer of individual learning outcomes, irrespective of the educational format (formal learning, non-formal learning and informal learning) in which learning took place.

In 2009 the European Parliament and the Council of the EU adopted the ECVET recommendation encouraging its implementation in all VET qualifications to foster the recognition of learning outcomes between qualification systems and facilitate mobility and lifelong learning. This recommendation was replaced by the adoption of the Recommendation on vocational education and training for sustainable competitiveness, social fairness and resilience by the Council of the EU on 24 November 2020, stating that for all post-secondary and higher professional qualifications, the European Credit Transfer and Accumulation System can be applied.

4.2.2. The European Credit Transfer and Accumulation System

The European Credit Transfer and Accumulation System (ECTS) is a learner-centered method to facilitate credit accumulation and transfer. ECTS helps plan, transfer, and evaluate study programs and learner mobility by recognizing and assessing the achieved learning outcomes and qualifications and the duration of learning. In this regard, ECTS makes possible lifelong learning and supports open learning opportunities. ECTS presents itself as a broadly used credit system not only in the European Higher Education Area (EHEA) but also in non-European countries. Nowadays, ECTS credits are widely used. It indicates the total of learning associated with the defined learning outcomes and their related workload.

4.2.3. SAM alignment with ECTS & ECVET

In a nutshell, both ECVET and ECTS have developed considerably in recent years in terms of facilitating the concept of education mobility, recognition of the learning achieved from different education systems and certification systems, in the VET and HE.

In both systems for a full-time academic year or its equivalent, 60 credits/points are assigned, which normally comprises some educational components to which credits are allocated. Here, workload expresses the total time of learning that the learner needs to achieve the learning outcomes such as contact hours in the classroom, hands-on experience, case studies, projects, self-study time, etc. According to the ECTS guideline, a workload from 1500 hours to 1800 hours is allocated to complete 60 credits for an academic year or its equivalent, which means one credit corresponds approximately to 25 to 30 hours of learning.

ECVET points and ECVET credits are two different terms with different meanings that should not be used interchangeably. ECVET credits mean a set of learning outcomes of an individual which have been assessed and which can be accumulated towards a qualification or transferred to other qualifications. However, ECVET points mean a numerical representation of the overall weight of learning outcomes in a qualification and the relative weight of units about the qualification. In other words, ECVET credit is associated with an individual and his/her achievement, whilst ECVET points are connected to the description of the qualification. This means that "credit" can be transferred and accumulated if the certified center evaluates it as a relevant part of the qualification for which the learner is asking for recognition, whereas "points" is independent of whether anyone has attained the qualification or not.

The allocation of points can facilitate the understanding of qualifications as a whole and its units as well. It is a numerical representation of the overall weight of learning outcomes and provides the student with information about the relative weight of what she/he has already gathered.

SAM methodology follows the general recommendations for ECVET and ECTS credits attribution, nevertheless, due to the specificities of its qualifications, two principles are applied for the calculation of credits assignment:

- **The weight of the CU for the Qualification:**
  Being focused on one job function, Functional CUs are determinants for the professional profile thus the assignment of 1 credit is made for an estimated workload of 21 hours while the assignment of 1 credit for a Transversal CU is made for an estimated workload of 28 hours.

- **The expected workload to achieve the learning outcomes**:
  The scope of the transversal CUs is often broader, requiring a bigger workload to achieve the learning outcomes, therefore, 1 learning hour will correspond to 2 hours of workload for transversal CUs and 1.5 hours for functional CUs, respectively.

. The rounding rule applied to the credit assignment is to round up to the closer quarter unit, as follows: [0.25]; [0.50]; [0.75]; [1.00].

To have a better understanding of how a point/credit is allocated, the following example demonstrates the calculation of points/credits for a transversal CU and a functional CU of the "Metal AM Coordinator" professional profile:

CU	Type of CU	Calculation Formula	Contact Hours	Workload	Point/Credit
CU00: Additive Manufacturing Process Overview	Transversal	Contact hours *2	35	7	0.25
CU35: Metal AM integration	Functional	Contact hours *1.5	21	31.5	1.5

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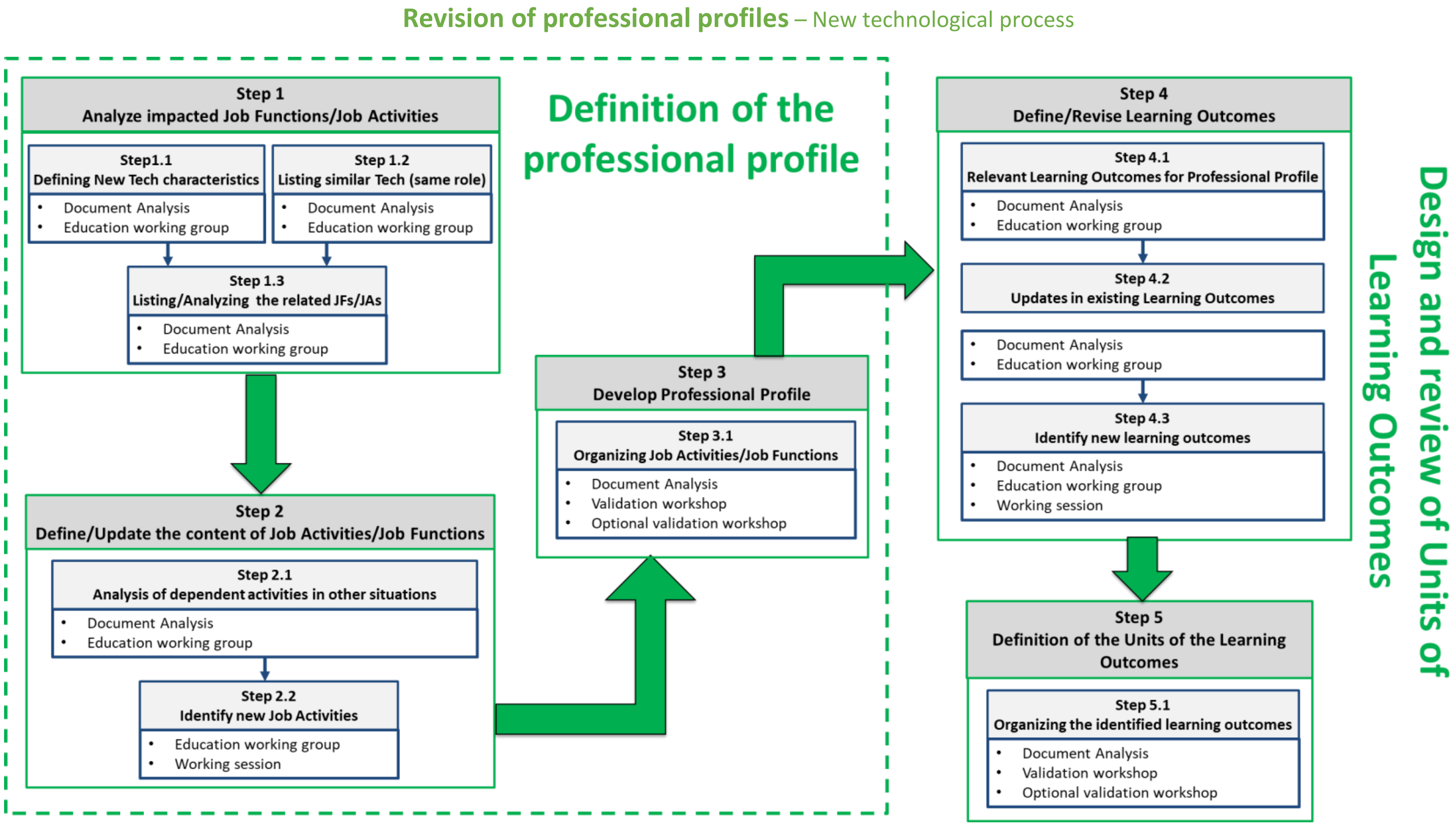
6. Appendix

A. Schematic view of revision and creation of professional profiles



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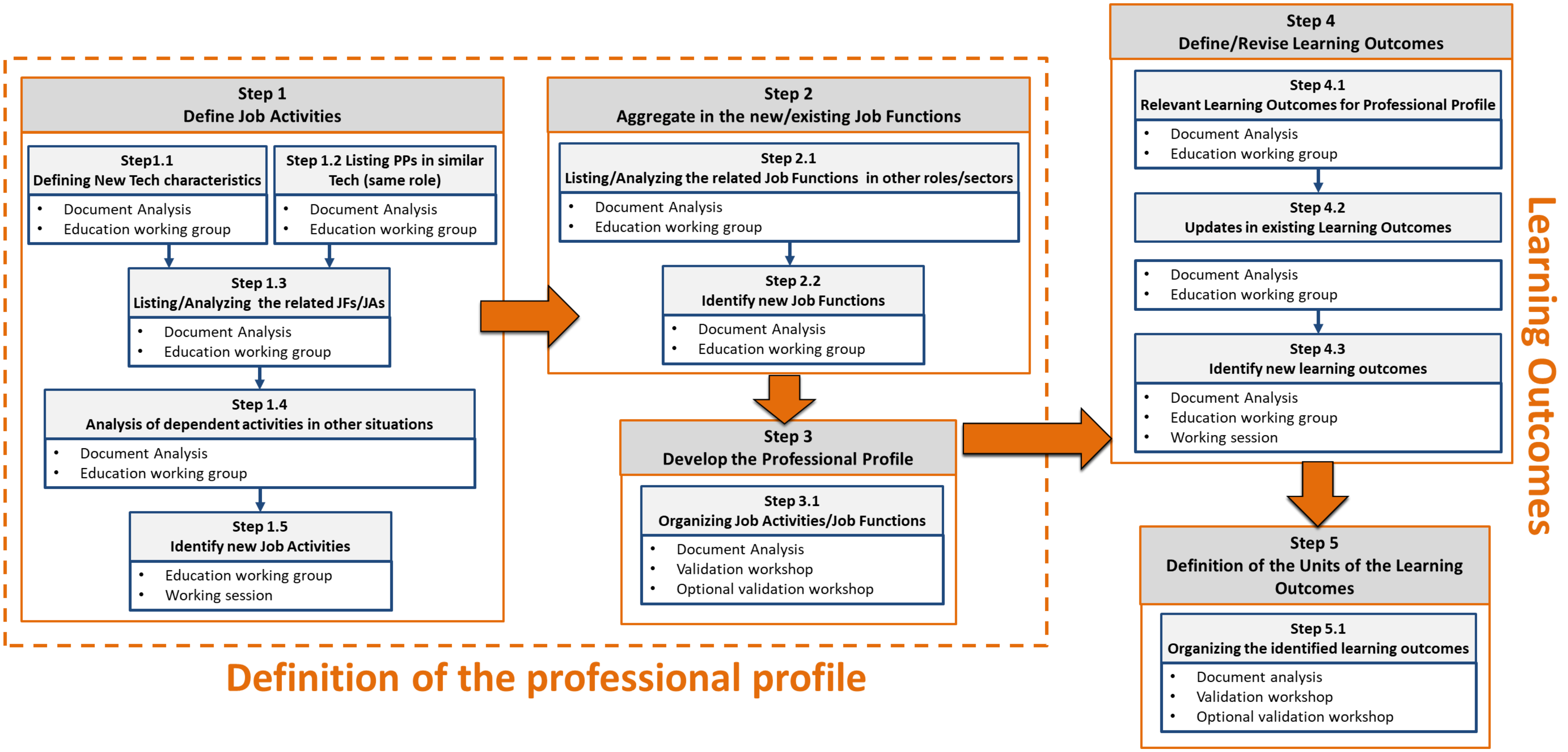
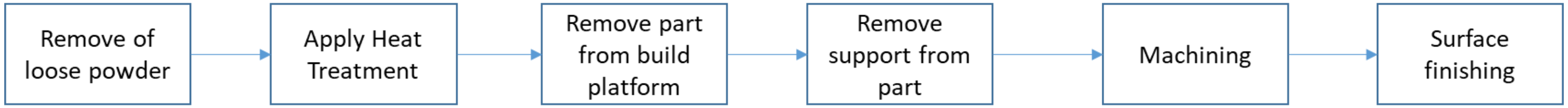
Creation of professional profile – New technological process



