Skills Strategy Roadmap 2021

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Contents

1. Executive summary

SAM (Sector Skills Strategy in Additive Manufacturing) project aims to deliver together with all partners and stakeholders a shared vision and collaborative skills solutions capable to foster and support the growth, innovation and competitiveness in the Additive Manufacturing (AM) sector.

Within Work Package 4 (see Figure 1), a structured approach has been followed to develop and implement the European Observatory, together with its specific set of rules and operational procedures (**D4.1** – Observatory Rules and Operations Procedures). As an interactive online tool, it has gathered inputs based on figures and trends on AM skills and shortages, through data that has been collected in different sources, then analysed and validated at project workshops (**D4.3 –** Workshop to Analyse Data and **D4.4** – Workshop for the Validation of Needs).
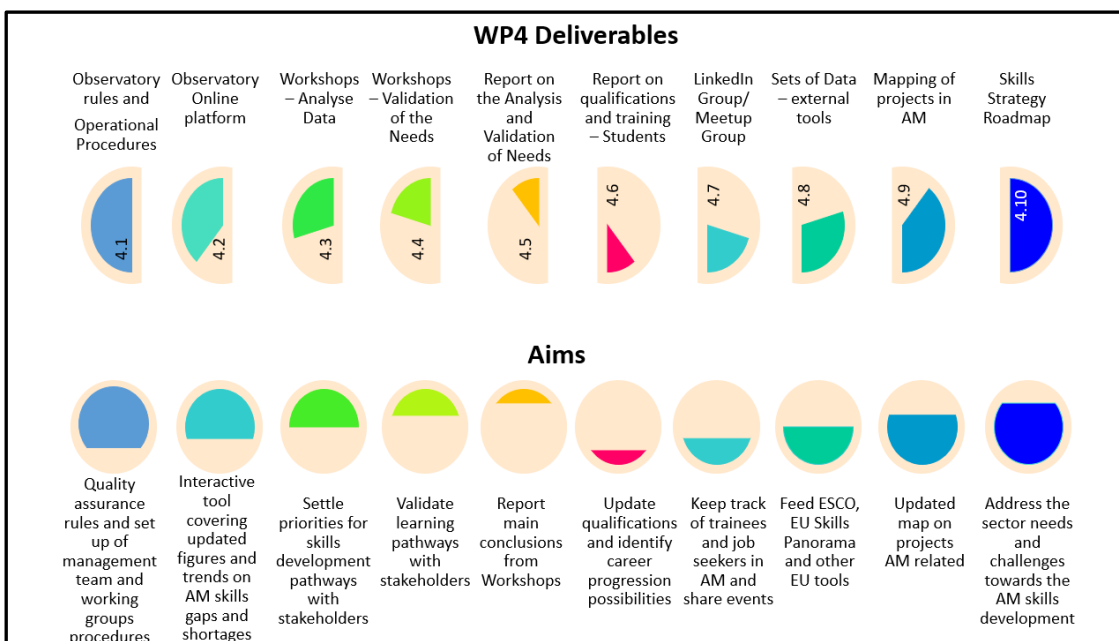
Figure 1 – Overview of WP4 deliverables and their objectives

The current deliverable **D4.10** corresponds to the **Skills Strategy Roadmap**, providing the overall guidance for implementing SAM's strategy until 2030, outlining how the project intends to address the evolving sector needs and challenges towards AM skills development.

A set of "Gap Drivers" were identified and represent the key challenges facing the sector now, (see Figure 3) which the Strategy will cover in detail.

The SAM project has identified strategic objectives in order to face up to this challenge and help mitigate its impact on the sector. The flagship activity of the Skills Strategy Roadmap will consist in the deployment of the International AM Qualification System (IAMQS) through a network of training providers, sustained by a strong connection between a wide range of industrial sectors, which are applying AM in their activity or intend to do so. The roadmap will also expand on how the individual strategies will translate as concrete activities / solutions as part of an implementation timeline, in parallel to the outstanding project activities.

2. Introduction

SAM addressed the common vision and actions to support the growth, innovation and competitiveness of the AM sector.

The Skills Strategy Roadmap (see **Error! Reference source not found.**) settles the Sector Skills Strategy for Additive Manufacturing until 2030. Two versions of the Roadmap will be published in different periods, namely, in 2020 and 2022, in order to reflect the dynamic features of the sector and increasing speed in which AM technologies are evolving. Moreover, the 2022 version will include the monitoring of the actions defined in the first version.
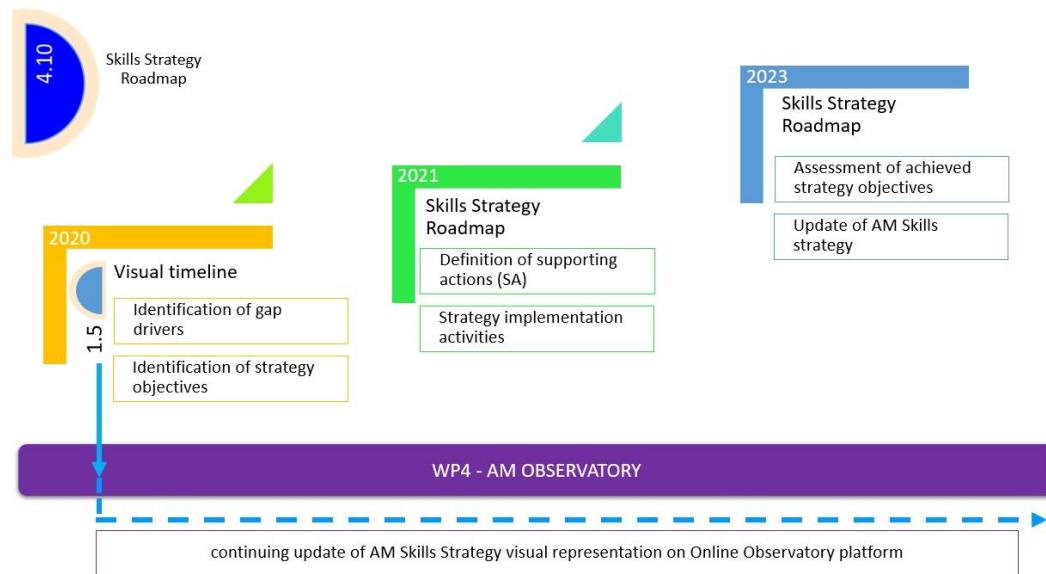
Figure 2 - Representation of planned timeline and "feedback loop" for the Strategy Roadmap for the next two years

For the subsequent two years of the project, the Roadmap will help steer the implementation of the individual activities that have been identified to mitigate each Gap Driver, as well as assess their effectiveness in tackling the problems highlighted in the sector, through the activities that have been planned to tackle these. The below diagram showcases (see Figure 2) how the proposed timeline in D4.10 is planned to be implemented.

In establishing such a roadmap, the consortium is presenting a clear analysis of the path it is going to take for the following two years of activities, particularly on how the Skills Strategy will, by necessity, evolve, adapt and adjust to the trends in the sector, the ongoing challenges it is facing on account of the present international pandemic, as well as the contingencies in place to face future uncertainties.

The Roadmap includes:

- **Key Challenges facing the AM Sector ("Gap Drives")**
- **Input of Strategic Objectives and outline of the proposed supporting actions and implementation activities put forward by SAM and beyond**
- **Proposed Timeline – Referencing the specific Implementation Actions and their relation to SAM tasks and deliverables.**
- **Mind map of the AM Skills Roadmap representing the required Professional Profiles, Qualifications and Skills linked with the AM value -chain, materials and processes.**
- **Summary conclusion about the Strategy**

The present Roadmap represents a critical input towards the successful implementation of the project, as it will help in providing basis for validation of the project strategies.

3. Methodology

Outlining a Skills Strategy Roadmap in the AM sector has required close integration of the wider project activities but incorporating the activities of the European Observatory.

Back in D1.2 "Global and Societal Milestones", the analysis of challenges per field, milestones and required set of skills enabled to identify drivers of actions, which are now being used to define the strategy. In addition, the set of data collected along the desk research (in Work Package 1), together with the surveys and workshops conducted (D4.3, D4.4) and, subsequently, treated through the technical reports produced by the consortium **(D4.5 -** Report on the Analysis and Validation of Needs), enable to design the current Skills Strategy.

To that end, the challenges facing the AM industry, i.e., the "Gap Drivers", are summarized individually in the following sections. For each, the specific reason for being considered a gap driver, together with relevant references, are provided. All of these, it must be stated, have been devised in close consultation (and based on specific input and feedback) from key AM industry representatives, stakeholders, and experts the project has been careful to involve from the outset.

In order to effectively convey the interaction between the key Gap Drivers identified, their equivalent strategy mitigation plans and relevant activities, the consortium has structured the Roadmap in the following structure:

- **Challenges in Additive Manufacturing (Gap Drivers)**, which have been the result of continued consultation, from the outset of project, with sector professionals and industry representatives, as illustrating the foremost obstacles to the development of the European AM sector.

- **Actions** are meant to offer concrete and feasible solutions to these challenges. They are layered in terms of Strategic Objectives, i.e,. a macro-level approach to a specific challenge. For the strategy to succeed, specific Supporting Actions need to be considered, together with support activities that can help maximize the success of the strategy.

- **Expected Impact** represents the expected degree of success at countering each Gap driver successfully. The report will provide a detailed breakdown of this, for each Gap Driver, and how the project has effectively contributed towards it.

This will require continuous and careful monitoring, to ensure that the link between gap driver and the relevant actions remains valid, but also, to ensure that the key stakeholders and industry experts remain engaged in validating the findings.

To seamlessly incorporate the key elements of the Roadmap into the project activities, a timeline will be developed and followed for the remainder of the project's lifetime. In this way, the activities can be properly plan, monitored and reviewed if necessary (additional details on the proposed timeline can be found in the relevant section), particularly following the implementation of the proposed Supporting Actions in 2021, an assessment will need to be carried out against the proposed Strategic Objective and, if necessary, an update to the AM Skills Strategy implemented.

The set of conclusions at the end, contains a summary table of the overarching structure detailed in the report, as well as summary descriptions of the activities implemented as per the roadmap timeline proposed.

4. CHALLENGES IN ADDITIVE MANUFACTURING

This section addresses, in detail, each of the seven gap drivers that have been identified by SAM.

This has been a key contribution from WP1, particularly with the development of D1.2, Global and Societal Milestones. By working towards identifying key transformations that can direct (and indirectly) impact the Additive Manufacturing sector and skills, SAM has been able to put forward concrete solutions, strategies and feasible activities that can allow the sector to adapt and reduce the potential negative impact, thereby contributing to the growth of the European AM field.

In this section, each Gap will be explained in full, together with the underlying references to why it was considered as such for the AM sector. Under each Gap Driver (see Figure 3Figure 3) the relevant strategies are also presented, together with the reasoning for the specific supporting actions that have been planned to help drive the implementation of each strategy plan.
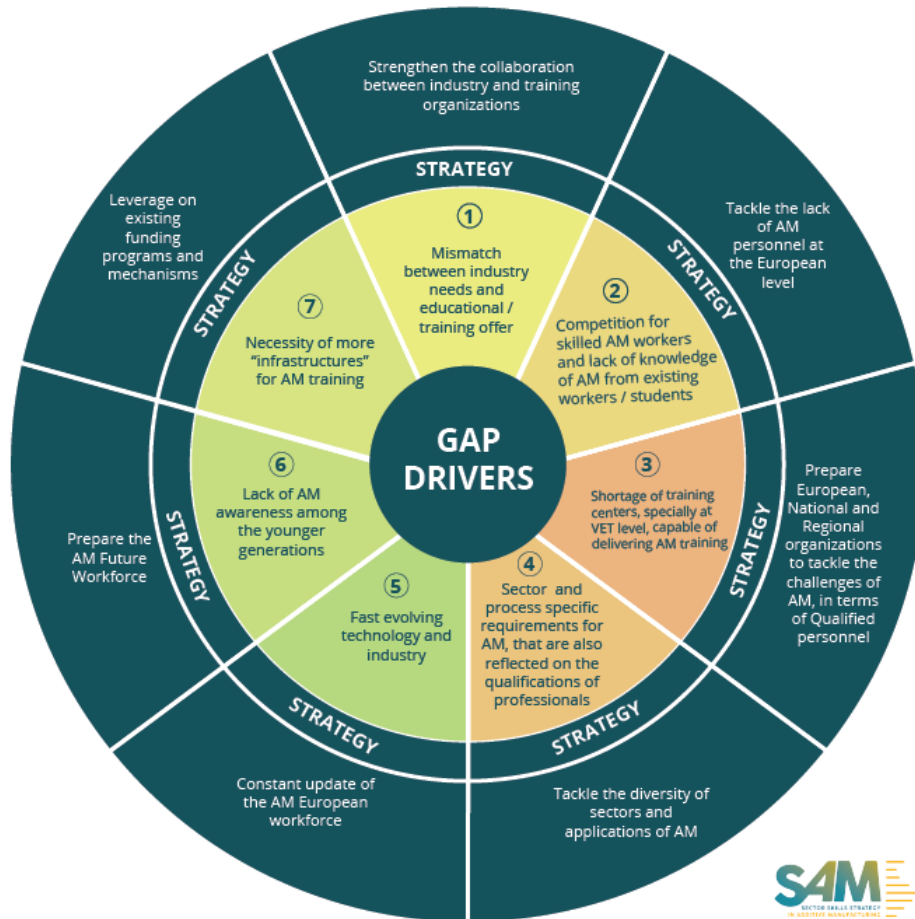
Figure 3 - AM Gap Drivers

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SECTOR SKILLS STRATEGY
IN ADDITIVE MANUFACTURING

4.1 Mismatch between industry needs and educational/training offers

As with most disruptive technologies, the AM sector growth and development happens more quickly than the pace of learning and the adaptation of the educational system. This lag generates a gap where there are simply not enough skilled professionals or/and workers with the needed skills to fill jobs and thus meet the demand from the AM employers. [1]

Implementation of AM at industrial level requires new technological, digital and transversal skills to exploit fully and sustainably the benefits offered by these technologies. With more applications arising lately, companies are increasingly demanding talented professionals that can work with and optimize the whole AM process and part production.