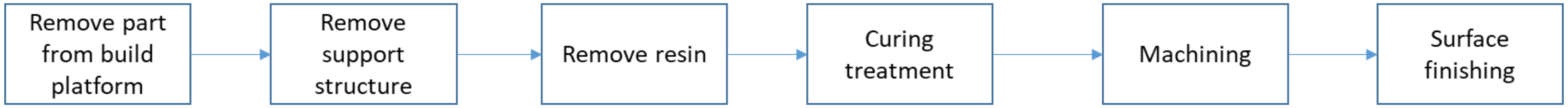
B. Exemplifying SAM methodology

B.1 Activities of an AM Operator in the post-processing stage, in three AM technologies

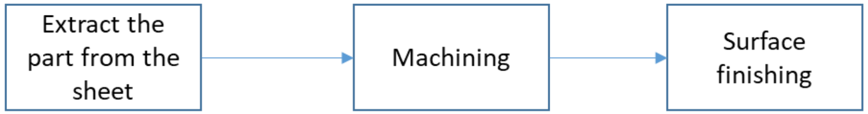
PBF



VAT



Sheet Lamination



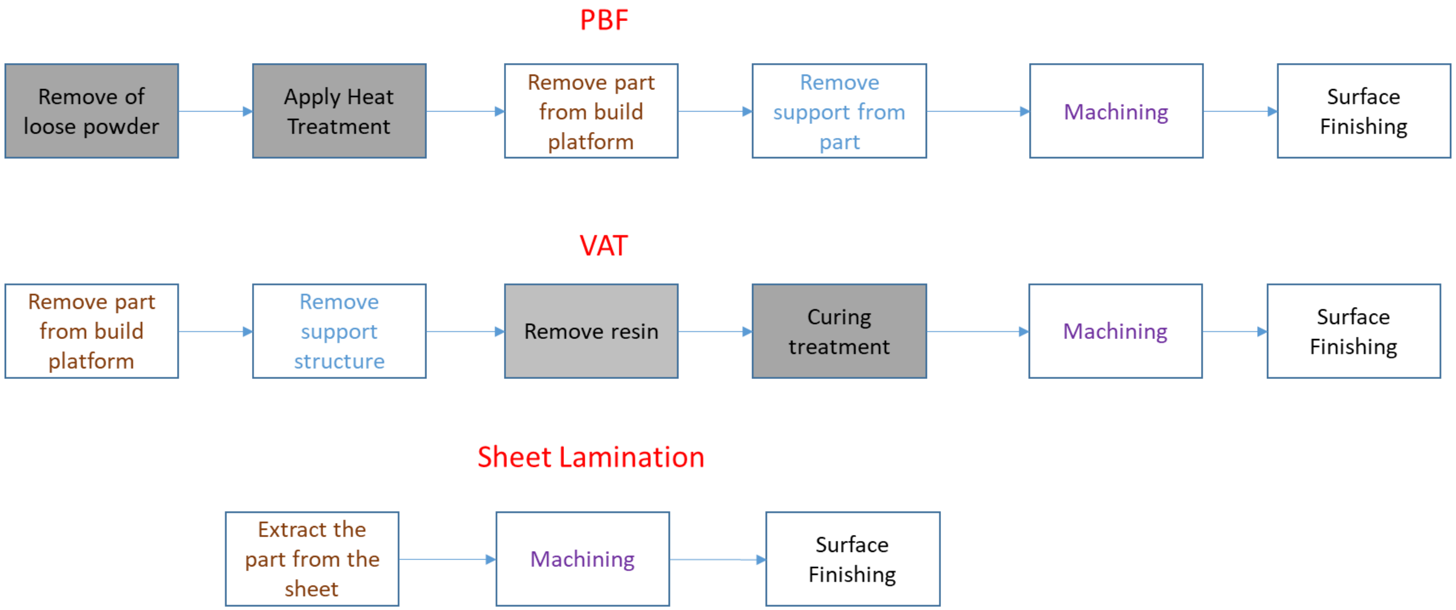
B.2 Identification of dependent and independent activities

Independent activities are those present in most of the professional profiles, regardless of the in-use technological process, as following:

- Remove support
- Remove extract/part
- Machining
- Surface finishing

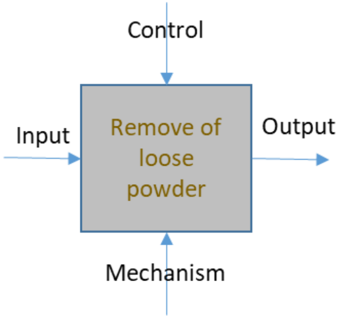
Dependent activities are those exclusively seen in the professional profile related to a specific technological process, as following:

- Remove loose powder (PBF)
- Apply heat treatment (PBF)
- Remove resin (VAT)
- Curing treatment (VAT)



Dependent Tech activity	Independent Tech activity
Remove loose powder Heat treatment Remove resin Curing treatment	Remove support Remove/Extract part Machining Surface Finishing

B.3 Identification of Knowledge and Skills for each activity (PBF Technology)



Input: Manufactured part (as-built part)

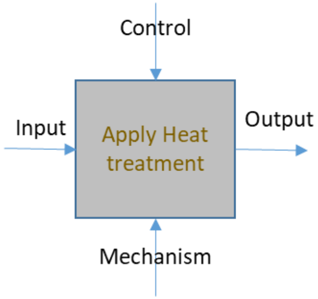
Output: Part without powder

Mechanism:

M1- removing powder Machine	Set up the machine Run the machine Operate the machine
M2- cleaning tools (brushing, hose)	Operate the cleaning tools
M3- Technique (shockwave)	Shockwave technique specification Use shockwave technique
M4- Operator	
M5- Endoscopic analysis (scan the quality of cleaning)	Endoscopic analysis specification Apply endoscopic analysis

Controls:

C1- Part geometrical complexity	*Geometric characteristics* Effect of geometrical on powder removing process
C2- General safety regulations	*General safety regulation and standards*
C3- Safety regulation in removing loose powder	Specific safety regulation and standards in removing powder
C4- Standard about the quality of cleaning	Specific standards about the quality of cleaning



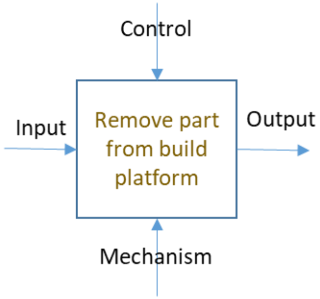
Input: Part without powder
Output: Heat treated part
Mechanism:

- **M1**- Oven (Hot isostatic pressing, etc.)
- **M2**- Operator

Controls:

- **C1**- Part dimension
- **C2**- Requirements based on the sector (clients)
- **C3**- Material characteristic
- **C4**- Material specification for the platform
- **C5**- General safety regulation
- **C6**- Safety regulation in heat treatment

- Set up the oven
  Run the oven
- Effect of the part dimension on heat treatment
- The characteristics of the finished product based on the sector and customer needs, affected the heat treatment
- *Material characteristic*
- Material specification for the platform
- *General safety regulation and standards*
- Specific safety regulation and standards in removing powder



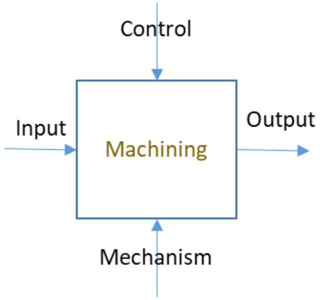
Input: Heat treated building part
Output: Part – Platform
Mechanism:

- **M1**- Wire-EDM (based on material and dimension)
- **M2**- Band saw (based on material and dimension)
- **M3**- Operator

Controls:

- **C1**- Part dimension
- **C2**- Material characteristics
- **C3**- General safety regulations
- **C4**- Safety regulations in removing part from the platform

- Wire-EDM technique specification
  Use Wire-EDM technique
- Band saw technique specification
  Use band saw technique
- Effect of part dimension on removing part from build platform
- *Material characteristics*
- *General safety regulation and standards*
- Specific safety regulation and standards in removing part from build platform



Input: Part

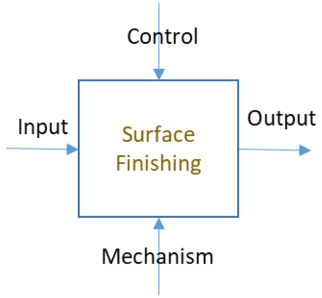
Output: Machined part

Mechanism:

- **M1**- Machining Techniques (Sanding, grinding,....)
  - Sanding technique specification
  - Use sanding technique
  - Grinding technique specification
  - Use Grinding technique
- **M2**- Tools and machines related to the techniques
  - Application of tools for sanding
  - Application of tools for grinding
- **M3**- Operator

Controls:

- **C1**- Requirement based on the sector
  - The characteristics of the finished product based on the sector and customer needs, affected machining
- **C2**- Functional area
  - The characteristics of the functional area
- **C3**- Surface state
  - The characteristics of the surface state (e.g. smoothness)
- **C4**- Material characteristics
  - *Material characteristics*
- **C5**- Geometric
  - *Geometric characteristics*
- **C6**- General safety regulations
  - *General safety regulation and standards*
- **C7**- Safety regulations in machining
  - Specific safety regulation and standards in machining



Input: Machined Part

Output: Finished part

Mechanism:

- **M1**- Surface finishing techniques (Plasma polishing, Hydroflouric Acid Etching, Water jetting, …)
- **M2**- Tools and machines related to the techniques
- **M3**- Operator

Controls:

- **C1**- Requirement based on the sector
- **C2**- Functional area
- **C3**- Surface state
- **C4**- Material characteristics
- **C5**- Geometric
- **C6**- General safety regulations
- **C7**- Safety regulations in surface finishing

M1:
Plasma polishing technique specification
Use plasma polishing technique
Hydroflouric Acid Etching technique specification
Use Hydroflouric Acid Etching technique
Water jetting technique specification
Use water jetting technique

M2:
Application of tools for Plasma polishing
Application of tools for Hydroflouric Acid Etching
Application of tools for water jetting