Without a well-trained workforce capable of adapting to—and adopting—the applications and uses of AM, organizations may fail in their ability to integrate AM effectively [2] . In this sense, industries are currently facing some obstacles to find out the missing necessary people (technicians, engineers, designers, operators...) specialized in technical and non-technical aspects of AM. The demands on—and expectations for—AM talent are high, especially because the technological, engineering, green and digital skills required vary widely and because AM professionals are expected to be at the same time creative, and able to constantly adapt to new developments.

According to "AM-Motion AM Implementation roadmap" [3] there is a need for AM specific educational and training modules both through linking with "regular" high education curricula (engineering, business schools) and training on the job approaches to foster AM development and market uptake in Europe. Proper communication campaigns, industry involvement, delivering suitable learning contents at all levels, specific educational programmes, workplace training, on-line education and reskilling actions for current work force are necessary. Training and education establishments need to preserve and develop the employability of workers. Industry and other employers (e.g. standardisation bodies, IPR entities, etc.) should be also engaged in the process in order to align their needs with regard to skills with the educational contents.

Existing courses on design, engineering and management related to advanced or digital manufacturing do not systematically deliver the necessary skills and knowledge for an effective deployment, meaning that the training offer provided is not aligned to the required needs of industry. There are also specific AM training courses of several types being implemented for the different levels of education. However, the capacitation approach of AM professionals is not consistent, lacking the harmonisation and consequent recognition of knowledge and skills. [4]

Moreover, companies are already identifying specific present and future AM skills and profiles needed. From the surveys and interviews with industries run in the framework of SAM the following needs were found (see Figure 4).
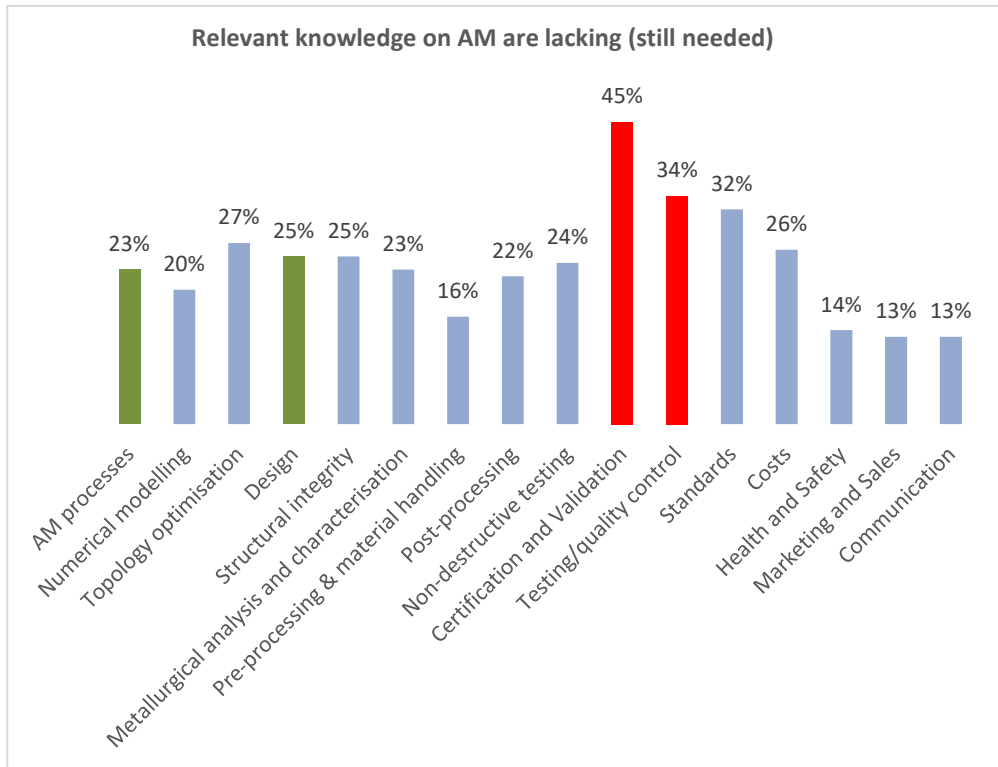
Figure 4 - Knowledge Lacking in AM, according to the company survey 2019 [5]

Although, some missing knowledge is covered by current existing courses (see Figure 5), there are specific industrial demands not being covered such as Certification and Standards as well as Testing/Quality, creating the mismatches. This shows the need of a systematic consultation/process on the industry needs in terms of required knowledge and skills, at short, medium and long terms.
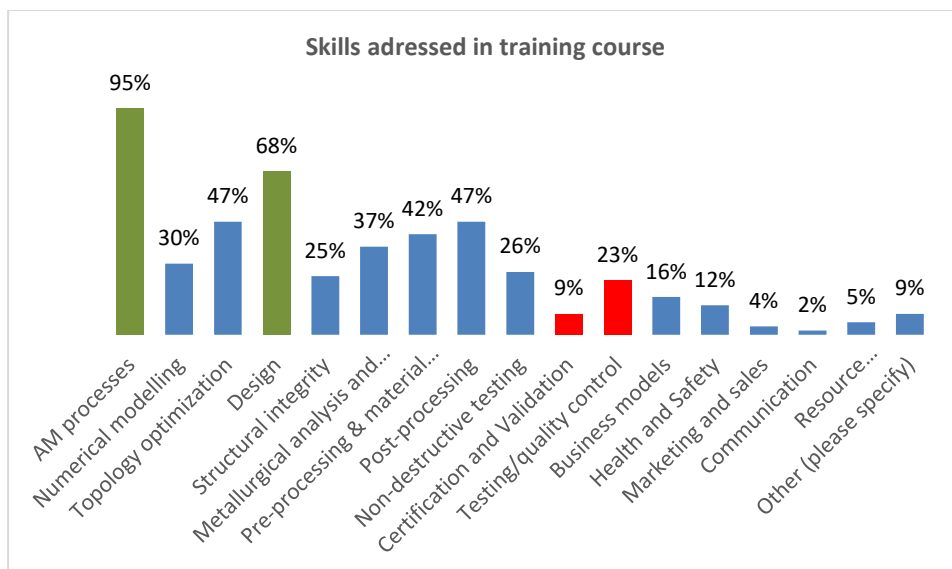
Figure 5 - Skills addressed in AM Training, according to the training centres survey, 2020 [5]

It is important that companies do not feel overwhelmed by AM adoption. Through commitment to the education of current and future workers, covering all their needs by enabling the regular interaction

between education and industry representatives, accessing the skills needed for the use of AM can be facilitated.

Moreover, although there are organisations, such as The European Technology Platform in AM "AM-Platform" [6], with dedicated groups to discuss the needs on AM skills and education, to the best of our knowledge, there is not any systematic consultation process on industry needs in terms of required training, which is able to anticipate and prioritize those needs.

To conclude, it is clear that the systematic collaboration between key stakeholders from industry and education side is fundamental to tackle the existing mismatch among the AM skills demand and supply.

4.2 Competition for skilled AM workers and lack of knowledge of AM from existing workers/students

AM technologies are evolving at a much faster pace than the development of the skills enabling the workforce to use them. According to a Deloitte article published in 2016 [7], "*growth for AM, while positive, also raises a significant challenge: heightened competition for a finite talent pool with the skills to use this technology. This challenge is expected to affect businesses of all sizes, from start-up to enterprise-level. Indeed, according to some reports, the number of job advertisements calling for 3D printing skills increased 1,834 percent between August 2010 and August 2014, with industrial engineers, mechanical engineers, software developers, and industrial designers among the most sought-after professionals.*" This is also supported by the literature review from D1.4 "Professional Profiles/ Set of Skills Roadmap", according to which there is a need to train and educate the current and future workforce to provide the required AM knowledge and skills to the existing workers and students. The AM process chain requires different skills and there is a need for highly-skilled workforce to operate advanced machinery such as those existing in AM systems. The growing use of AM technology in industry is increasing the demand for AM workers, but the offer doesn't match the existing workforce – this generates a high competition for skilled AM workforce.

There are a number of courses available from universities focussed on Additive Manufacturing (from example from Cranfield University in the UK), however these are primarily at Masters level (level 7 in the European Qualifications Framework). As they are at quite a high academic level, they may be inaccessible for a great number of workers that could potentially be "skilled up". In this sense, a higher number of qualifications for lower EQF levels is deemed to be necessary in the AM education system, preferably qualifications recognised at a European/international level. On the other hand, highly complex, varying and knowledge-intensive production processes will demand a high level of specialisation of the different AM workers, and this is still not being addressed by a great majority of AM education centres.

There is a lack of communication between AM education and training providers, preventing a concerted action in terms of possible synergies between institutions to overcome the lack of equipment in training institutions, promoting AM awareness, AM skills and preparation of the workforce to meet the industry's needs. Adding to that, high costs associated to AM training also prevent access to training from individuals, especially if we are talking about lower-skilled personnel. Specially for those who already have a job, flexible skilling pathways are necessary to increase the attractiveness of the AM field and increase the possibilities for workers to upskill or reskill.

There is also a lack of data on number of job offers and current positions in AM, which creates increasing difficulties in providing a targeted/matching training offer and may cause an unbalance between training offers and the needs of the market, making it impossible to close the existing gap in AM professions and, thus, increasing competition for those professionals.

To supply all the skilled personnel needed by industry (and services) for the next decade, actions should be taken at all education levels, maybe even preparing training plans starting from primary school to

university degrees, particularly in engineering. Future technicians will need to have cognitive competence to deal with a changing technological environment (mathematics, logic, data processing, project management) and non-cognitive skills (critical thinking, teamwork, achievement of goals, interpersonal relationship skills, or troubleshooting abilities).

A 2016 article by Deloitte [8]concludes that nine out of ten manufacturers are struggling to hire workers with the right skills. The skills shortage, then, is one faced by manufacturing as a whole. Again in 2019, a Deloitte communication [9] identified that one of the main challenges faced by the manufacturing industry is the shortage of skilled technicians familiar with the technology and capable of applying 3D printing. Deloitte and The Manufacturing Institute launched their fourth skills gap study in 2018 and they noticed that the skills gap may leave an estimated 2.4 million positions unfilled between 2018 and 2028, with a potential economic impact of 2.5 trillion. Further, the study shows that the positions relating to digital talent, skilled production, and operational managers may be three times as difficult to fill in the next three years. Although this study was done taking the US reality in, a correlation may be seen in the European labour market.

Given all the above, it is clear that there is need to tackle the lack of AM personnel and a current talent shortage for working in the AM at the European level in order to mitigate the high competition for skilled AM workers.

4.3 Shortage of training centres, specially at Vocational Education and Training level, capable of delivering AM training (cost of the equipment/software, qualified personnel for delivering training)

Surveys carried out within the SAM project show that there is currently a clear focus on higher qualification levels in the educational provision for AM. 2/3 of the offers (65.52%) and thus the majority can be assigned to the level of the Bachelor's or Master's degree (see Figure 6). These qualifications are typically awarded at Universities and Universities of applied sciences. While AM is therefore already very well represented in student education, there are hardly any offers for the level of vocational qualification of EQF level 4, typically offered by vocational schools and continuing vocational education and training providers and none for EQF level 5.

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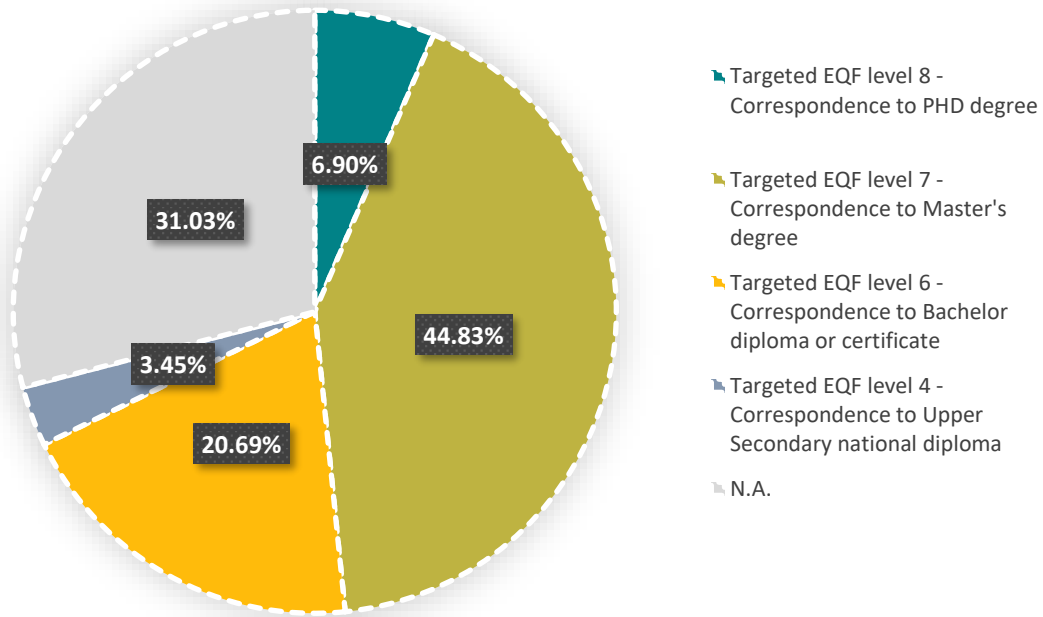
Figure 6 - Targeted AM Training Levels, according to Survey to the Training Centres, 2020 [5]

The training providers deliver their training at customer's premises or at the training centre itself. The last point is not suprising, as the majority of the offers is for EQF Level 6 & 7 and assumed these are mainly offered by Universities. Another significant proportion of training courses are offered online. From the sum of the answers it can be concluded that individual providers use several ways to offer training (at company site/education centre or as mixture of presential and online-training, e.g. blended learning). See Figure 7.Figure 7 - AM Training Nature of Delivery, according to Survey to the Training Centres, 2020

How do you provide training?

Figure 7 - AM Training Nature of Delivery, according to Survey to the Training Centres, 2020 [5]

As part of the same survey, the participants that did not provide AM courses were asked to identify the main obstacles to this. The majority (45.5%) answered that there was the lack of requested training from

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the AM world. This lack of requests can be justified in two opposite ways: i.) either the training offers are low and do not fit to the costumers needs; ii) either the number of training centres given AM courses is huge enough to generate the diffusion/ fragmentation within a certain country or region, thus given the impression that there is a lack of demand. At 36.4% was the lack of AM equipment whereas the lack of trainers was only 9.1% of the responses (see Figure 8). Obviously that in addition to the lack of equipped training centres, the lack of training offers and demand from the industry are important aspects to consider when analyzing gap driver 3.

What is main reason for not providing AM courses?

- ▶ Lack of trainers
- ▶ Lack of equipment
- ▶ Lack of need/Request from market
- ▶ Other (please specify)

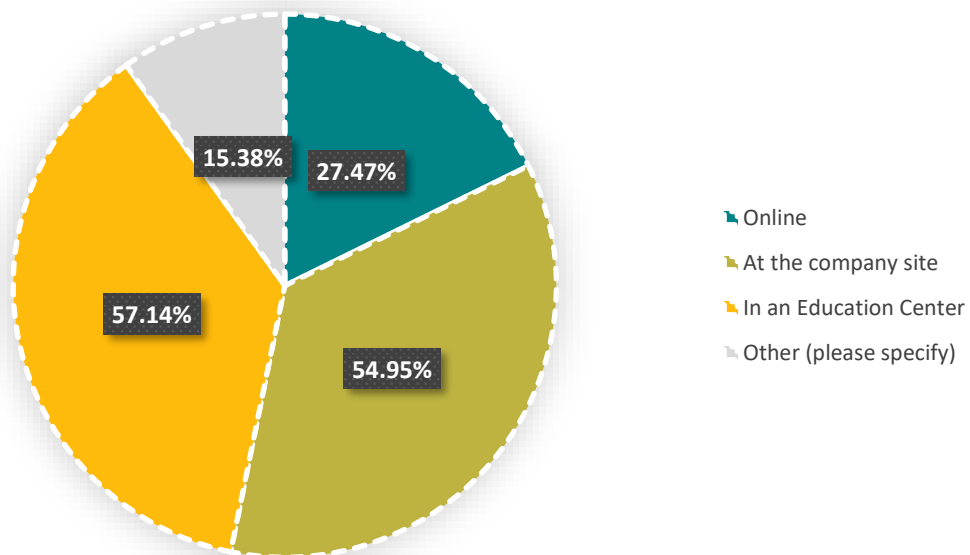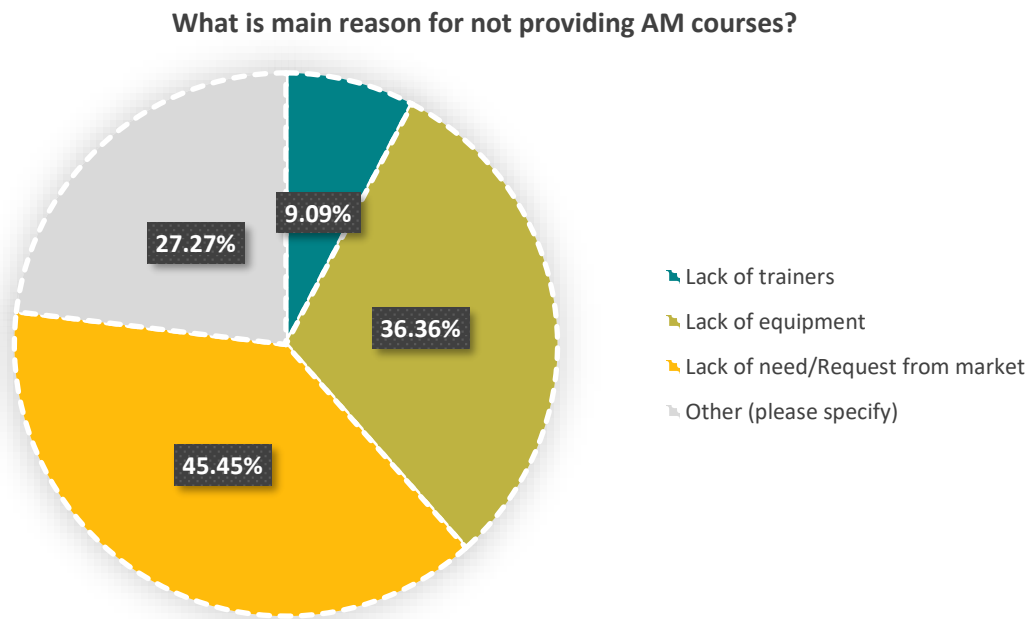*Figure 8 - Obstacles to AM training, according to Survey to the Training Centres, 2020 [5]*

Moreover, the 3DP-VET project (KA2 Erasmus+) investigated the spread of 3D printing in education, recently identified factors limiting the use of 3D printing in VET and (evaluated existing international and national training programmes referring to 3D printing in education with special attention to VET (VET (IO1: Research report (3DP-VET) 2020, respectively p.37 and p7). The conclusion points that 31% of experts indicated that the main factor limiting the use of 3D printing in VET is the "Lack of competence to use 3D printers", 30% identified "Cost of 3D printers" as the main factor ((3DP-VET) 2020, p37). 20% identified "Lack of methodologies for 3D printing in education" and 13% "Rigidity of curricula" (3DP-VET) 2020, p7). Only 1 to 4% identified "Absence of benefits from using 3D printers or "Health Hazard" (IO1: Research report (3DP-VET) 2020, p37). [10]

In a nutshell:

- The higher levels of qualifications are well served, however they may be primarily at universities and not VET focused . There seems to be a significant gap at the "lower" end of the EQF scale which would translate directly (in most cases) to a vocational qualification at the Technician level
- The lack of training facilities with ready access to AM equipment is hampering the provision of education and up-skilling which must be overcome

The lack of competence/knowledge of the training staff also influences why training centres cannot provide training, although this is not the dominant factor which indicates a need to capacitate trainers.

To conclude, the preparation of the European, National and Regional Training organizations in terms of equipment and qualified personnel is a crucial objective to tackle the challenges of AM for qualified personnel.

4.4 Sector and process specific requirements for AM, that are also reflected on the qualifications of professionals

The substantial growth of AM is partly attributed to the fact that AM is being utilised across various sectors, which include (but not limited to): Transportation (e.g. aerospace, automotive and maritime), Medical and health, Energy (e.g. oil and gas), Fashion and retail, Industry equipment and tooling and also Construction.

However, one of the gap drivers identified is the sector-specific requirement for AM professionals. This means that there are different AM requirements across various industrial sectors. For example, desk-based research within Work Package 1 (e.g. Deliverables 1.2 and 1.4), surveys and workshops (e.g. Deliverable 4.5) alongside information from the literature showed some examples of some sector-specific requirements for AM across different sectors [11] [12] [13] [14](see Table 1).

Medical and health	Transportation (aerospace, automotive and maritime)	Energy	Construction
• Customisation and complexity (i.e. patient-specific necessities) • Regulatory issues and quality assurance • Material limitations (e.g. biomaterials) • Affordability and accessibility • Sterilizable materials • Modelling capabilities for interactions with human parts (e.g. organs, cells) • Fast production rate	• Geometric design freedom (e.g. fabrication of large components, complex geometries) • Scalable and efficient material/production process • Customisation • High precision and consistency • Sustainable and lightweight materials with good mechanical properties (i.e. high strength to weight ratio) • Low cost • High-temperature materials • Standardisation, consistency and quality assurance	• Scalability and modularity • Use of multi-materials (e.g. composites) • Excellent surface finish • Complex shapes and parts • Smart and sustainable materials with excellent mechanical properties	• Good surface finish and layer-by-layer appearance • Excellent and consistent mechanical properties • High precision and complexity • Low cost • Scalable part size • Standardisation and quality assurance

Table 1 - AM requirements across different sectors

Therefore, there is a need for a harmonised approach for training involving different sector stakeholders to address the skills development programmes focused on sector-specific needs in AM. Furthermore, AM is considered a disruptive technology, and its rapid progress also means that there are not enough skilled professionals available to meet the demands, and especially to operate across sectors [15], [16]. The significant growth and technological advancements of AM have led to the demand and changes in the skills requirements and qualifications for professionals across different sectors. Also, advanced manufacturing contributes to about 1.6 million jobs in the EU, which is expected to increase significantly soon [17]. However, there is a challenge of finding suitable professionals in AM across different sectors as there is currently no AM platform or organisation that addresses the sector-specific requirements or the mobility or adaptation of AM professionals for various sectors and countries. There is also a need for modular and flexible training programmes that can upskill AM workers and ensure their mobility between different sectors and countries.

According to The Manufacturer [18], the most common barrier for the adoption of AM across different sectors is a lack of appropriate skills in design, production, materials and testing. There is also a growing demand for highly skilled AM professionals with a multidisciplinary and more comprehensive skillset, covering different aspects of AM (e.g. design, material and process selection, post-processing, testing, quality inspection) [9] [19]. This is further complicated due to the diverse range of manufacturing processes available within AM [2]. More precisely, ISO/ASTM 52900 has seven main categories of AM, which are binder jetting, directed energy deposition, material extrusion, material jetting, powder bed fusion, sheet lamination and vat photopolymerisation [20]. In addition, different materials are increasingly being used in AM, which include metals and alloys, polymers, concrete and composites. In general, there is a need for a combined approach involving stakeholders from different sectors including standardisation bodies, educational and industrial councils to develop relevant qualifications that cover the aforementioned skills, educate and prepare a diverse workforce of AM professionals to meet sector-specific requirements.

4.5 Fast evolving technology and industry

Another gap which is preventing the development and advancement of a dedicated AM workforce has been identified as the "fast evolving technology and industry in AM". This means that not only the technology is advancing at rapid speeds, as will be further described below, but also the industry is changing at very fast pace. In order to stay on track with developments, the workforce must be constantly alert as to what new developments are available on the market. Furthermore, the available education programmes must be able to adapt to new developments and incorporate them very quickly in order to deliver the most up-to-date courses. For this, flexible and interchangeable training systems are the key.