C1: The characteristics of the finished product based on the sector and customer needs, affected surface finishing

C2: The characteristics of the functional area

C3: The characteristics of the surface state (e.g. smoothness)

C4: *Material characteristics*

C5: *Geometric characteristics*

C6: *General safety regulation and standards*

C7: Specific safety regulation and standards in surface finishing

B.4 List of Knowledge and Skills for each activity (PBF Technology)

B.4.1 Cross-cutting Knowledge and Skills

- *General safety regulation and standards*
- *Material characteristic*
- *Geometric characteristics*

B.4.2 Functional Knowledge and Skills

- Remove of loose powder
  - Set up the machine
  - Run the machine
  - Operate the machine
  - Operate the cleaning tools
  - Shockwave technique specification
  - Use shockwave technique
  - Different types of geometrical complexities
  - Effect of geometrical on powder removing process
  - Specific safety regulation and standards in removing powder
  - Specific standards about the quality of cleaning
- Apply heat treatment
  - Set up the oven
  - Run the oven
  - Effect of the part dimension on heat treatment
  - The characteristics of the finished product based on the sector and customer's needs affected by the heat treatment
  - Material specification for the platform
  - Specific safety regulation and standards in removing powder
- Remove part from build platform
  - Wire-EDM technique specification
  - Use Wire-EDM technique
  - Band saw technique specification
  - Use band saw technique
  - Effect of part dimension on removing part from build platform
  - Specific safety regulation and standards in removing part from build platform
- Remove support from the part
  - Operate the cutting tools
  - Effect of the part dimension on removing support
  - The points that are fragile and difficult to access
  - Specific safety regulation and standards in removing support from the part
- Machining
  - Sanding technique specification
  - Use sanding technique
  - Grinding technique specification
  - Use Grinding technique
  - Application of tools for sanding

- Application of tools for grinding
- The characteristics of the finished product based on the sector and customer needs, affected machining
- The characteristics of the functional area
- The characteristics of the surface state (e.g. smoothness)
- Specific safety regulation and standards in machining

o Surface finishing
  - Plasma polishing technique specification
  - Use plasma polishing technique
  - Hydrofluoric Acid Etching technique specification
  - Use Hydrofluoric Acid Etching technique
  - Water jetting technique specification
  - Use water jetting technique
  - Application of tools for Plasma polishing
  - Application of tools for Hydrofluoric Acid Etching
  - Application of tools for water jetting
  - The characteristics of the finished product based on the sector and customer needs, affected surface finishing
  - The characteristics of the functional area
  - The characteristics of the surface state (e.g. smoothness)
  - Specific safety regulation and standards in surface finishing

B.5 Different performance of the same activities in different sectors (Aeronautic, Luxury, Orthopaedic)

o **Apply heat treatment**
  - It is a very critical activity in Aeronautic sector to manufacture strength and high resistance finished parts. In this sector, there are some experimental procedures for Heat treatment need to be considered in design the Professional Profile and related learning outcomes.
  - Its importance in the Luxury sector is often less unless the beauty of the finished part depends on the Heat treatment process.
  - In the Orthopaedic sector, it can be an important activity if the robustness of the finished part is critical.

o **Machining**
  - It is a necessary activity in the Aeronautic sector, while its importance level is medium.
  - It is not a common activity in the Luxury sector unless the beauty of the finished part depends on the Machining process.
  - This activity is less important In the Orthopaedic sector, compared to the Heat treatment and Surface finishing activities.

o **Surface finishing**
  - It is less important in the Aeronautic sector due to the less effect on robustness of the finished part.
  - It is a critical activity in the Luxury sector because of its significant effect on appearance and beauty of the finished part.

- This could be an important activity in the Orthopaedic sector, where the compatibility of the finished part is a critical feature.

Table 2. The importance of each activity in three different sectors

	Apply Heat treatment	Machining	Surface Finishing
Aeronautic	Very important	Important	Less important
Luxury	Less important	Less important	Very important
Orthopaedic	Important	Less important	Important

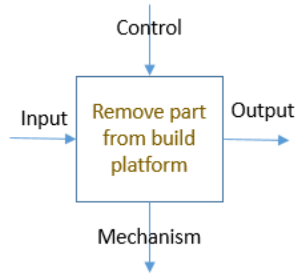
B.6 Knowledge and Skills related to in-use material in different technological process

For every technological process the professional profile and related learning outcomes need to be defined based on the in-use material. For example:

- Since VAT technology is based on only Polymer material, then the definition of learning outcomes in the professional profile design must contain knowledge and skills related to the Polymer material.
- If the Professional Profile exclusively relates to the metal finished part, then those learning outcomes that address the VAT can be removed.

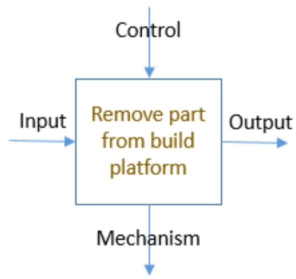
B.7 An example of different Knowledge and Skills for the same activity in different technologies

PBF



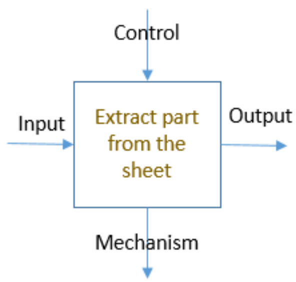
Mechanism:
Tool / Method: Wire-EDM and band saw techniques
Learning outcomes:
- How Wire-EDM technique works
- How band saw technique works

VAT



Mechanism:
Tool / Method: Specific knife and cutting tools
Learning outcomes:
- How to use the knife
- How to use the cutting tools

Sheet Lamination



Mechanism:
Tool / Method: Cross hatching
Learning outcomes:
- How Cross hatching method works

C. Current methodologies in the definition and revision of professional profiles

Professional profiles' development is a subject that has been under discussion for several years. A meta-literature analysis in competency identification, modelling and assessment in the US addresses the first studies carried out by Air Force Aviation Psychology Program in the years between 1941 and 1946 (Rothwell & Lindholm, 1999). There is no doubt that professional profiles' development is built upon a series of competences, and it is expected that the graduated from educational institutes bring those competences when they enter a profession. Nevertheless, not surprisingly, getting a diploma has become a dominant attitude and goal of societies, making a deviation from what the mission of educational institutes is, often named as "diploma disease" and "competence crisis" (Mudler, 2014).

Professional associations, therefore, took responsibility to revise existing curricula and training methods to shorten this gap and make a better alignment between demanding competences in industry level and those presented by the graduates of educational institutes. In recent years, some models have presented themselves interestingly as an effective guideline to develop professional profile considering an adjustment between performance requirements and curricula contents.

In this chapter, we try to provide a holistic approach coupling both theoretical and empirical studies that have been done on competence and qualification models, the basis of professional profile development. It begins with discussing some dominant theoretical framework and follows with introducing two prominent empirical projects. This critical literature review aims to provide a good insight, enabling us to develop a methodology to design professional profiles in the Additive Manufacturing domain.

C.1 SAM Overarching models

C.1.1 Process modelling with IDEF0 methodology

IDEF0 is used to model decision, function, and activities of a system. Its origin goes back to graphic modelling language, Structured Analysis and Design Technique (SADT). This capability enables IDEF0 to depict a process of activities in different levels of details. It represents graphically a precise, as well as understandable, flow of activities. A schematic of the IDEF0 diagram is shown in Figure 9.

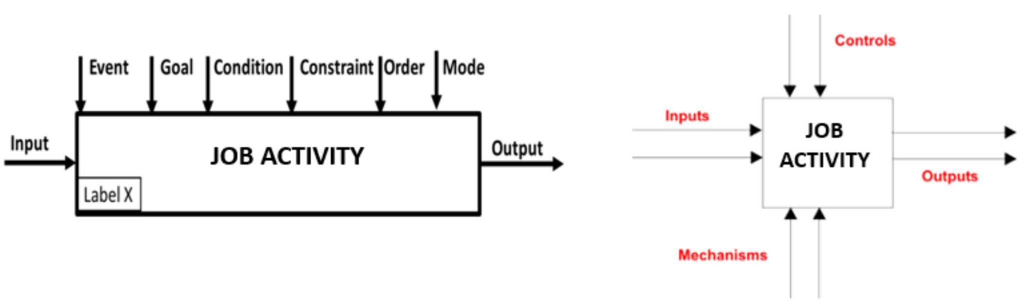


Figure 9- A schematic of IDEF0 model (System Engineering Fundamental, 2001)

<u>Activity:</u> refers to the operational unit of work conducting to the transformation of a set of input to output. The transformed flows can be informational, material, energy, etc.

<u>Process:</u> refers to groups of activities that are consistently linked to meet a specific objective. To do that, various resources are employed to transform input to output. Figure 4 shows a simple schematic of a process including a group of connected activities. In a professional profile, a process can be defined in different levels. In one level a group of job activities form a job function, but in one level deeper and to perform an specific job activity it needs to apply other processes (e.g. a set of activities to prepare, run and operate removing powder machine at PBT technology)

<u>Input flow:</u> refers to whatever there is to be consumed by an activity, and consequently to be transformed to a new flow.

<u>Output flow:</u> refers to whatever there is coming out of a transformation process produced by the activity.

<u>Control:</u> refers to set of data, conditions and constraints that manage the transformation of input into output. Several types of events may affect a transformation process. Especially, standards linked to one specific industrial sector or technology, as well as business rules or other knowledge to configure a given AM process/ machine, are typical kinds of control elements that help to define the necessary required skills.

<u>Resources (Mechanism):</u> refers to resources that enable carrying out the transformation process. A professional profile can be considered as the actor of some job activities. So, the analysis of a professional profile and related qualification, together with its corresponding learning outcomes, will be based on the analysis of all resources and flows of the job activities in which this professional profile is involved. For example, an operator who performs the job activity "set-up the DED-Arc system" should learn the standard and rules related to this kind of technology.

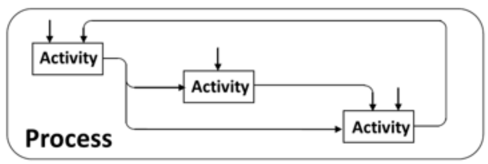


Figure 10- A schematic of a process with connected activities

C.1.2 EWF Sectoral Approach

The EWF Sectoral Approach was developed in the RAINBOW project to address a methodology for the design of European qualifications in the field of welding, joining and related technologies. It is built upon subsequent activities that begin with a general description of what a job is, as professional profile, and ends with a set of smallest units of learning outcomes that fed the required qualification for that professional profile. Based on a modular approach, each qualification consists of a set of competence units where learners will develop the identified learning outcomes.

Interestingly, this methodology not only applies to create a new qualification design but also is applicable to redesign and modernized existing ones.

A top-down approach is obviously seen in its structure. Initially, a general description of an occupation is done; then, in the 2nd and 3rd levels, the major job functions to satisfy professional profile and necessary activities to support the major job functions are defined, respectively. Identification of competence units result to achievement of the expected learning outcomes carried out in the last level. In this regard, to assist a better qualification design process, it recommends answering the four questions as shown in Figure11.