Based on the reports of deliverable D1.3 "Long Term Technological and Industrial Plan" and the D4.5 "Report on the Analysis and Validation of needs" it can be seen that a lot of topics are currently evolving in AM technology. Some examples can be seen in the sharp rise of new processes or the evolvement of "old" processes but also the quick adaptation of needs in terms of automated post-processing technologies. Furthermore, as AM is often considered one the pillars of Industry 4.0, digitalisation of the process chain and the advancement in software development such as "deformation prediction" or machine learning algorithms often go hand in hand with a quickly evolving technology.

Figure 9 gives a good description of the current market situation in AM in 2020. It can be seen that the market is already extremely diverse with a lot of start-ups and small companies. Moreover, the market will become even more diverse when "new" topics will enter the market such as cybersecurity, multi-materials, machine learning and printed electronics. This scattered diversity is beneficial in terms of technology evolution, upgrading of existing ones and competition, but also allows for the AM workflow to very quickly lose the overview of the current situation and evolving trends. Furthermore, a quickly evolving market could easily lead to outdated education programs lagging behind the technology or industry needs.
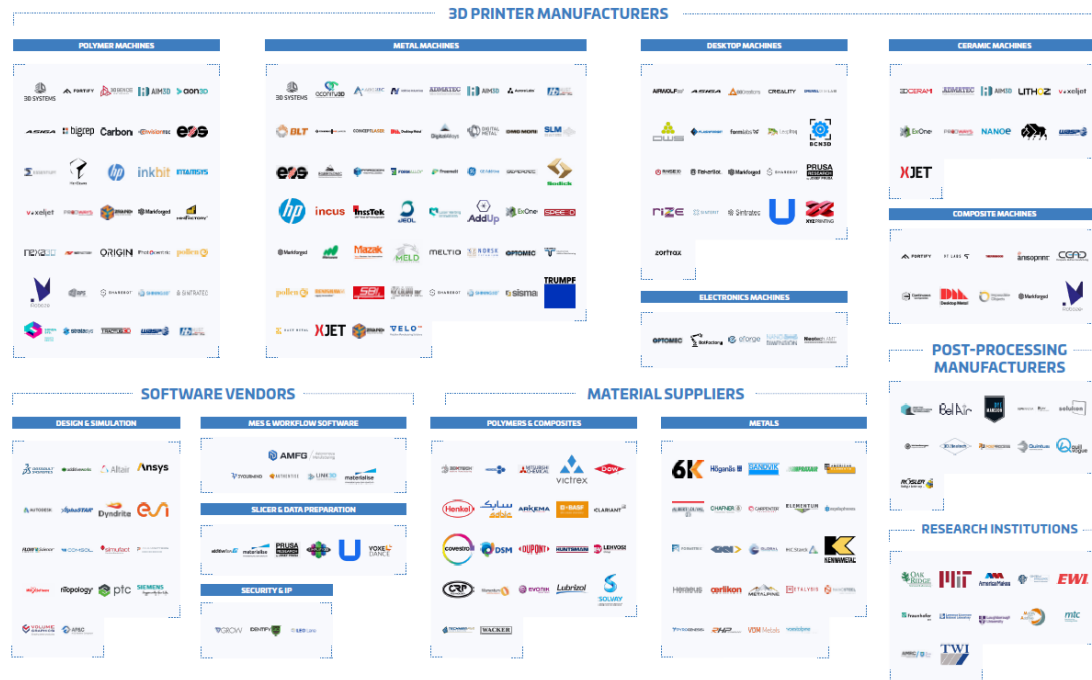
Figure 9 - Overview of market segments and companies for Additive Manufacturing in 2020 (courtesy of AMFG)

Further specified in deliverable D1.3, looking at the long-term topics in terms of ICT and PROCESSING, there is a clear trend towards the "Market uptake of new AM technologies and downfall of existing AM technologies" as well as the development of new automation concepts, modular printers operated by robots and an increasing demand in desktop machines. For ICT, the long-term trends will be advanced monitoring systems, advanced data analytics and advanced close-loop controls for automated adaptation. Along with these topics goes the need to increase and adapt the knowledge in order to implement the technologies properly. New knowledge will be created at significant speeds and depending on the type of specialisation, industry needs might not be successfully matched due to a lack of knowledge.

In terms of post-processing, an overall automation process will be seen to reduce the manpower as this is still generating a significant amount of part costs. Along with the automatization of post-processing, monitoring process control and an increasing demand for modular systems, goes the need for new standards creation. The knowledge of an operator for example will increase from the manufacturing process itself to knowledge about all process steps in the AM process workflow.

Materials will possibly play one of the largest parts in evolution of the AM technology. The customisation, increased productivity and material characteristics of parts will further the advancement of new material creation, new applications and products. Currently, printed electronics, fit-for-purpose, multi-material, bioprinting and 4D printing are expected to be evolving quickly in the long-term run. Along with the development of the materials, will be the development and upgrade of technologies in order to process the upcoming materials. As an example: in 2019 the SEMVOL database listed 1700 available and researched AM materials. In 2020, this database expanded to 2245 AM materials.

In Figure 10, an overview of the trends identified for AM, based on industry and research can be seen: new material development and real-time control and monitoring will play an increasing role in the future of AM to provide zero defect manufacturing.

Figure 10 - Relevance of different AM technology trends up to 2025, according to survey to RTO, 2019 [5]

Another example which substantiates the gap driver "fast evolving technology and industry" can be seen in the amount of research papers published and the filing of patents: from 2018 until 2020 the amount of publications in AM doubled. The same trend is seen for patent filing in between 2017 and 2019. Hence, it is likely that a lot of new ideas, technologies and upgraded components will emerge to the market over the next years. Furthermore, as the output of research papers and patents has doubled in the last 3 years alone, while only slowly gaining speed in the beginning between 2000 and 2017, a wave of output in terms of AM technology, materials and ICT can be expected which needs to be dealt with in terms of AM workforce evolvement (see Figure 11). [21]
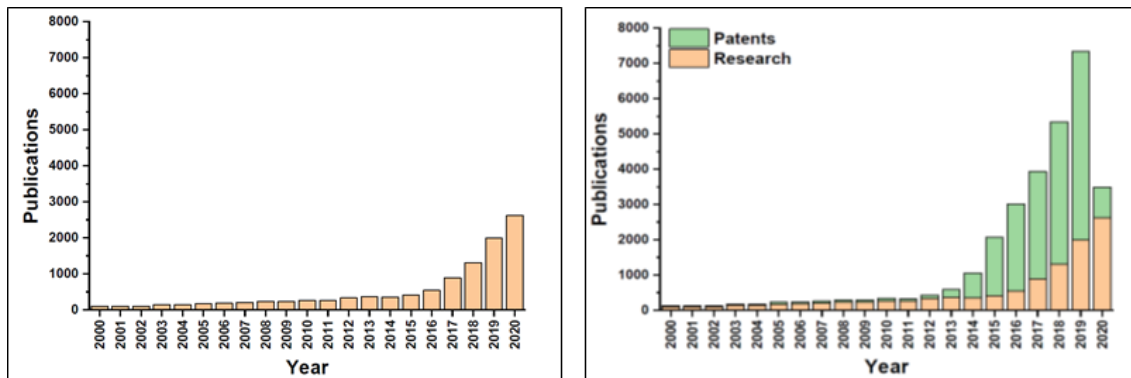
Figure 11 - Overview of AM publications and Patent Filings from 2000 until 2020 [21]

The need to follow-up closely in terms of technology and industry evolution is not only limited to the workforce itself but also the trainers which educate the workforce. Even more so, as the trainers will be the ones that can deploy the advancements address in the teaching programmes in order to update the workforce. Moreover, in order to track the changes, developments and advancements efficiently, the need for the education system or institution to monitor the development of the before mentioned three topics is important. This has also and been identified in D1.3 and in 4.5. In order to ensure that needs for a skilled workforce can be evaluated and identified, continuous watching of the market while using a strategic approach to cover the most important trends will be vital. In order to keep up with technological changes, an active approach able to anticipate current and future needs is needed. A lot of initiatives cover only certain aspects or only identify needs in various areas but an overall approach from the EU cannot be found to tackle the issue of monitoring fast evolving technologies. Along with a monitoring

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system for the market, goes an education system which can easily adapt to market trends. As mentioned before, interchangeable small education units might help to constantly reassemble education programs.

4.6 Lack of AM awareness among the younger generations

Another gap driver, which is preventing the full formation of dedicated AM workforce, has been identified in the lack of AM awareness among the younger generation. Several factors can be addressed as the cause of such unawareness: the fast development of the technology, and the subsequent absence of a role-model industry in the sector, which should help to increase the visibility and interest in such technology, are just the most detectable ones, together with the lack of substantial promotion of AM courses in academia or professional trainings.

Firstly, being AM one of the key enabler technologies of the new industrial revolution, it has a much higher speed of development, thanks to a high number of research all around the world, positioning the wider Europe area only second to North America. The outcomes of such research are striking engineers and designers with new horizons since these new developed technologies are truly diversified than conventional ones, and remain rather niche: multi-materials AM is a typical example, where the period from lab to production, e.g. from Technology Readiness Level (TRL) 2-3 to TRL 7 has been completed in less than three years.

Moreover, another issue resulting from the fast speed of AM, is that the industry is still immature and did not have time to bring out legendary names such as Henry Ford, Karl Benz of automotive or Thomas Edison, Nikolai Tesla of electrics; such role-models are, in fact, important to motivate and attract young generations to take part in a certain business. If we then consider that the average age of the current active workforce in AM is currently at their forties, the need to introduce and promote pioneers of the industry that succeeded in stunning inventions and developments of Additive Manufacturing becomes essential.

On the other hand, academia and educational providers have their own responsibilities. In fact, if we take a glance at universities of engineering and technical studies, we can observe that the lion's share in their curriculum is still on traditional disciplines, such as mechanical or electrical engineering, just to mention the most famous ones. The consequence of this slow implementation of tailored CVs for AM is that academia and VETs are dropping behind in providing the right workforce needed in this 'young' industry. A similar path can be observed in the way technical schools try to attract students to their programmes: the promotion materials, such as posters or flyers, as well as general advertisement, are usually built on the 'traditional' disciplines, as they are still considered more appealable because more known. On the other hand, the same extended media campaign does not apply when it comes to promoting tailored education in AM, which, therefore, remains fragmented and inhomogeneous among EU countries.

If we consider the most recent available data on EU graduates as Bachelor of Science (BS) and Master of Science (MS) specific disciplines given by Eurostat [22] , we can notice that the trend of numbers remains stable by looking and comparing it with the percentage changes in Figure 12 of the report on 2012 employment rate in manufacturing mechanical engineering, highlighting a standard way of communicating such disciplines.

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Sector	Indicator	2010		Annual average growth rate in %			
				1995–00	2000–05	2005–08	2008–10
Manufacturing ME[1]	Production, in current prices	bn €	5,885	5.3	2.1	6.7	-5.2
			502	4.0	2.3	10.4	-8.4
Manufacturing ME[1]	Gross value added, in 2010 prices	bn €	1,504.0	2.1	0.0	1.5	-5.2
			157.5	2.4	0.3	6.0	-9.3
Manufacturing ME[1]	Employees	1,000	30,063	-0.6	-1.3	-0.3	-4.8
			2,901	-1.6	-2.2	1.8	-4.8
Manufacturing ME[1]	Productivity[2]	1,000 €	50.0	2.7	1.3	1.8	-0.4
			54.3	4.0	2.6	4.1	-4.7
[1] ME = mechanical engineering 2) Value added per capita and annum at 2010 prices.							

Figure 12 - Key figures for EU-27 in Mechanical Engineering. 'An introduction to Mechanical Engineering: Study on the Competitiveness of the EU Mechanical Engineering Industry within the Framework Contract of Sectoral Competitiveness Studies – ENTR/06/054'. Ecory. Source: Eurostat: Cambridge Econometrics; Ifo Institute

If we then take into account the data collected on AM specific courses at higher-education level, we notice the very small number of 6 courses specifically focused on AM technology at postgraduate level, identified by the AM-Motion project in 2016. In the latest years, there has been a slight increase in courses specific on AM, as the data collected for the SAM AM Observatory show. Nevertheless, most of the courses available are not entirely focused on AM, and they are still seen as a branch of classical engineering. Many courses on AM are instead classified as 'short courses' or courses in the context of Summer Schools. These data also show that AM specialized university or post-graduate programmes are concentrated in particular geographical areas of the EU-28, namely UK, Germany, and Spain.

The lack of AM awareness among the young generation is being reflected in the mismatch between supply and demand of AM workers in Industry, preventing the European AM to thrive and to be exploited at its full potential. In fact, the results obtained by the SAM survey on the industry needs show that there is a mismatch between the supply and the demand of AM workers. The industry is struggling to find AM professionals with the full set of skills needed to exploit the potential of AM technology. Specifically, the survey revealed that the current professionals are still lacking knowledge on post processing being expected that within the next 2 years AM professionals will need even more knowledge on certification and validation.