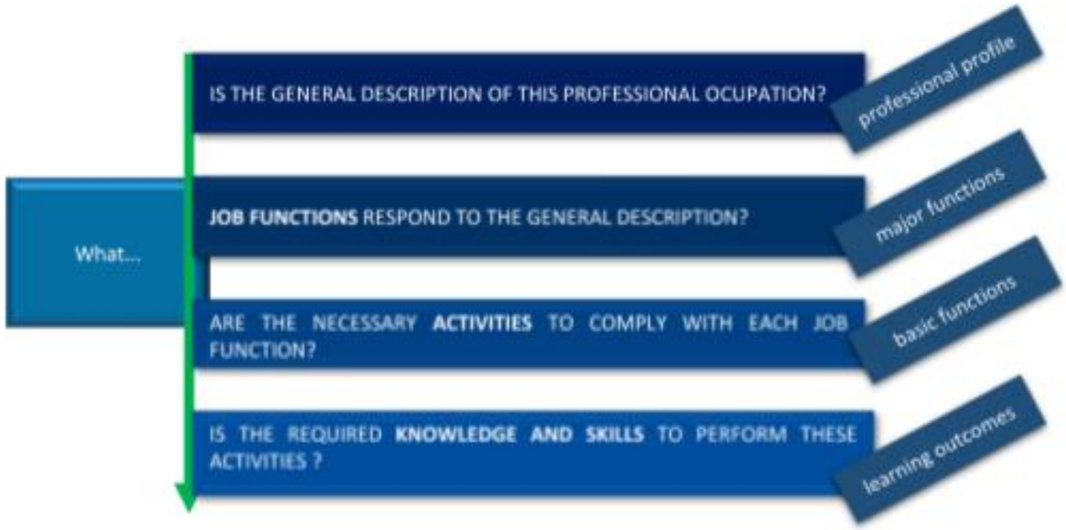


Figure 11 - Questions supporting the design of qualifications (RAINBOW, 2018)

Providing a big picture of a professional occupation gives a holistic awareness about what the job profile is. In addition, the definition of the job function clarifies what are described in the job professional profile. Next, a better understanding of both professional profile and job function appears when the major functions are broken down into the specific activities, those are necessary to comply with the job requirements. Thus, it makes possible to map a set of competence units including a set of specific knowledge and skills, which are unavoidable to comply job activities described in the previous level. With such detailed and accurate process ensures all necessary requirement of a professional profile.

This process makes it possible to identify knowledge and skills that should be presented within the curricula, being formed with some learning modules. A Competence Unit is the smallest learning component of a Qualification. It can individually address a qualification or being a part of complete qualification. This capability of modular approach enables this methodology to be well flexible with various requirements. Meaning that, a student/employee can easily align within the system by selecting only those modules that cover his knowledge and skills gaps, without needing to complete the whole learning programs.

Regarding this system, each competence unit addresses a certain proficiency level, it can be a part of different qualifications. Meaning, a competence unit can touch down various qualification if its learning outcomes fulfil the related qualification requirements. The capability of mobilization makes it flexible enough in order to integrate to various qualification necessities and requirements.

Moreover, there are two types of competence units, either functional or cross-cutting. The former one addresses those learning outcomes straight connected to at least one job function and the achieved knowledge and skills can be mobilized in the specific job function and the related activities. The latter one refers to those learning outcomes are not necessarily linked with a specific job function and therefore the achieved knowledge and skills will be mobilized in different job functions and the related activities.

In this regard, three elements are obvious within the designed curricula. First, competence units should be in alignment with imperative knowledge and skills; second, methods and tools used throughout the evaluation processes; third, the minimum requirement and resources in the evaluation phase.

According to practical approach, this methodology presents a sequential process to design and implement qualifications, Figure 15. The 1st step encompasses definition of professional profile, and consequently identification of proficiency level is necessary in the 2nd phase. Next, the 3rd step begins with definition of "job functions", "job activities", and "competence units". To do that, this step follows Bloom taxonomy in terms of using accurate verbs and adverbs to define learning outcomes. And this step ends with making an adjustment between learning outcomes and the proficiency levels. In the next step, based on the developed curricula, a revision of proficiency levels is carried out. Validation is the main theme of the next step for being able to end the process with implementation.

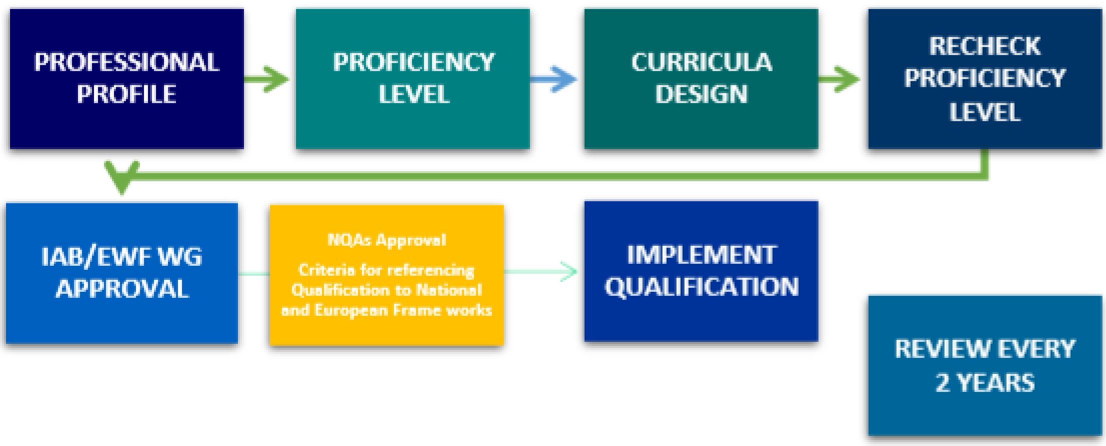


Figure 12 - Steps of EWF sectoral methodology for the design and implementation of qualifications (RAINBOW, 2018)

As an advantage of this model, it has its own proficiency categorization. Each qualification, therefore, is clustered in seven levels where "Elementary" is in the bottom, follows top in order with "Basic", Independent", "Specialized", "Advanced", and "Expert" is located in the highest level. Moreover, each proficiency level, within a big picture, addresses the required knowledge, skills, autonomy and responsibility to be assigned to that level. This proficiency categorization is in alignment with the European Qualifications Framework (EQF).

C.2 Other Theoretical models

C.2.1 Boyatzis model

Boyatzis presents a five-step model (Boyatzis, 1982). Selecting a convenient measure of job performance for data gathering is the initial step. Later, it goes on, identifying job elements to understand how activities necessary to perform a job lead to competent performance, and then it is followed by some behavioural event interviews to characterize the identified elements toward listing related competences. In the fourth step, the extracted competences undergo some test and assessments, and finally the process ends with a validated competency model consisting of a causal relationship between competencies and job performance. Boyatzis' work is prominent in term of focusing on both the job and the person; however, the validity of the model regarding the relationship between competences and job performance is under argument.

C.2.2 Rothwell and Kazanas model

Several studies have been done in the US regarding the competency identification, modelling, and assessment. Rothwell and Kazanas (1998) described five main approaches in the competency model applied at industry level in the US. "The process-driven approach" is the oldest one with focus on the job process. This approach includes three steps that begin with work characterization (task, responsibilities, environment, etc.), goes on with a screening step where appropriate competences are identified through observing and interviewing exemplary performers, and finally ends with verifying the competency model.

"The outputs-driven approach" takes into consideration how well the outputs of the specific job are, meaning competences are identified through analysing successful performances and outstanding outputs. It includes eight steps, beginning with splitting an occupation (task, responsibilities, environment, etc.), following with an expert panel, including field supervisors and exemplary performers, who raises ideas about any circumstances that will probably change in the professional profile. In the following steps, a list of work output is necessary for being able to identify the related work quality requirements. Documentation of competencies and behavioural anchors, as well as roles identification, are two main activities in the next steps that go on to the closing step with a version of competency model.

"The invented approach" presents itself interestingly for those jobs largely changing and consequently experts' assumptions are less reliable to define the necessary competences. Although its validity and reliability are still a concern, being quicker than other methods makes it attractive, namely when the expert panel is not dependable enough to gather data.

"The trend driven approach" aims to address those indicators that will have an impact on the job and occupation, in the future. Contrary to the previous approaches, the main focus is on teaching the specific knowledge and skills that enable people to respond well to changing issues and trends in the future job environments. Therefore, screening those events affecting the future job, as well as those competences necessary to ensure a successful performance, are two key activities that should be carried out.

"The work responsibilities-driven approach" focuses on work responsibilities and activities in terms of extracting competences and quality requirements. To do that, a panel of experts, including some exemplary performers in a specific job category and a few supervisors, focuses on the activities and responsibilities of this job category. In this panel assistant facilitators lead the session to articulate the required job functions/activities. Then, to verify the outcomes, a mix of validation processes, including panel review and survey, are conducted.

C.2.3 Organization Goals and Objectives Models

This model asserts being a strong linkage between competences and organizational strategies and objectives (Sing & Srivastava, 2014). In this regard, the required competences are derived from analysing those job functions/activities directly associated with the business strategies. According to this model, a clear definition of organization objectives and strategies is the initial step that allows identifying necessary competences that lead to fulfil these objectives and strategies (Figure 13). As a point, these competences do not always reflect the objective, but sometimes refer to one-step back, a group of work necessary to gain that objective. Moreover, this model notices central competences not necessarily related to the goals and objectives. Accordingly, these fundamental competences mostly translate to lower-level jobs, while those competences related to organization strategies are more relevant to higher-level jobs.

Figure 13 Organization Goals and Objectives Models (Sing & Srivastava, 2014)

C.2.4 ASTD Competency model

This model was presented by the American Society for Training & Development (ASTD) to support its members in the recruitment procedure and promote better professional development. The original draft was published in 2004, and its fourth edition was released in 2014.

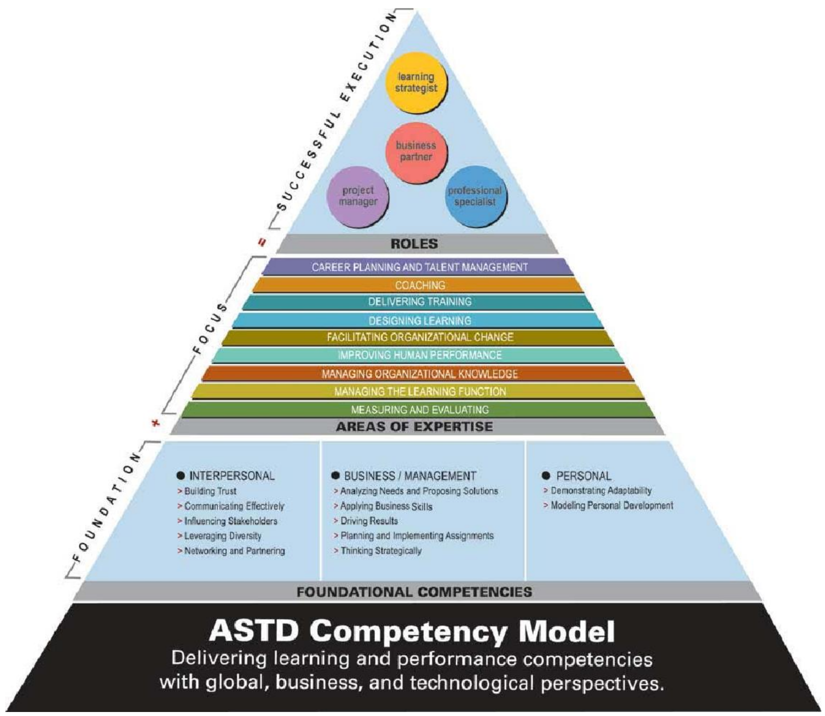


Figure 14- ASTD Competency model (Arneson et al, 2013)

In this model competences are laid out in three layers, namely Foundational level, Focus level, and Execution level (Figure 14). The bottom layer, Foundation, indicates necessary competencies in three categories that affect successful performance regardless of job and roles. These are Interpersonal, Business/Management, and Personal competencies. The middle layer, Focus, is established on the Foundation level and addresses technical and professional competences necessary to perform successfully a group of jobs in the specific field. In the top layer, Roles, the focus is on the four roles, which are extremely fluid according to the trait of the work and project. They comprise several responsibilities to be a good professional and strongly rely upon the gained competences in the Foundation and Focus layers.

C.3 Empirical models

C.3.1 Singapore Workforce Skills Qualifications

This organization published a WSQ model aiming to support various industries in training and recruiting well-qualified persons - those who pose the required competences at the workplace. The WSQ competency standard presents a systematic documentation consisting of all information about specific professional profiles and its related job functions/ activities. It describes what are the targeted outcomes, the level of proficiency, and the required competencies to gain a desirable performance. In other words, it makes clear the expected performance of the responsible person and consequently the necessary knowledge, skills and attitudes that lead to a successful performance.

The models are established in “Competence units” and “Competence standards”. Competence units are the smallest modules that shape the WSQ model extracted from different types of analysis including occupational analysis, value chain analysis, functional analysis, job-family analysis, and proficiency level analysis. Often, only one of the analysis methods is dominant considering the nature of the industry; for instance, manufacturing industries analysis mostly is based on value-chain analysis while the functional analysis is mostly applicable for precision engineering companies.

On the other hand, competence standards include information and contents that fed competence units. In other word, some competence units collectively build a specific qualification, and the competence standard documents the expected performance for each competence unit. But, using them interchangeably makes this model slightly confusing, to get a better understanding of the relation between a course title and the course material is a simplified example of the relation between competence unit and competence standard respectively (Figure 15)

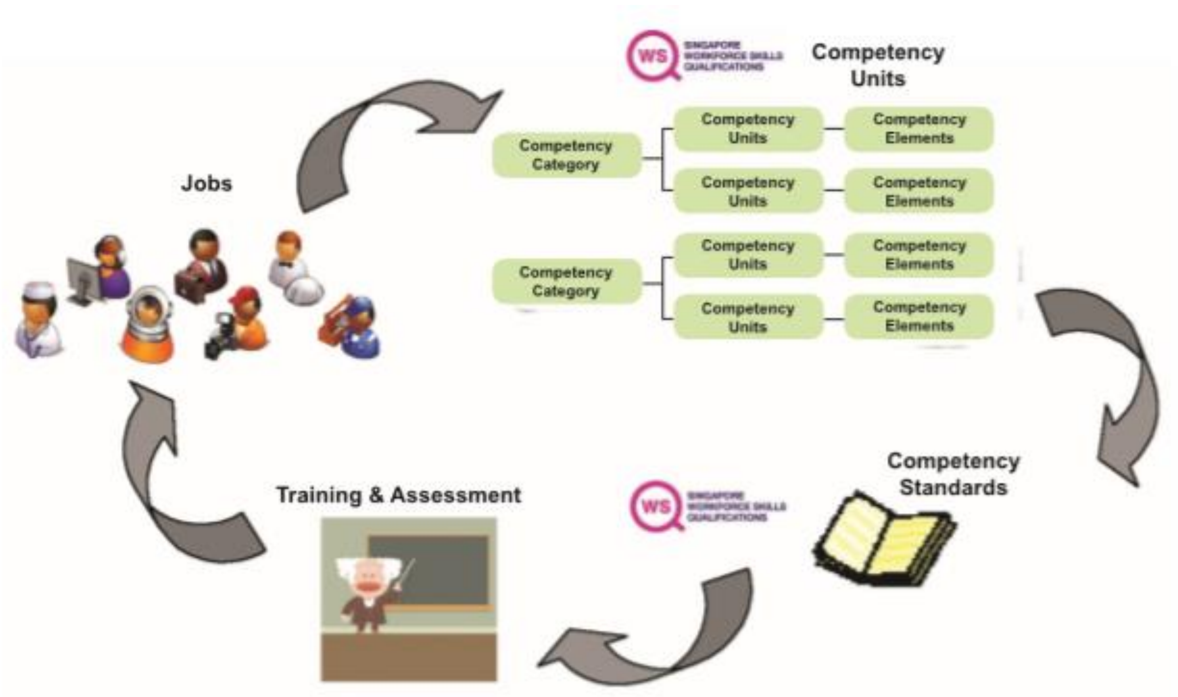


Figure 15 – The linkage between Competency Units and Competency Standards at WSQ model (Bound & Lin, 2011)

The WSQ Model provides a guideline, assisting users to define both competence units and competence standards. For competence standards, replying to 15 pre-defined questions provides all necessary information to task analysis. Given the gathered information, the model then proposes some guidance items that lead to the definition of competence units.

Moreover, this model clusters competences in five dimensions (Figure 16).

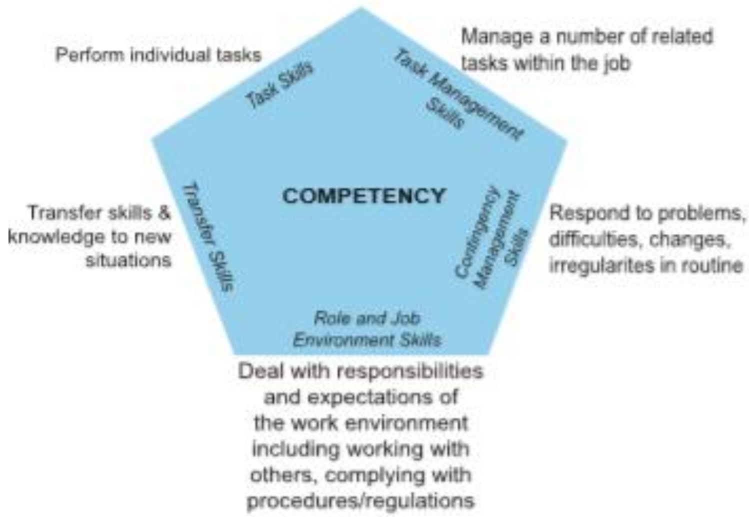


Figure 16 – Competency dimensions (Bound & Lin, 2011)

1. Task skills address mandatory Knowledge, Skills, and Attitudes (KSA) to complete a specific job.

2. Task management skills refer to those KSA enabling a person to manage routine aspects of an occupation.

3. Contingency skills are those KSA that permit a person to confront unpredictable situations and events in a work.

4. Role and job environment skills point necessary KSA to handle environmental attributes related to an occupation like team working and group decision making.

5. Transfer skills refer to those KSA that enforce a person to implement work item in different context.

Identification of competency level is one of the crucial tasks in this model. In this regard, this model presents six levels of competency/qualification. Table 4 presents a short definition of each level, as "Certificate" in the bottom to "Graduate certificate/Graduate diploma" in the top.

Table 3. Competency levels and their characteristics based on WSQ model (Bound & Lin, 2011)

Competency level	**Characteristics**
Level 6 Graduate certificate/ Graduate diploma	• Integration and contextualization skills and knowledge • Tasks in complex and changing contexts • Complicated knowledge gained in higher education and industry experience • Full accountability and autonomy • Very broadly boundaries • Considerable degree of strategic thinking and judgment • Non-routine, complicated, and multifaceted problems
Level 5 Specialist diploma	• Complex technical and professional activities • Tasks in wide variety of contexts • Some unexpected tasks • Strategic knowledge and important understanding of progress in the field • Full accountability and considerable autonomy • Under minimal supervision • Significant judgment

	• Non-routine, complicated, and multifaceted problems
Level 4 Diploma	• High level technical and professional activities • Tasks in wide variety of contexts • Theoretical knowledge in the related field study • Substantial Individual accountability and autonomy • Broad boundaries • Under minimal supervision • Considerable degree of judgment and decision making • Mainly non-routine-based problems
Level 3 Advanced certificate	• Mostly non-routine and complex activities • Tasks in variety of contexts • Some abstraction and theoretical knowledge • Requiring contextualized skills and knowledge • Significant Individual accountability and autonomy • Under general supervision • Considerable degree of judgment • Non-routine-based problems
Level 2 Higher certificate	• Some non-routine and complex activities • Tasks in variety contexts • Some abstraction and theoretical knowledge • Specific boundaries in responsibilities • Under frequent supervision • Needing some judgment • Mostly routine-based problems
Level 1 Certificate	• Mostly routine-based activities • Tasks in specific context • Factual and procedural knowledge needing basic comprehension skills • Basic task in entry level • Clear boundaries in responsibilities • Clear instructions • Close supervision • Minimal interpretation • Mostly routine-based work problems

D. Other relevant AM system frameworks

D.1 EWF Systems Framework (Generic description for all Qualification systems)

FIELD OF ACTIVITIY		EWF PROFICENCY LEVEL	KNOWLEDGE	SKILLS	AUTONOMY AND RESPONSIBILITY
INSPECTORS &SUPERVISORS/ COORDINATORS/MANAGERS		**EXPERT**	Highly specialised and forefront knowledge including original thinking, research and critical assessment of theory, principles and applicability of metal additive manufacturing or welding related technologies.	Highly specialised problem- solving skills including critical and original evaluation, allowing to define or develop the best technical and economical solutions, when applying metal additive manufacturing or welding related technologies, in complex and unpredictable conditions	Manage and transform the metal additive manufacturing or welding and related technologies processes in a highly complex context. Fully responsible for the definition and revision of personnel's tasks.
		ADVANCED	Advanced knowledge and critical understanding of the theory, principles and applicability of metal additive manufacturing or welding and related technologies.	Advanced problem-solving skills including critical evaluation, allowing to choose the proper technical and economical solutions, when applying metal additive manufacturing or welding and related technologies, in complex and unpredictable conditions	Manage the applications of metal additive manufacturing or welding and related technologies in a highly complex context. Act autonomously in decision making and definition in the definition of the metal additive manufacturing or welding and related personnel's tasks.
		SPECIALIZED	Specialised, factual and theoretical of theory, principles and applicability of metal additive manufacturing or welding and related technologies	Specialised range of cognitive and practical skills, allowing to develop solutions or choose the appropriate methods, when applying metal additive manufacturing or welding and related technologies, in common/regular problems.	Manage and supervise common or standard metal additive manufacturing or welding applications and related technologies, in an unpredictable context. Take responsibility in standard work and supervise the metal additive manufacturing or welding and related personnel's tasks.
	WELDERS & OPERATORS	**INDEPENDENT**	Factual and broad concepts in the field of metal additive manufacturing or welding technology	Fundamental cognitive and practical skills required to develop proper solutions and application of procedures and tools on simple and specific metal additive manufacturing or welding problems.	Self-manage of professional activities and simple standard applications of metal additive manufacturing or welding and related technologies in predictable contexts but subject to change. Supervise routine tasks and similar function workers, as well as take responsibility for decision making in basic work.
		BASIC	Basic facts, principles, processes and general concepts of welding, joining and related technologies	Be able to check and follow the information on the welding procedure specification, to produce butt and fillet welds in plates and or tubes, and or profiles in a variety of geometries and positions to the required quality and of specified dimensional accuracy	Work under supervision, taking personal responsibility for own actions and for the quality and accuracy of the work produced.
		ELEMENTARY	Elementary principles of welding, joining and related technologies	Able to check and follow the information on the welding procedure or adhesive bounding specification, and to produce weld/joints in a variety of geometries and positions to the required quality and of specified dimensional accuracy	Work under supervision.