The foresight on the AM market expansion trend confirms the need to address this specific gap driver, as *'the global market revenue generated by the AM sector accounts for USD 12 Billion in the year 2020 and it is anticipated to reach around USD 78 Billion by the year 2028* [23][1]'. Such growth without a proper and prepared skill force of the future risks to create unequal growth opportunities and social discrepancies, both at European level and worldwide. To conclude, it is clear that the factors that impact the lack of AM awareness among the young generation is to be found both in the industry and the academia; therefore, a collaboration of all the stakeholders involved in AM becomes fundamental to understand the industry needs first, and consequently create flexible ad-hoc academic curricula and professional training to match those fast-changing needs. It is in this framework that the project SAM has identified specific actions to tackle this challenge.

4.7 Necessity of more "infrastructures" for AM training

The need of having funding programmes to equip AM training centres allied with strategies to bring together VET providers and equip companies with AM knowledge are fundamental pillars of the Sector Skills Strategy.

As the revenue from the global market created by the AM will be increasing in the following years, makes the need of investing in AM curricula for academia and professional training and utmost importance gap to address. Nevertheless, it has to be mentioned since that due to the quiet novelty of AM technology for Industry, almost only big companies have the ability to invest in AM process awareness and training. As consequence, the smaller companies, such as SMES, are facing challenges with AM application and training, which hampers them to have a fair profit from the AM advantages in manufacturing and industrial lines [24].

There are several initiatives who can offer AM knowledge in industry and academy, with valuable advantages to both. A couple of examples from strategies enhancing AM awareness are for instance AM Platform [25],the European AM Committee and the Smart Specialisation platform [26], who contribute to a coherent strategy, understanding, development, dissemination and exploitation of AM between Companies, RTOs and Academic institutions. Also, the ERRIN European Regions Research and Innovation Network, [27] is an important a platform that promotes knowledge exchange between its members, focusing on joint actions and project partnerships, supporting regional research and innovation capacity building by facilitating regional collaboration and partnerships that enhance EU's research and innovation to build a competitive Europe that supports smart, sustainable and inclusive growth in all regions [28].

Additionally, the examples of platforms enhancing the AM understanding and development, the European or International Committees and research associations are promoting the development of new and innovative production technologies like AM. Any other method that offers new ways to develop innovative products, targeted transfer of know-how and information, identifying new business areas and creating profitable small businesses, are some of the benefits gained from the funded initiatives. Promoting research and Innovation-based strategies is capable of achieving a high rate of industrial transformation into high value-added products, processes and services, securing the employment of highly skilled workers and gaining a significant share of the global product in the knowledge economy.

Contiguously it would be useful to indicate some of the Funded Initiatives, namely EIT Manufacturing "Additive manufacturing for full flexibility" flagship more analytically EIT Manufacturing is a pan-European partnerships among leading universities, research labs and companies working together to fully integrate business, education and research. "Additive manufacturing for full flexibility" is one of the 4 flagships of EIT manufacturing, also I4MS initiative is the EU initiative to digitalize the manufacturing industry shortly described It is a program promoted by the EC to expand the digital innovation of manufacturing SMEs in Europe, SMEs can apply for technological and financial support to experiment with different technologies and services to improve innovation skills of their staff and the technologies and services that they provide.

Funded initiatives [29] have an important role in the development of AM and will enable the development and implementation of programmes regarding AM educational and training aspects. Adopting AM requires a highly skilled workforce, with a substantially different skillset from those of the more conventional manufacturing techniques. Qualified professionals are able to take advantage of this technology and bridge the gap between job offers and job seekers. There is currently a fragmentation of the EU landscape in the provision of AM training and a lack of a common curriculum, both for the qualification of young people and for the re-qualification of the existing workforce. This has resulted in the provision of in-house training to several companies [30].

The significance of interregional collaborations and the construction of the AM value chain relies on the fact that the regions have a large role to play in moving AM to the highest TRLs and in the infrastructure/pilot lines' sustainability. The AM-motion outcome will be used for further discussion and for next steps to be developed by listening to the demand side. To conclude, leverage on existing funding

programs and mechanisms, namely given by the European Commission, is key objective towards the investment in educational institutions, so that get into the position of training the next generations of designers, engineers and other specialists on manufacturing-capable 3D printers. [3]

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5. REQUIRED ACTIONS

The Skills Strategy Roadmap is grounded in seven strategic objectives, which were defined in order to face up the previous gap drivers (see Figure 13). In a nutshell these objectives refer to:

- Strengthen the collaboration between industry and training organizations
- Tackle the lack of AM personnel at the European level
- Prepare European, National and Regional organizations to tackle the challenges of AM, in terms of Qualified personnel
- Tackle the diversity of sectors and applications of AM
- Constant update of the AM European workforce
- Prepare the future workforce
- Leverage on existing funding programs and mechanisms
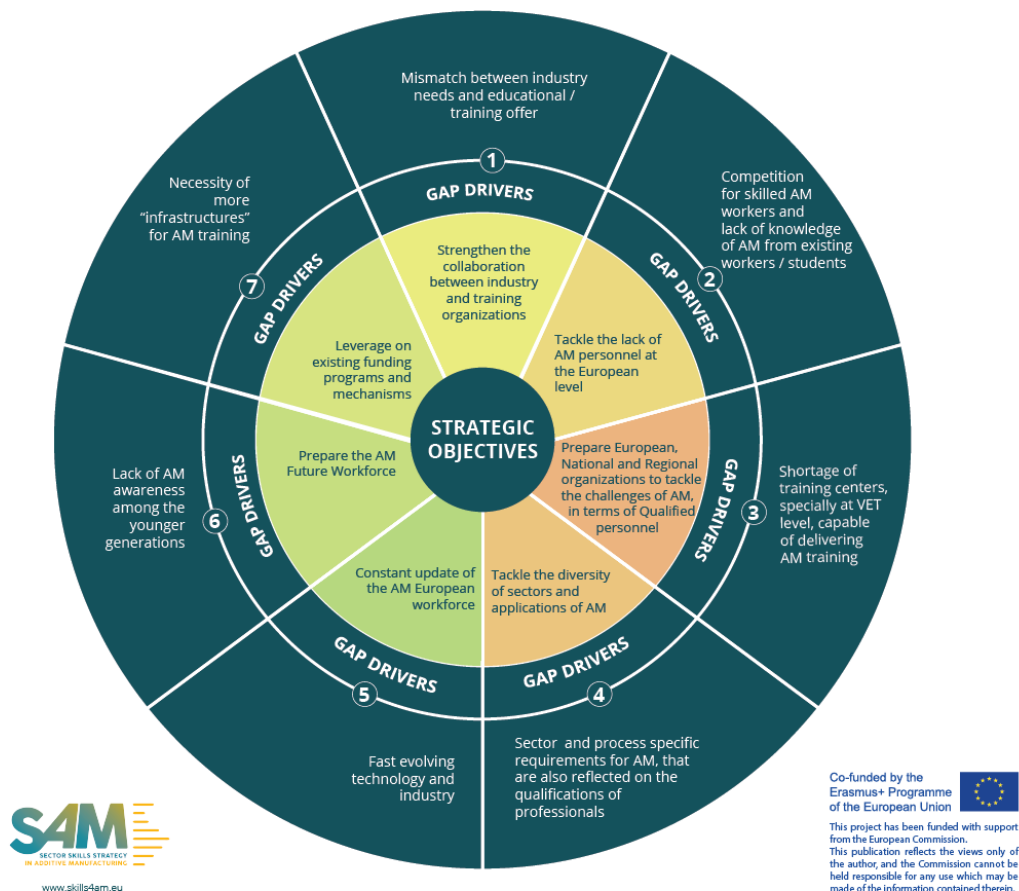
Figure 13 - Strategic Objectives foreseen in the Strategy

Each individual objective translates into concrete activities, differentiated in **Supporting Actions (SA)**, which are general activities defined to address the objectives, and **Implementing Activities,** which are more concrete actions that need to be undertaken in order to achieve the expected results. More analytically, each action is depicted within this section.

The roadmap will incorporate these solutions as part of an implementation timeline, in parallel to the outstanding project activities.

It is important to highlight that flagship activity of the Skills Strategy Roadmap consists in the deployment of the International AM Qualification System (IAMQS) through a network of training providers, sustained by a strong connection between a wide range of industrial sectors, which are applying AM in their activity or intend to do so (see Figure 15).

European Network of Training Centres using the IAMQS

Creation of the European AM Observatory

International AM Qualification System Implementation & National Roll Out

European AM Observatory is responsible for collecting and analysing data through a forecast methodology for the identification and anticipation of skills needs in the AM sector, as well as manage the implementation of an International Qualification System for AM.

International AM Qualification System is composed by a set of qualifications for different proficiency levels in the field of AM technologies, grounded in industry requirements and validated by experts.
Within the system, a single syllabus for each level is defined, supported by a harmonized system for assessment and quality assurance, resulting in the same qualification being awarded independently from the country.

A Network of Training Centres in AM is brought together, from both VET and HE, which are implementing the common trans-national curriculum. The training centres belonging to this network also share the same Quality Assurance standards in the assessment of learning outcomes, in accordance with the IAMQS Training Guidelines.

The Qualification of the AM Workforce is possible through the upskilling (improving existing skills) and reskilling (training in new skills) of workers. The IAMQS uses a modular structure to design its qualifications and training programs. The outcome is that training guidelines can be used in a flexible way, aligned with the specific needs of users.

The existing AM Qualification System covers Metal AM Qualifications for Operators, Designers, Supervisor, Inspector, Coordinator and Engineers. More are to come namely for Polymers.

5.1: Strengthen the collaboration between industry and training organisations

A series of up actions and supporting activities were strategically defined to strength the collaboration between AM industry and training organizations to narrow the skills mismatch (see Figure 15).
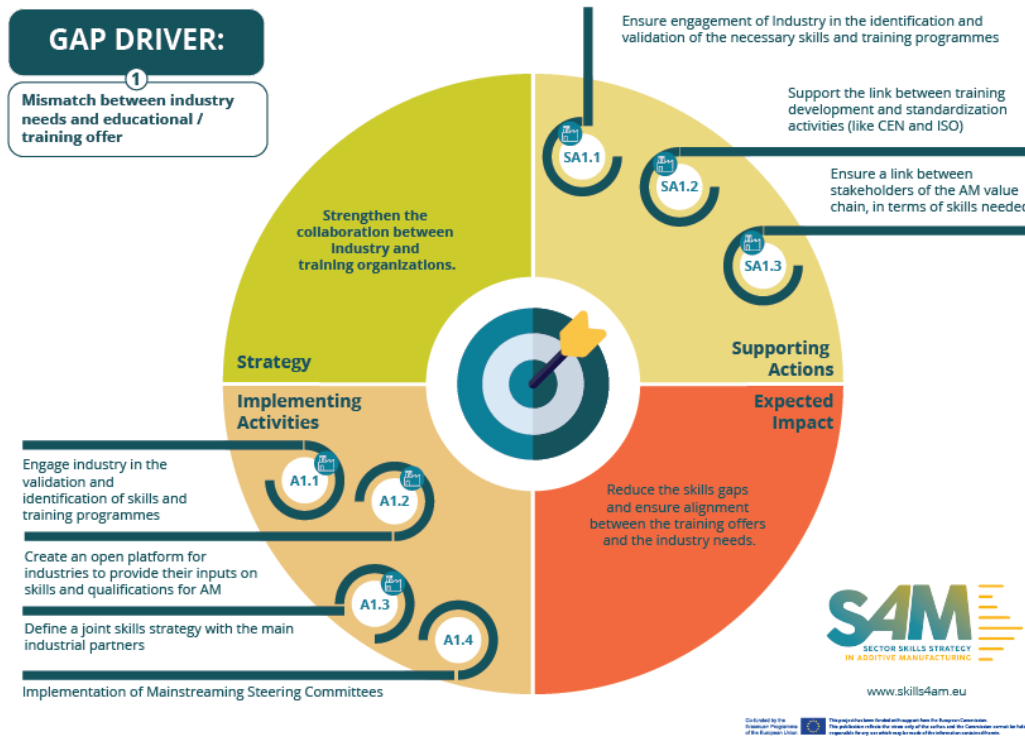
Figure 15 - Actions to strengthen collaboration between industry and training organisations

SA1.1 Ensure engagement of industry in the identification and validation of the necessary skills and training programmes and its correspondent implementation activity, **A1.1 Engage industry in the validation and identification of skills and training programmes,** will enable a better alignment with real companies profiles and skills 'needs when adopting AM at industrial level. This way, the lack of knowledge will not constitute a barrier to invest in and implement these technologies. Another reliable source to be aware of industrial developments and needs are the Standardisation Committees and its activities. In this sense, the supporting activity **SA1.2 Support the link between training development and standardisation activities (like CEN and ISO)** will help incorporating industrial requirements source into the skills system and roadmap activities.