D.2 European e-Competence Framework 3.0 Overview

European e-Competence Framework 3.0 overview

Dimension 1 5 e-CF areas (A – E)	Dimension 2 40 e-Competences identified	Dimension 3 e-Competence proficiency levels e-1 to e-5, related to EQF levels 3–8				
		e-1	e-2	e-3	e-4	e-5
A. PLAN	A.1. IS and Business Strategy Alignment				■	■
	A.2. Service Level Management			■	■	
	A.3. Business Plan Development			■	■	■
	A.4. Product/Service Planning		■	■	■	
	A.5. Architecture Design			■	■	■
	A.6. Application Design	■	■	■		
	A.7. Technology Trend Monitoring				■	■
	A.8. Sustainable Development			■	■	
	A.9. Innovating				■	■
B. BUILD	B.1. Application Development	■	■	■		
	B.2. Component Integration		■	■	■	
	B.3. Testing	■	■	■	■	
	B.4. Solution Deployment	■	■	■		
	B.5. Documentation Production	■	■	■		
	B.6. Systems Engineering			■	■	
C. RUN	C.1. User Support	■	■	■		
	C.2. Change Support		■	■		
	C.3. Service Delivery	■	■	■		
	C.4. Problem Management		■	■	■	
D. ENABLE	D.1. Information Security Strategy Development				■	■
	D.2. ICT Quality Strategy Development				■	■
	D.3. Education and Training Provision		■	■		
	D.4. Purchasing		■	■	■	
	D.5. Sales Proposal Development		■	■		
	D.6. Channel Management			■	■	
	D.7. Sales Management			■	■	■
	D.8. Contract Management		■	■	■	
	D.9. Personnel Development		■	■	■	
	D.10. Information and Knowledge Management			■	■	■
	D.11. Needs Identification			■	■	■
	D.12. Digital Marketing		■	■	■	
E. MANAGE	E.1. Forecast Development			■	■	
	E.2. Project and Portfolio Management		■	■	■	■
	E.3. Risk Management		■	■	■	
	E.4. Relationship Management			■	■	
	E.5. Process Improvement			■	■	
	E.6. ICT Quality Management		■	■	■	
	E.7. Business Change Management			■	■	■
	E.8. Information Security Management		■	■	■	
	E.9. IS Governance				■	■

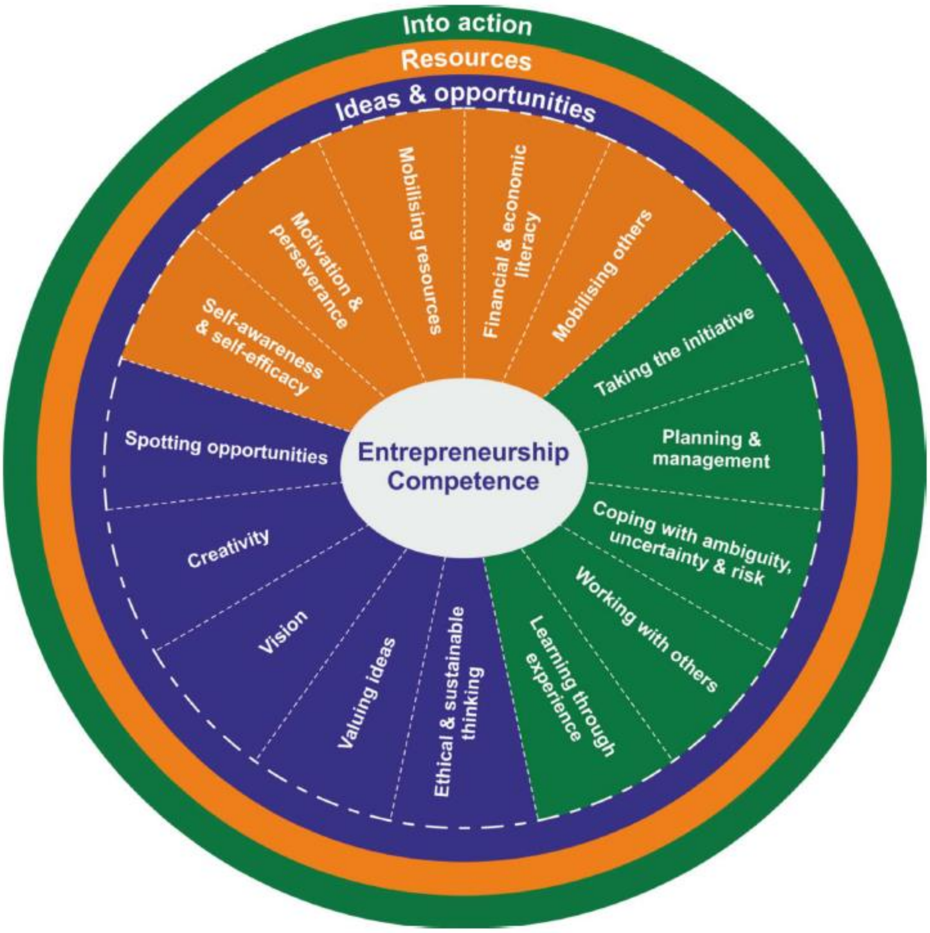
. Source: http://ecompetences.eu/wp-content/uploads/2014/02/European-e-Competence-Framework-3.0_CEN_CWA_16234-1_2014.pdf

D.3 European e-Competence and EQF levels table

EQF levels	EQF Levels descriptions	e-CF Levels	e-CF Levels descriptions	Typical Tasks	Complexity	Autonomy	Behaviour
8	Knowledge at the most advanced frontier, the most advanced and specialised skills and techniques to solve critical problems in research and/or innovation, demonstrating substantial authority, innovation, autonomy, scholarly or professional integrity.	e-5	**Principal** Overall accountability and responsibility; recognised inside and outside the organisation for innovative solutions and for shaping the future using outstanding leading edge thinking and knowledge.	IS strategy or programme management	Unpredictable – unstructured	Demonstrates substantial leadership and independence in contexts which are novel requiring the solving of issues that involve many interacting factors.	Conceiving, transforming, innovating, finding creative solutions by application of a wide range of technical and/or management principles.
7	Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking, critical awareness of knowledge issues in a field and at the interface between different fields, specialised problem-solving skills in research and/or innovation to develop new knowledge and procedures and to integrate knowledge from different fields, managing and transforming work or study contexts that are complex, unpredictable and require new strategic approaches, taking responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams.	e-4	**Lead Professional / Senior Manager** Extensive scope of responsibilities deploying specialised integration capability in complex environments; full responsibility for strategic development of staff working in unfamiliar and unpredictable situations.	IS strategy/ holistic solutions		Demonstrates leadership and innovation in unfamiliar, complex and unpredictable environments. Addresses issues involving many interacting factors.	
6	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles, advanced skills, demonstrating mastery and innovation in solving complex and unpredictable problems in a specialised field of work or study, management of complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts, for continuing personal and group professional development.	e-3	**Senior Professional / Manager** Respected for innovative methods and use of initiative in specific technical or business areas; providing leadership and taking responsibility for team performances and development in unpredictable environments.	Consulting	Structured – unpredictable	Works independently to resolve interactive problems and addresses complex issues. Has a positive effect on team performance.	Planning, making decisions, supervising, building teams, forming people, reviewing performances, finding creative solutions by application of specific technical or business knowledge/skills.
5	Comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge, expertise in a comprehensive range of cognitive and practical skills in developing creative solutions to abstract problems, management and supervision in contexts where there is unpredictable change, reviewing and developing performance of self and others.	e-2	**Professional** Operates with capability and independence in specified boundaries and may supervise others in this environment; conceptual and abstract model building using creative thinking; uses theoretical knowledge and practical skills to solve complex problems within a predictable and sometimes unpredictable context.	Concepts/ Basic principles		Works under general guidance in an environment where unpredictable change occurs. Independently resolves interactive issues which arise from project activities.	Designing, managing, surveying, monitoring, evaluating, improving, finding non standard solutions.
4	Factual and theoretical knowledge in broad contexts within a field of work or study, expertise in a range of cognitive and practical skills in generating solutions to specific problems in a field of work or study, self-manageme nt within the guidelines of work or study contexts that are usually predictable, but are subject to change, supervising the routine work of others, taking some responsibility for the evaluation and improvement of work or study activities.				Structured – predictable		Scheduling, organising, integrating, finding standard solutions, interacting, communicating, working in team.
3	Knowledge of facts, principles, processes and general concepts, in a field of work or study, a range of cognitive and practical skills in accomplishing tasks. Problem solving with basic methods, tools, materials and information, responsibility for completion of tasks in work or study, adapting own behaviour to circumstances in solving problems.	e-1	**Associate** Able to apply knowledge and skills to solve straight forward problems; responsible for own actions; operating in a stable environment.	Support/ Service		Demonstrates limited independence where contexts are generally stable with few variable factors.	Applying, adapting, developing, deploying, maintaining, repairing, finding basic-simple solutions.

. Source: http://ecompetences.eu/wp-content/uploads/2014/02/European-e-Competence-Framework-3.0_CEN_CWA_16234-1_2014.pdf

D.4 EntreComp Conceptual Model



. Source: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC101581/lfna27939enn.pdf

D.5 EntreComp Progression Model

Foundation		Intermediate		Advanced		Expert	
Relying on support[6] from others		Building independence		Taking responsibility		Driving transformation, innovation and growth	
Under direct supervision.	With reduced support from others, some autonomy and together with my peers.	On my own and together with my peers.	Taking and sharing some responsibilities.	With some guidance and together with others.	Taking responsibility for making decisions and working with others.	Taking responsibility for contributing to complex developments in a specific field.	Contributing substantially to the development of a specific field.
Discover	Explore	Experiment	Dare	Improve	Reinforce	Expand	Transform
Level 1 focuses mainly on discovering your qualities, potential, interests and wishes. It also focuses on recognising different types of problems and needs that can be solved creatively, and on developing individual skills and attitudes.	Level 2 focuses on exploring different approaches to problems, concentrating on diversity and developing social skills and attitudes.	Level 3 focuses on critical thinking and on experimenting with creating value, for instance through practical entrepreneurial experiences.	Level 4 focuses on turning ideas into action in 'real life' and on taking responsibility for this.	Level 5 focuses on improving your skills for turning ideas into action, taking increasing responsibility for creating value, and developing knowledge about entrepreneurship.	Level 6 focuses on working with others, using the knowledge you have to generate value, dealing with increasingly complex challenges.	Level 7 focuses on the competences needed to deal with complex challenges, handling a constantly changing environment where the degree of uncertainty is high.	Level 8 focuses on emerging challenges by developing new knowledge, through research and development and innovation capabilities to achieve excellence and transform the ways things are done.

. Source: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC101581/lfna27939enn.pdf

D.6 DigiComp competence areas and skills

COMPETENCE AREAS	COMPETENCES
1. **Information and data literacy**	1.1 Browsing, searching and filtering data, information and digital content 1.2 Evaluating data, information and digital content 1.3 Managing data, information and digital content
2. **Communication and collaboration**	2.1 Interacting through digital technologies 2.2 Sharing through digital technologies 2.3 Engaging in citizenship through digital technologies 2.4 Collaborating through digital technologies 2.5 Netiquette 2.6 Managing digital identity
3. **Digital content creation**	3.1 Developing digital content 3.2 Integrating and re-elaborating digital content 3.3 Copyright and licences 3.4 Programming
4. **Safety**	4.1 Protecting devices 4.2 Protecting personal data and privacy 4.3 Protecting health and well-being 4.4 Protecting the environment
5. **Problem solving**	5.1 Solving technical problems 5.2 Identifying needs and technological responses 5.3 Creatively using digital technologies 5.4 Identifying digital competence gaps

D.7 DigiComp proficiency level

T.4 Main keywords that feature the proficiency levels

4 OVERALL LEVELS	Foundation		Intermediate		Advanced		Highly specialised	
8 GRANULAR LEVELS	1	2	3	4	5	6	7	8
COMPLEXITY OF TASKS	Simple task	Simple task	Well-defined and routine tasks, and straightforward problems	Tasks, and well-defined and non-routine problems	Different tasks and problems	Most appropriate tasks	Resolve complex problems with limited solutions	Resolve complex problems with many interacting factors
AUTONOMY	With guidance	Autonomy and with guidance when needed	On my own	Independent and according to my needs	Guiding others	Able to adapt to others in a complex context	Integrate to contribute to the professional practice and to guide others	Propose new ideas and processes to the field
COGNITIVE DOMAIN	Remembering	Remembering	Understanding	Understanding	Applying	Evaluating	Creating	Creating

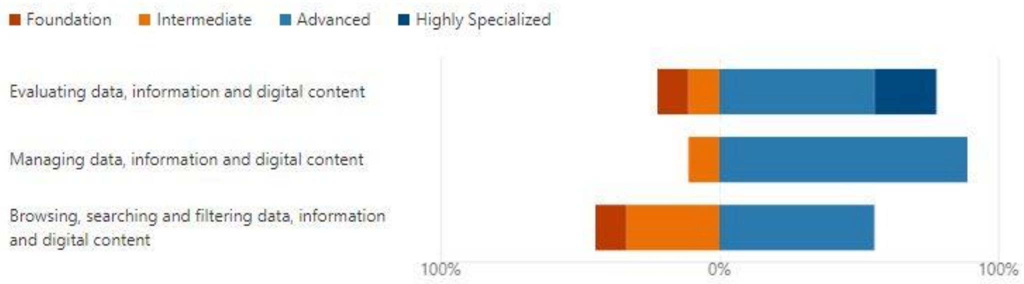
D.8 EnterComp proficiency level

Level of proficiency		Foundation		Intermediate		Advanced		Expert	
Progression		Relying on support from others		Building independence		Taking responsibility		Driving transformation, innovation and growth	
		Under direct supervision.	With reduced support from others, some autonomy and together with my peers.	On my own and together with my peers.	Taking and sharing some responsibilities.	With some guidance and together with others.	Taking responsibility for making decisions and working with others.	Taking responsibility for contributing to complex developments in a specific field.	Contributing substantially to the development of a specific field.
		Discover	Explore	Experiment	Dare	Improve	Reinforce	Expand	Transform
Descriptor	Thread[10]	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8

D.9 Outcome of allocation of level to each digital Skills for the AM Process Engineer for PBF-LB

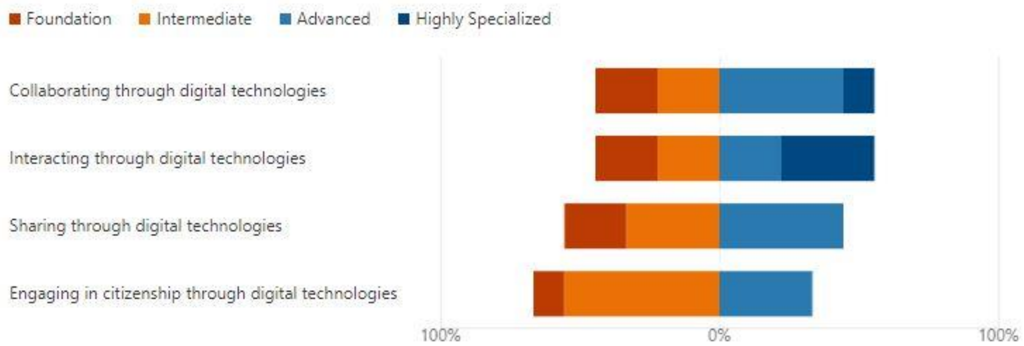
1. Which proficiency level for the Information and Data literacy skills ?

More Details



2. Which proficiency level for the Communication and Collaboration skills ?

More Details

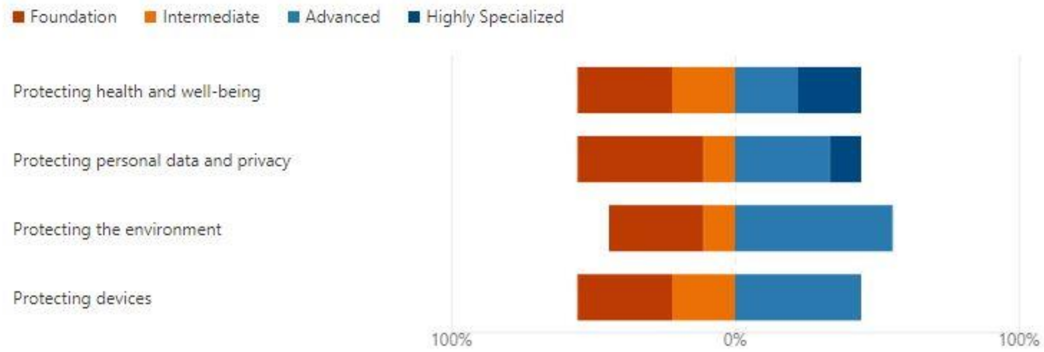


3. Which proficiency level for the Digital Content Creation skills ?

More Details

4. Which proficiency level for the Safety skills ?

More Details



5. Which proficiency level for the Problem Solving skills ?

More Details

E. An example of the application of RPL methodology in the 3rd stage of pilot study

IDONIAL Technology center, one of the partners in the SAM project, conducted a pilot study for the CU43 – Production of PBF-LB parts- in March 2022. This study used the tools and templates developed at WP3 to perform the RPL process for four candidates.

Technical Interview:

IDONIAL used the kit of templates developed for personal interviews to assess the theoretical technical knowledge of the candidates. The list of questions and the scores per candidate are shown Table 4

Table 4: The interview template used for assessment of candidates for CU43

Skills	Question	Candidates			
		A	B	C	D
1.Discuss design for AM features with other AM staff	Q11: Indicate the course of action when, to be manufacturable, a part must undergo modifications in its geometry or dimensions.	1	1	1	1
	Q12: A 3D geometry that has been supplied by a customer presents external details of high precision, in principle difficult to reproduce by means of 3D printing technology. Indicate the possible course of action in order to assess the viability of producing the part.	1	1	1	1
	Q13: The customer wants to produce a part with 2 open tubes at right angles to each other and an internal circular cooling channel. Name at least two aspects that you have to consider or adapt with regard to geometry and positioning.	1	1	1	0,5
2. Interpret finite element analysis and numerical modelling to AM (e.g. topology optimisation, distortion, residual stresses, hatching, nesting)	Q21: Identify and describe the main advantage provided by topological/structural optimization techniques and software, and its relationship with additive manufacturing technologies.	1	1	1	1
	Q22: You have been provided with a simulation report on the manufacture of a part, which basically gives you the expected heat map of the part. Describe how you would use that information.	1	1	1	0,5
	Q23: Justify why an FEM analysis focusing on the determination of residual stresses before AM process start is useful and explain whether you can rely on this analysis or not.	1	1	1	0,5
3. Apply workflows for virtual pre-processing (e.g. part orientation, supports)	Q31: List the operations involved in the pre-processing of a 3D file in a PBF-LB technology, prior to its manufacture.	1	1	1	1
	Q32: Indicate when support structures are required when manufacturing a part by PBF-LB means.	1	1	1	1
	Q33: Explain how you would position a cube-like part in the build space if at least 2 sides need to have a good surface finish without reworking.	1	1	1	0,5
4. Demonstrate competency in working with scanning strategy software	Q41: In relation to PBF-LB processes, define what a scanning strategy is.	1	1	1	0
	Q42: What is the scanning strategy? Name at least two variants.	1	1	0,5	0
	Q43: Describe the main reason/s why scanning strategies are relevant for PBF-LB processes.	1	1	1	0
5. Select specific materials for different applications to meet part requirements.	Q51: List at least 4 different materials that have been developed for PBF-LB technology.	1	1	1	0,5
	Q52: List at least 3 specifications that can advise the choice of a certain metallic material to manufacture a part.	1	1	1	1
	Q53: Name at least one material for the usage in lightweight design and explain why and when special safety measure are required when using this material.	1	1	1	0,5
6. Propose methods to reduce distortion for a variety of part geometries and processes.	Q61: Explain what the phenomenon of distortion refeers to, speaking of PBF-LB processes.	1	1	1	0,5
	Q62: Name and describe briefly one strategy for avoiding or mitigating distorsion in PBF-LB processes. (refering to part properties and design)	1	1	1	0,5
	Q63: Name and explain briefly a method to reduce distorsion and internal stresses during the process.	1	1	1	0,5
7. Identify the cause of defects and propose methods for their mitigation.	Q71: Identify the main cause of the existence of large pores or cracks, distributed throughout a manufactured part.	1	1	1	0,5
	Q72: Time after it was separated from the build plate, a part has undergone a deformation. Describe the most likely cause of the deformation and propose a possible strategy to avoid it.	1	1	1	1
	Q73: The finished part deviates from the geometry of the original model. Identify at least two possible causes and propose a solution to solve the problem.	1	1	1	0,5

Skills	Question	Candidates			
		A	B	C	D
8. Identify the most suitable post processing technique for a specific AM process and application	Q81: List at least three operations involved in the finishing of a PBF manufactured post-treatments usually applied to metal additively manufactured parts.	1	1	1	1
	Q82: Indicate the post-processing operation to be used when it is desired to reduce the internal porosity of a part.	1	1	0	0
	Q83: Identify at least 2 tools each for the removal of support structures and for the removal of powder particles after the PBF process.	1	1	1	0,5
9. Create a PBF-LB AMPS.	Q91: Name at least 5 of the aspects to take into account when defining an Additive Manufacturing Process Specification (AMPS).	1	1	1	0
	Q92: List at least 3 hazards to be considered in a risk assessment of the PBF process.	1	1	1	0
	Q93: Explain how to dispose powder contaminated gloves, disposable coveralls and cloths and why.	1	1	1	0
10. Produce work instructions for the PBF-LB Operator	Q101: Enumerate at least 5 operations where internal procedures for managing additive manufacturing materials, machines or manufactured parts could be defined.	1	1	1	0
	Q102: List the sequence of operations related to the removal of a part / set of parts from the PBF-LB machine.	1	1	1	0
	Q103: Name the required PPE (personal protection equipment) when opening the build chamber to remove the part and the powder.	1	1	1	0

AM demonstration:

Based on the developed template for this part of the assessment, as shown in Figure 17, the job required activities for the CU43 are listed under the Task title. There is an explanation of what a candidate is expected to demonstrate for each task/activity. Moreover, the weights of the assessment criteria are identified per task/activity.