For AM being able to provide successful solutions for industrial applications, all the value chain, from design to post-production and end of life needs to be considered. This fact needs to be considered also at skills level. With this purpose the S**A1.3 Ensure a link between stakeholders** of **AM value chain in terms of skill needs** is introduced.

To facilitate knowing and gathering industrial needs in real time so that training centres can be able to adapt their offer, forecast tools need to be provided in a continuous way. With this in mind, the implementation activity **A1.2 Create an open platform for industries to provide their inputs on skills and qualifications for AM** is included**.**

Implementation activity **A1.3 Define a joint skills strategy with the main industrial partners** will provide the framework for a common vision and clear path to keep a sustainable strategy during time. This will be reinforced with A**1.4 implementation** o**f mainstreaming Steering Comm**i**ttees**, that will follow all the

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process. Strengthening the collaboration between industry and education is the strategy to follow in order to reach the expected impact which is reduced skills gaps and ensured alignment of training offers and industry needs.

5.2: Tackle the lack of AM personnel at the European level

Being a European challenge to find AM personnel, so should be the objective to overcome it. In this case, the strategy objective consists in tackling the lack of AM personnel at the European level. A series of SA and Implementing activities was strategically set to deploy (see Figure 16):
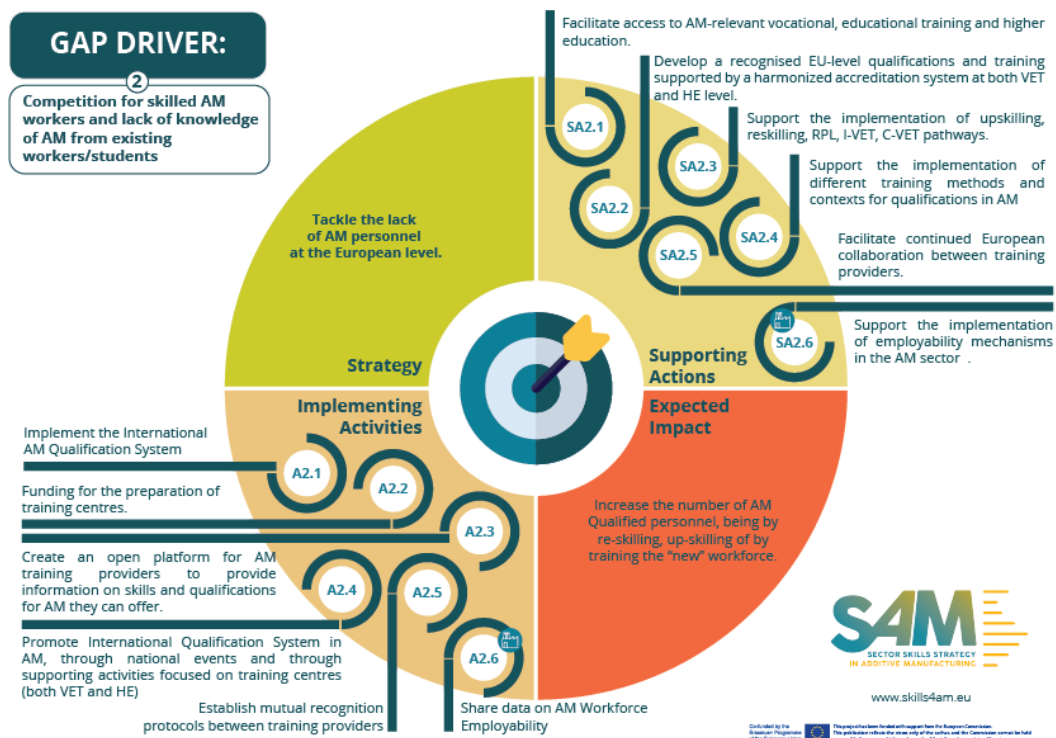
Figure 16 - Actions to tackle the lack of AM personnel at European level

Supporting actions **SA2.1**: **Facilitate access to AM-relevant vocational educational training and higher education** and **SA2.2**: **Develop a recognised EU-level qualifications and training supported by a harmonised accreditation system for training and educational organizations, at both VET and HE levels** materialised in, at least, two implementing activities:

A2.1: **Implement the International AM Qualification System (IAMQS) -** Through a series of initiatives in recent years, to provide the demanded workforce to the labour market, an international AM qualifications system was set up in the CLLAIM project, an Erasmus+ project conducted between 2017 and 2020.

A2.2: **Funding for the preparation of training centres** - To allow more training centres to acquire the equipment required to be properly equipped and provide practical training and active learning opportunities, as well as to prepare their trainers.

To increase the numbers of qualified personnel in Europe, a harmonised training offer must increase as well, and access to quality and flexible education options must be facilitated. With this target in mind, supporting action **SA2.3: Support the implementation of different paths for qualifications in AM** was set, covering the following training schemes, e.g.:

- Continuous education and training (C-VET)

- Initial education and training (I-VET)
- Recognition of Prior Learning (RPL)
- Reskilling
- Upskilling

A specific implementing activity was set to respond to a varied range of lifelong learning opportunities: **A2.3: Create an open platform for AM training providers to provide information on skills and qualifications for AM they can offer**.

It is important to think about the new generations of workers and the attractiveness of AM training, besides accounting for new work regimes and training possibilities. This is considered under supporting action **SA2.4: Support the implementation of different training methods and contexts for qualifications in AM,** e.g.:

- Work-based Learning
- Project based Learning
- Distance Learning
- Lifelong Learning
- Blended Learning

To foster SA2.4, the implementing activity **A2.4: Promote International Qualifications in AM, through national events and through supporting activities focused on training centres (both VET and HE)** will translate in the implementation of harmonised AM courses, recognised internationally by industry, using a diversified range of training methods in each country. National events dedicated to the dissemination of AM technology and qualifications are to be organised, as well as the capacitation of trainers.

Supporting action **SA2.5**: **Facilitate continued European collaboration between training providers** is meant to ensure support between training providers, both nationally and internationally. Implementing activity **A2.5 Establish mutual recognition protocols between training providers** reflects one of the possible forms of collaboration: establishing mutual recognition protocols (a kind of Memorandum of Understanding between training institutions which provide the same qualifications) that will allow to foster the upskilling and reskilling of trainers, as well to enhance the mobility of trainees belonging to the network. As the training centres belong to the network share the same international AM scope of Training, the Competence Units are automatically recognised, thus allowing the mobility of workers/students, increasing flexibility and opportunities for personnel to get the qualifications and corresponding needed skills – for instance, in case a worker is displaced into another country due to work obligations. A collaboration between training providers may even open the door to other possible collaboration and joint training schemes offer, for instance taking advantage of the equipment that one training provider may or may not have, or the expertise that may exist in one or another organisation. Of course, as with other implementing actions and related implementing activities, this will help close other gaps and feed other actions, as there are some common aims among them.

As to **SA2.6: Support the implementation of employability mechanisms in the AM sector**, Implementing activity **A2.6: Share data on AM Workforce Employability** will promote the establishment of specific meet up groups, bridging job seekers and recruiting organisations. Also, it is important to keep following-up the students that undertake AM courses, in order to identify in which sense that particular training contributed to improving the overall performance in the labour market.

Tackle the lack of AM personnel at European level is the strategy to follow in order to reach the expected impact of increasing the number of AM qualified personnel, by means of either re-skilling, up-skilling the "new" workforce.

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5.3: Prepare European, National and Regional organizations to tackle the challenges of AM, in terms of Qualified personnel
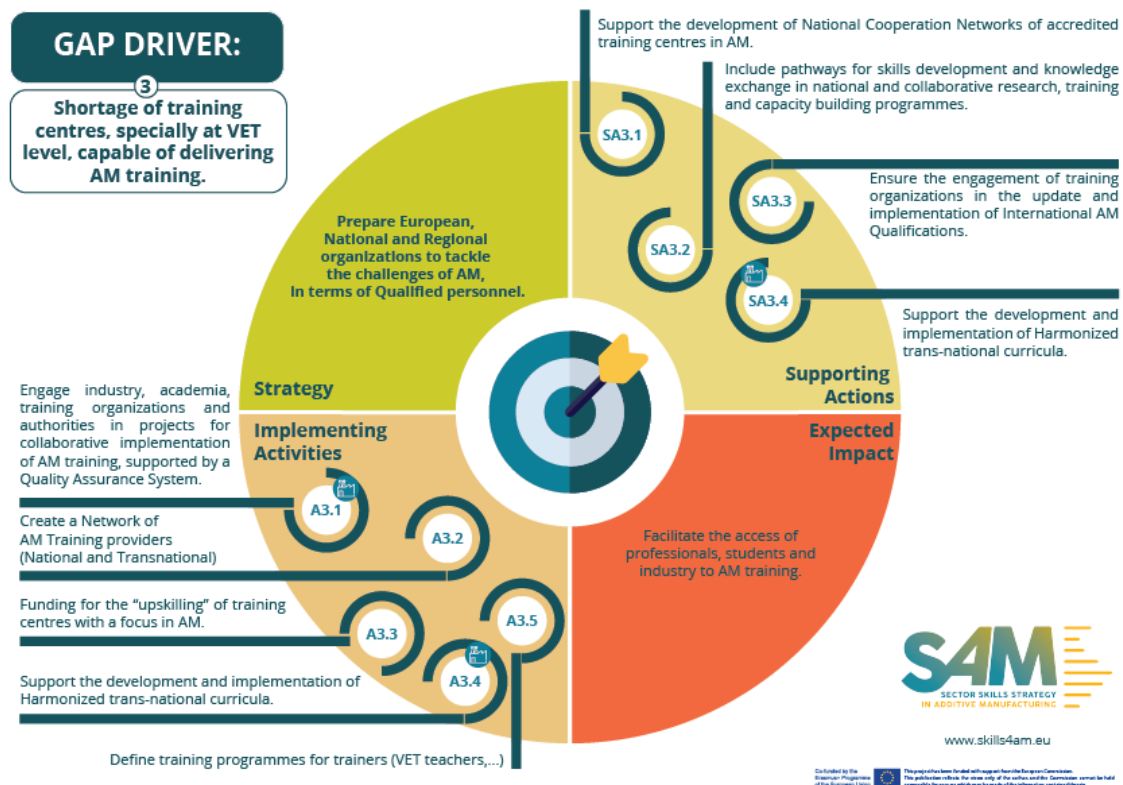

Figure 17 - Actions to prepare European and National organizations to tackle the challenge of AM in terms of Qualified Personnel

To fill the gap of training centres, especially at VET level, capable of providing AM training, several supporting actions are needed and actions to implement them. The **support of the development of National Cooperation Networks of accredited training centres in AM (SA3.1)** with the **Engagement of industry, academia, training organizations and authorities in projects for collaborative implementation of AM training**, **supported by a Quality Assurance System (A3.1)** is generally the basis to develop a suitable educational landscape in AM. By integrating all stakeholders, a good coordination over the entire range of training and integration into the national education systems is achieved.

In addition to SA3.1 the second supporting action (SA3.2) the **inclusion of pathways for skills development and knowledge exchange in national and collaborative research, training and capacity building programmes** will ease the way for the training centres to develop capacities. Thus, the implementation activity **A3.2, Create a Network of AM Training providers (National and Transnational)** is essential. The aspect of supporting the training centres through a quality assurance system is reached to a large extent also by **A3.2,** since members of a network can, for example in a quality circle, ensure comparable quality at all training centres. Such a network will go hand in hand with **SA3.3 Ensure the engagement of training organizations in the update and implementation of International AM Qualifications. Supporting the development and implementation of harmonized trans-national curricula (SA 3.4 and A3.4)** will push both **A3.1 and A3.2.**

The lack of trainers and technical equipment in AM training centres is a challenge. For this, A3.3 funding of the "upskilling" of training centres with a focus in AM" is defined. **A 3.5 Training programmes for VET-teachers and trainer**s will support the development of human resources in AM training organisations.

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Prepare the European, National and Regional organisations to tackle the challenge of lack of AM personnel is the strategy to follow in order to facilitate the access of professionals, students and industry to AM training.