To perform AM demonstration assessment, the IDONIAL team defined two practical activities (cases) which allow the candidates to demonstrate their practical skills to carry out the requested tasks and based on the predefined assessment criteria.

			Relation to Assessment criteria							
	Tasks		Compliance with HSE rules	Ability to take decisions and solve problems	Demonstration of conceptual and technical knowledge	Compliance with the appropriate sequence of work	Selection and use of spaces, equipment, tools and materials	Quality of the final product/ result	Time spent in the execution	
1	**Discuss design for AM features with other AM staff**	Although during the exercise the examinee must show the ability to make decisions independently, they must be able to resolve doubts and raise questions to different profiles: - Designer: possible design modifications based on aspects potentially not compatible with the technology. - Machine operator: availability of materials and readiness of PBF machine. - Workshop manager: aspects related to manufacturing strategies when the combination of technologies is required.	0%	25%	35%	10%	0%	20%	10%	**100%**
			----	1	1	1	----	1	1	10
2	**Interpret finite element analysis and numerical modelling to AM (e.g. topology optimisation, distortion, residual stresses, hatching, nesting)**	The examinee will be provided with a document / report / data from previous part calculation or simulation. The examinee must identify the relevant aspects for subsequent 3D printing: non feasible geometries, areas of high thermal concentration, areas of high mechanical stress concentration, etc.	0%	35%	35%	0%	0%	20%	10%	**100%**
			----	1	1	----	----	1	1	10
3	**Apply workflows for virtual pre-processing (e.g. part orientation, supports)**	From a proposed case (a specific part), the examinee should be able to decide the best placement for the part/s, as well as add the most optimal supporting structures.	0%	15%	35%	10%	20%	15%	5%	**100%**
			----	1	1	1	1	1	1	10
4	**Demonstrate competency in working with scanning strategy software**	The examinee mush show competence in discussing pros and cons of different available scanning strategies for the geometrical features of the part provided as use case	0%	15%	35%	10%	25%	10%	5%	**100%**
			----	1	1	1	1	1	1	10
5	**Select specific materials for different applications to meet part requirements**	The examinee will be given a series of specifications or general manufacturing objectives for a given part, in such a way that a compromise between weight, resistance to expected stresses and price must be reached, depending on the material. Thus, the examinee must suggest the most appropriate material.	0%	30%	35%	0%	20%	10%	5%	**100%**
			----	1	1	----	1	1	1	10
6	**Propose methods to reduce distortion for a variety of part geometries and processes.**	The 3D part supplied to the examinee may present a section especially susceptible to thermal distortion during the manufacturing process. The examinee should be able to suggest some strategy to avoid these distortions (additional supports, slight design modifications, post-heat treatments, etc.).	0%	35%	40%	0%	0%	20%	5%	**100%**
			----	1	1	----	----	1	1	10
7	**Identify the cause of defects and propose methods for their mitigation.**	The examinee will be presented with a defect related to the initial geometry, in such a way that he must foresee some way to avoid it. For example, a part with either lack-of-fusion or over-melting pores in certain locations can be provided to the examiness, who is asked to discuss the root cause of those defects and a possible change of process parameters/scanning strategies to mitigate/avoid them.	0%	35%	40%	0%	0%	20%	5%	**100%**
			----	1	1	----	----	1	1	10
8	**Identify the most suitable post processing technique for a specific AM process and applicationt.**	The examinee will be provided with a case in which the part presents, for example: - A detail which reproduction by PBF LB may be complicated or not possible (for example a threaded hole) so that it can be identified and established which would be the best combination between manufacturing operations, in order to obtain this detail. - A part size or geometry that is susceptible to distortion after cutting the part from the build plate.	0%	20%	25%	15%	25%	10%	5%	**100%**
			----	1	1	1	1	1	1	10
9	**Create a PBF-LB AMPS**	The examinee must be able to make a general workflow of the entire process, from the reception of a 3D file to the final delivery of the part, including the difficulties that may arise and contingency actions at each stage.	15%	10%	20%	20%	15%	20%	0%	**100%**
			1	1	1	1	1	1	----	10
10	**Produce work instructions for the PBF-LB Operator**	The examinee must be able to outline the specific sequence of operations of some specific machine handling operation: machine setup, removal of machine parts, etc.	10%	5%	30%	25%	15%	15%	0%	**100%**
			1	1	1	1	1	1	----	10
			100	100	100	100	100	100	100	**100,000**
			Final Assessment							PASS

Figure 17: The AM demonstration template used for assessment of candidates for CU43

Case 1: medium-sized part corresponding to the railway sector, presenting stress and wear requirements. The examinee is asked about aspects related to tasks 1 to 8, assessing aspects such as the ideal manufacturing position, need for supports, assessment of machining tasks and/or subsequent post-processing, suitable materials, operations for avoiding distortions, etc.

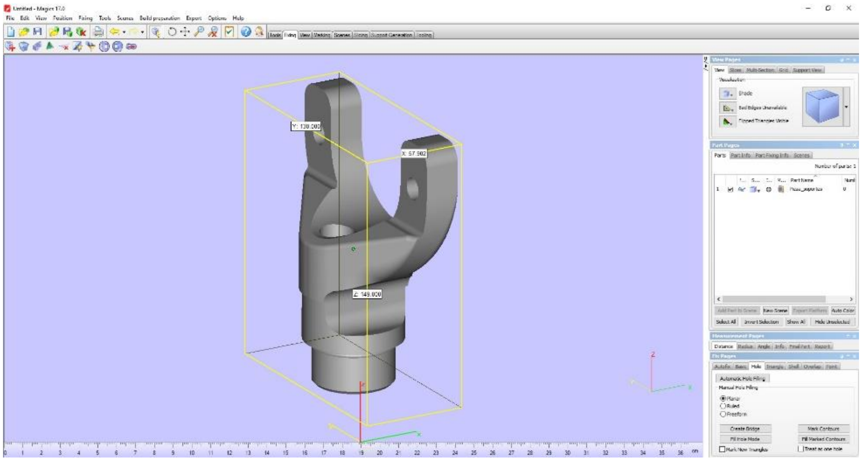


Figure 18: part defined for case 1 for assessment in the AM demonestration phase

Case 2: The examinee is given a 3D file in the shape of a casing, presenting defects in its geometry. The person must detect the imperfections and proceed to solve them, leaving the file ready for further treatment. Specifically, it is intended to evaluate the ability of the examinees to review the manufacturability of the file, as well as their ability to resolve possible defects that would prevent the part from being additively manufactured.

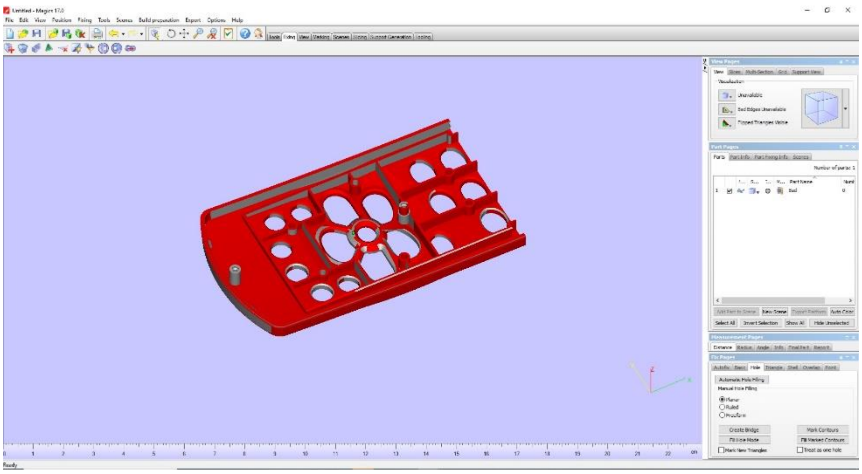


Figure 19: part defined por case 2 for assessment in the AM demonestration phase

The result of assessment of AM demonstration for the candidate “C” is shown in below

		Relation to Assessment criteria							
	Tasks	Compliance with HSE rules	Ability to take decisions and solve problems	Demonstration of conceptual and technical knowledge	Compliance with the appropriate sequence of work	Selection and use of spaces, equipment, tools and materials	Quality of the final product/ result	Time spent in the execution	
1	**Discuss design for AM features with other AM staff**	0%	25%	35%	10%	0%	20%	10%	**100%**
		----	1	1	1	----	1	1	10
2	**Interpret finite element analysis and numerical modelling to AM (e.g. topology optimisation,**	0%	35%	35%	0%	0%	20%	10%	**100%**
		----	1	1	----	----	1	1	10
3	**Apply workflows for virtual pre-processing (e.g. part orientation, supports)**	0%	15%	35%	10%	20%	15%	5%	**100%**
		----	1	1	1	1	1	1	10
4	**Demonstrate competency in working with scanning strategy software**	0%	15%	35%	10%	25%	10%	5%	**100%**
		----	0	0	0	0	0	0	0
5	**Select specific materials for different applications to meet part requirements**	0%	30%	35%	0%	20%	10%	5%	**100%**
		----	1	1	----	1	1	1	10
6	**Propose methods to reduce distortion for a variety of part geometries and processes.**	0%	35%	0%	0%	0%	20%	5%	**60%**
		----	1	1	----	----	1	1	6
7	**Identify the cause of defects and propose methods for their mitigation.**	0%	35%	40%	0%	0%	20%	5%	**100%**
		----	1	1	----	----	1	1	10
8	**Identify the most suitable post processing technique for a specific AM process and**	0%	20%	25%	15%	25%	10%	5%	**100%**
		----	1	1	1	1	1	1	10
9	**Create a PBF-LB AMPS**	15%	10%	20%	20%	15%	20%	0%	**100%**
		1	1	1	1	1	1	----	10
10	**Produce work instructions for the PBF-LB Operator**	10%	5%	30%	25%	15%	15%	0%	**100%**
		1	1	1	1	1	1	----	10
		100	90	90	83,33333333	83,33333333	90	87,5	**86,000**
		Final Assessment							PASS