5.4: Tackle the diversity of sectors and applications of AM
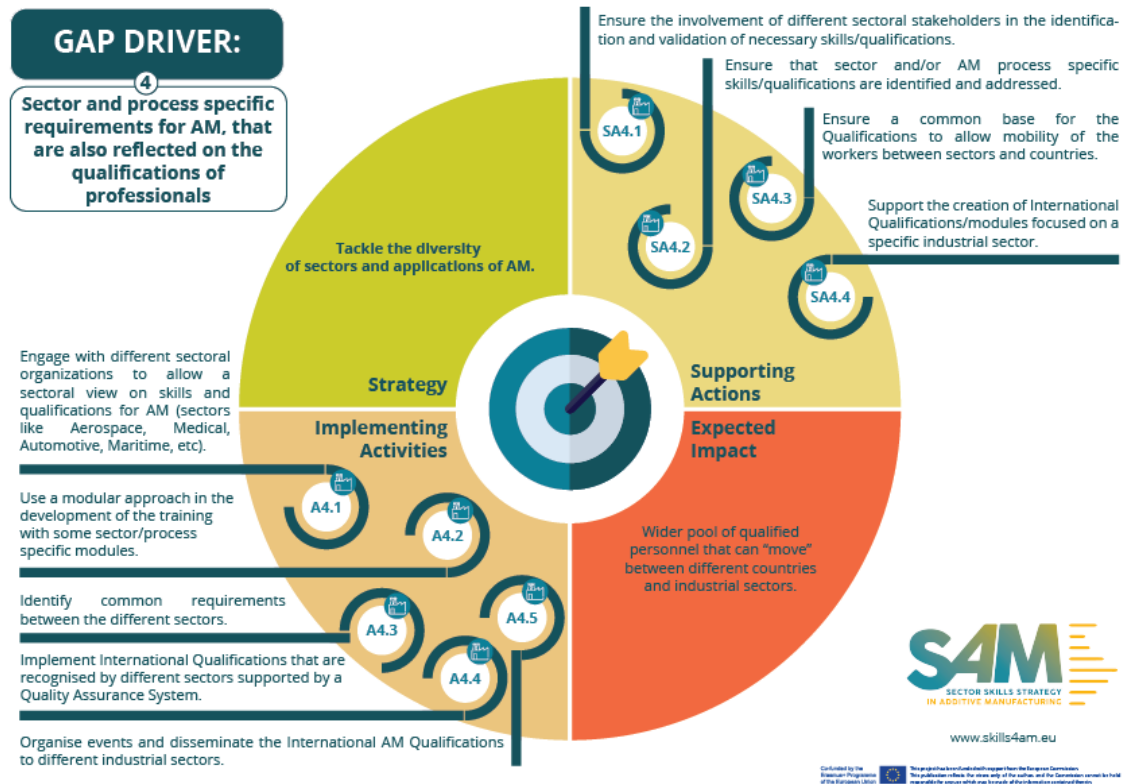
Figure 18 - Actions to tackle the diversity of sectors and applications of AM

To foster the implementation of AM in various sectors, several actions are defined (see Figure 18) to improve the diversity of sectors and applications of AM, by ensuring the mobility of AM professional and workers across different sectors and countries.

SA4.1: Ensure the involvement of different sectorial stakeholders in the identification and validation of necessary skills/qualifications and **A4.1: Engage with different sectorial organizations to allow a sectorial view on skills and qualifications for AM (sectors like Aerospace, Medical, Automotive, Maritime, etc)** – This supporting action and implementation activity will enable a better understanding of the skills required in different sectors through engagement with the stakeholders. The stakeholders can include the workers, engineers, scientists, professionals and standardisation bodies across different roles within each sector. The understanding of these required skills will lead to the development of suitable training courses needed to train and upskill the workforce for the rapid application of AM across different sectors. Broadly, this action will also allow the development of suitable sector-specific qualifications (**SA4.2: Ensure that sector and/or AM process specific skills/qualifications are identified and addressed**; **SA4.4: Support the creation of European Qualifications/modules focused on a specific industrial sector** and **A4.4: Implement European Qualifications that are recognised by different sectors supported by a Quality Assurance System**), which will allow the increased uptake of AM across these different sectors.

A4.2: Use a modular approach in the development of the training with some sector/process specific modules – Dividing the qualification into smaller modules or courses, which can be independently learnt, will be useful for workers from different sectors. This is because, based on a modular approach, a module or course can have sector-specific learning outcomes. Therefore, the AM workers can partake in flexible training programmes and choose modules that align well with their relevant sectors.

SA4.3: Ensure a common base for the Qualifications to allow mobility of the workers between sectors and countries and **A4.3: Identify common requirements between the different sectors** – Engagement will suitable stakeholders including academics, industry representatives and standardisation/regulatory bodies during the development of the qualifications will foster mobility of AM workers between sectors and countries. Furthermore, the development of common or cross-cutting modules, which are not necessarily sector-specific, can be applied across different job functions, sectors and countries. For example, AM professionals need to have a top-level understanding of AM as well as the relationship between the different AM designs, materials, processes, equipment, software, standards and end-of-life processing options. This action will lead to enable the widespread implementation of AM across different sectors.

A4.5: Organise events and disseminate the European AM Qualifications to different industrial sectors – The organisation of events, seminars, webinars and workshops will help raise awareness, support, promote and increase knowledge about AM to different stakeholders across several sectors and countries, which would also facilitate the uptake of AM.

In general, implementing these supporting actions and activities will tackle the gap driver related to the sector-specific requirements for AM professionals, and thereby develop a wider pool of qualified personnel that can move between different countries and industrial sectors.

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5.5: Constant update of the AM European workforce
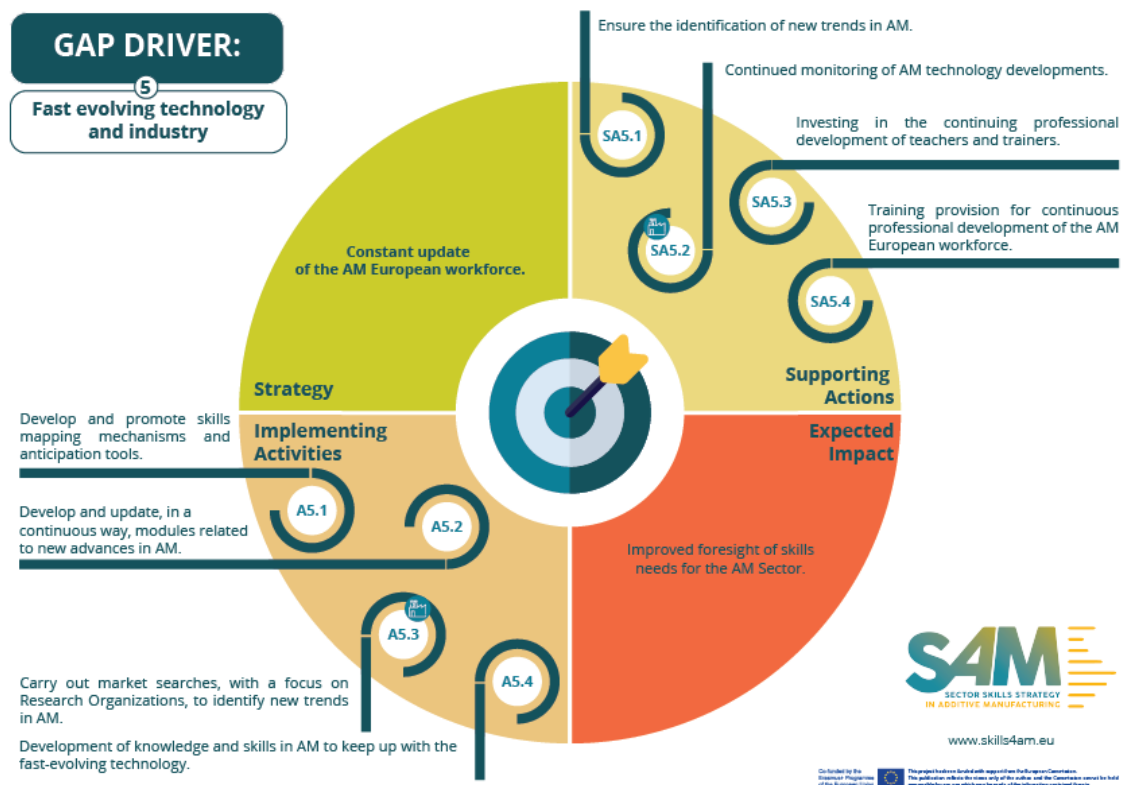

Figure 19 - Actions to guarantee the constant update of the AM European workforce

From Figure 19, it can be seen that the supporting activities have been divided into four implementing activities:

The supporting action **SA5.1: Ensure the identification of new trends in AM** relates to the implementing activity **A5.1 "Develop and promote skills mapping mechanisms and anticipation tools"** and **A5.3 "Carry out market research with focus on research organizations to identify new trends".** In order to effectively follow existing trends in AM, a scanning of the AM market in terms of new developments should be constantly carried out. Special focus should lie on research organizations as they usually are the first in line to work on new projects and products Along with the monitoring of the market goes the mapping mechanism for new skills that might be needed for new roles in AM. Moreover, anticipation tools can help effectively discover and monitor market trends. Here surveys can aid to reveal the newest trends for AM for short-term and long-term trends.

The supporting action **SA5.2: Continued monitoring of AM technology developments** is represented by activity **A5.3 "Carry out market research with focus on research organizations to identify new trends": constant market research carried out both, for industry and research organisations".** To continuously monitor the technology developments in AM, a close look at the AM market will help identify new technologies or upgrades of existing technologies. Here, market surveys and review of existing technologies can aid to identify advancements in the AM technology.

The supporting action **SA5.3: Investing in the continuing professional development of teachers and trainers** will be implemented via **A5.2 "Continuously update the learning modules related to advances in AM"** and **A.5.4 "Development of knowledge and skills in AM to keep up with the fast-evolving technology":** teachers and trainers in AM must always be up-to-date with their knowledge about AM technologies and the newest trends. Hence, a support system to support and advance the professional development of teachers must be implemented. This can then guarantee that the newly qualified

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workforce will always receive training or education covering the newest aspects of AM paired with the basics.

SA5.4: Training provision for continuous professional development of the AM European workforce - requires the implementation of **A5.2 "Continuously update the learning modules related to advances in AM"** and **A5.4 "Development of knowledge and skills in AM to keep up with the fast-evolving technology"**. In order to provide efficient training for the upcoming European workforce, nearly all implementing action will need to closely work together to secure the newest professional development in AM. The workforce can rely on the implementing actions to get provided with the newest technology trends as well as the updating and expansion of learning modules which could be retaken. Furthermore, tracking of the knowledge and skills in fast-paced AM can help discovering lack of knowledge for older AM workforces.

Guaranteeing the constant update of the AM European workforce is the strategy to follow in order to improve the foresight of the skills needs for the AM sector.

5.6: Prepare the AM Future Workforce

The lack of AM awareness among the young generation results in an unprepared workforce, and consequently it does not allow the European AM sector to thrive as its potential allows, neither it allows to keep the peace with the AM fast-changing technological trends. Within this context, the European AM Skills Strategy envisages tailored actions to tackle this major challenge and fulfil the long-term objective of a prepared and duly skilled AM future workforce. Supporting actions and implementing activities aimed to raise awareness among the young generation and enable their potential as future AM professionals has been therefore identified (see Figure 20 - Actions to prepare the future AM workforce)
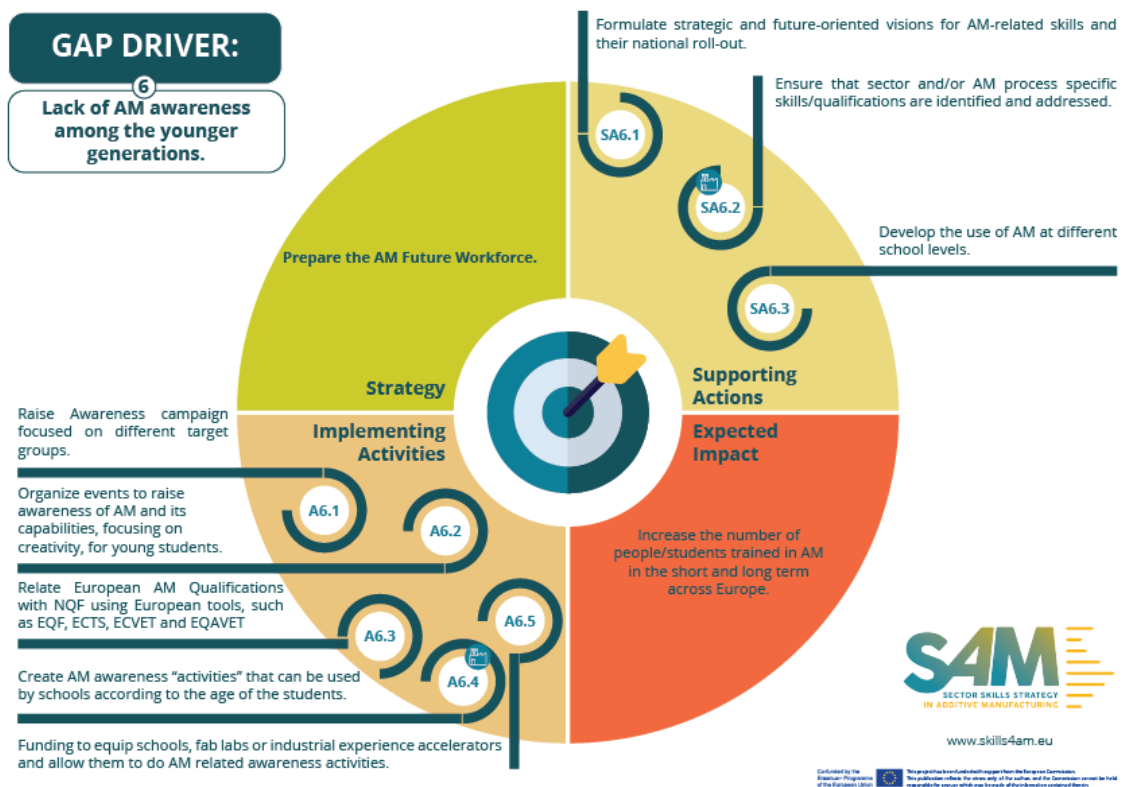

Figure 20 - Actions to prepare the future AM workforce

The future-oriented nature of the gap driver number 6 is, in fact, envisaged already in S**A6.1: Formulate strategic and future-oriented visions for AM-related skills and their national roll-out**. To reach this, two different implementing activities have been identified targeting two different implementing bodies: **A6.1: Raise Awareness campaign focused on different target groups,** addressed to all the stakeholders involved in AM, from students -or youth in general- to current industrial workers, engineers, and all those with a potential to be part of the AM workforce of the future, and **A6.3: Relate European AM Qualifications with NQF (National Qualifications System using European tools, such as EQF, ECTS, ECVET, and EQAVET[1],** which requires the involvement of both public and private national bodies responsible for the alignment of their qualification systems with the European one.

In addition to a long-term vision, it is equally crucial to take into consideration the actual demand of the AM job market when developing *ad-hoc* raise awareness campaigns. In this sense, **the SA6.2: Ensure that sector and/or specific skills/qualifications are identified and addressed** has been determined. The cooperation made of solid partnerships with the Industry becomes therefore essential and implementing activities such as **A6.5: funding to equip schools, fab labs or industrial experience accelerators and allow them to do AM related awareness activities** will enable and allow on-site learning experience and disclose opportunities for concrete case-study and problem-solving situations, as well as learning directly from AM processes from professionals in a real industrial ecosystem.

Within this gap driver, specific attention is given, for obvious reasons, to the young generation and the role of education at every school level. **SA6.3: Develop the use of AM at different school levels** is the action translating the theory to practice. Once students are aware of the potential of a career in AM, in fact, they need schools to provide them with the right education according to their age and their previous knowledge. It is in this context that **A6.2: organize events to raise awareness of AM and its capabilities, focusing on creativity, for young students** takes shape. It should be taken into consideration that children are, for instance, at a different stage of neural development than a high school student, or that adolescences have different personality traits and natural inclinations towards certain studying fields Considering the 'creativity' trait of AM allows to catch the attention of a child, as well as to reach out to those students who are not incline to undertake the traditional engineering path, in an attempt to enlarge and differentiate the future pool of AM workers.

The **A6.4: Create AM awareness 'activities' that can be used by schools according to the age of students** is ultimately related to SA6.2 and SA2.3. Not only, in fact, the activities should be tailored to the stage of development of the students, but the industries should be also directly involved in the design and validation of activities that may be then transferred to schools to be used as didactic material.

Prepare the AM future Workforce is the strategy to follow in order to reach the expected impact which is to increase the number of people/students trained in AM in a short and long term across Europe.

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[1]   NQF (National Qualifications Framework), EQF (European Qualifications Framework), ECVET (European Credit System for Vocational Education and Training) and EQAVET (European Quality Assurance for VET).

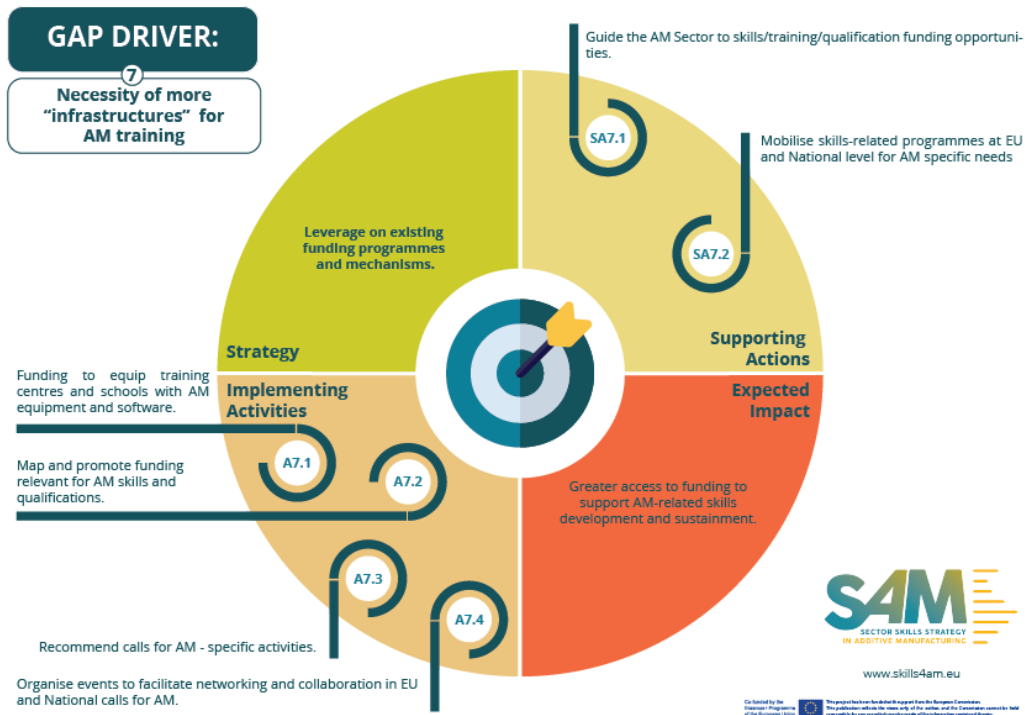## 5.7: Leverage on existing funding programs and mechanisms

Figure 21 - Actions to leverage existing programmes and mechanisms

Two main supporting actions are defined to leverage the existing Training Programmes (see Figure 21) **SA7.1** and **SA7.2.**

SA7.1 Guide the AM sector to skills/training/qualifications funding opportunities. Offering a guide to the interested in AM technology Industries and Educational Institutions, on how they can be funded in order to enchase the AM skills, training and qualifications. Furthermore, the stakeholders also need to be mobilised in order to exploit the business opportunities that AM provides, facilitating the take-up of this technology in Europe, with a focussed promotion and support strategy for AM technologies.

The related implementing activities to develop are:

A7.1 Funding to equip training centres and schools with AM equipment and software. Enhancing the AM understanding and development, from funding programmes regarding AM educational and training aspects. Also, design, review and deployment of relevant qualifications in the AM sector, built with a learning outcomes approach. Development of best practices to help stakeholders to achieve large scale deployment.

A7.2 Map and promote funding relevant for AM skills and qualifications. It is really important to promote the AM advantages since additive manufacturing shares features – autonomy, flexibility, intelligence, and adaptability – with the industry of the future, it can be considered a key factor in industrial transformation and acceleration [31]. Promoting synergies with complementary expertise, skills, techniques, and other resources among various sponsors.

SA7.2: Mobilise skills related programmes at EU and National level for AM specific needs. Develop a Sector Skills Strategy in AM by establishing a platform for AM skills at European, National and Regional levels, by designing professional profiles according to the industry requirements, develop specific relevant qualifications to be delivered for the AM Sector, and strengthen education-research-industry partnerships

and encourage creativity in the AM field. Recommendations for developing new education and training programmes to support the provision of AM-skilled designers, engineers and managers.

The related implementation activity is to have **A7.3 Recommended calls for AM –** Specific activities which will enforce the increase of the attractiveness and knowledge of the sector of AM and encourage the creativity in companies, relevant educational and scientific institutions. Support information exchange and collaboration between EU funded projects which address the same AM areas to exploit synergies, particularly through SMEs.

Finally, to **A7.4 Organize events to facilitate networking and collaboration in EU and National calls for AM**. These events are capable to foster and support the growth, the innovation and competitiveness of the AM sector by collaboration of EU and National Industries and educational institutions. Additionally track students, trainees and job seekers and promote match making between job offer and search.

Leverage on the existing funding programmes and mechanisms is the strategy which is has to be followed in order to reach the expected impact which is greater access to funding to support AM and AM related skills development and sustainment.

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SAM
SECTOR SKILLS STRATEGY
IN ADDITIVE MANUFACTURING

6. SAM CONTRIBUTION TO ACHIEVE THE STRATEGIC OBJECTIVES

This section describes how SAM project activities are addressing the defined European Skills Strategy Roadmap and contributing to achieve the following expected results:

1) Reduce the skills gaps and ensure alignment between the training offers and the industry needs

2) Increase the number of AM Qualified personnel, being by re-skilling, up-skilling of by training the "new" workforce

3) Facilitate the access of professionals, students and industry to AM training

4) Wider pool of qualified personnel that can "move" between different countries and industrial sectors

5) Improved foresight of skills needs for the AM Sector

6) Increase the number of people/students trained in AM in the short and long term across Europe

7) Greater access to funding to support AM-related skills development and sustainment

Based on the Implementing Activities recognized in section 5, the SAM project has been developing specific tasks to tackle each one of them, which are highlighted in the sub-sections below and illustrated in the timeline in section 7.

As the European AM Observatory is a key structure involved in the implementation of the strategy, the linkage between the described actions and the AM Observatory (platform) is undertaken, whenever applicable.

6.1 Strengthen the collaboration between industry and training organisations

A1.2 Engage industry in the validation and identification of skills and training programmes

The methodology and kits created at WP2 allow determining the skills mismatches in the AM sector. A set of guidelines and tools have been created for each kit in order to collect the necessary data on three different scenarios (deliverables 2.1 to 2.4):

- Scenario 1: Real case, less than 6 months.
- Scenario 2: Short-term, less than 2 years.
- Scenario 3: Foresight scenarios, future-10 years.

Industry/employers are one of the target groups of these kits. Their engagement is being made at different levels, by using surveys and interviews, to identify their needs with regards AM skills and existing gaps, mainly in the scenarios 1 and 2. In scenario 3, the aim is to explore long-term needs to be able to anticipate possible coming mismatches and gaps and tackle them in due time. For this purpose, other tools such as Delphi method, brainstorm or world cafe will be applied.

Moreover, validation workshops with industry guidelines are provided (D2.8) to organise them. Their objective is to validate the findings (data, needs...) gathered under WP2 and further analysed at WP4, along the Observatory.

Observatory section: *Happening Now in AM > Open Surveys*

A1.3 Create an open platform for industries to provide their inputs on skills and qualifications for AM and **A1.4 Define a joint skills strategy with the main industrial partners**

The AM Observatory created, is an interactive platform constantly updated that aims to track the evolution of this sector. It aims at gathering and presenting data of the Additive Manufacturing sector, with special focus on current and future skills. Inputs will be gathered as well by the International Additive Manufacturing Industrial Council (IAMIC) as part of the AM Observatory structure. This council, formed by industrial representatives, will also design the joint skills strategy.

Observatory section: *Abouts Us > AM Observatory Structure*

A1.5 Implementation of mainstreaming Steering Committees

The IAMIC guarantees that developments and findings of the AM Qualification System are done in total alignment with industrial needs. It also has the role of nominating Industry Advisory Groups to collaborate with Education Working Groups during the validation of the industrial requirements, which will facilitate the updating of existing AM qualifications or development of new ones.

Moreover, within the Observatory structure the Additive Manufacturing Qualification Council (IAMQC) is also included. It counts currently with 2 groups, one focusing in metal materials and the other in polymers, with experts both from industry and research covering the main AM technologies. Its objective is to revise and update the qualifications, competence units and provide feedback on the delivered training and identified needed skills.

Observatory section: *Abouts Us > AM Observatory Structure*

6.2 Tackle the lack of AM Personnel at European Level

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A2.1: **Implement the International AM Qualification System (IAMQS) -** existing qualifications in AM are being revised and new qualifications are being designed. At the current stage, one qualification is already being tested under SAM project, concretely the Metal AM Engineer for Powder Bed Fusion – Laser Beam (LPBF) Qualification.

Observatory section: *AM Education and Training > IAMQS /> Training Offers*

A2.2: **Funding for the preparation of training centres** - a counselling strategy for funding programmes by providing relevant data is foreseen and at least two train-the-trainers workshops will take place.

A2.3: Create an open platform for AM training providers to provide information on skills and qualifications for AM they can offer. AM Observatory will contain a database with AM training offers. Procedures for updating training offers in the observatory are being settled. An online qualifications catalogue is to be included in observatory.

As part of the Observatory, SAM is creating a European Educational Council that will be composed of VET and HE organisations as well as RTO, Companies, Recruitment and Educational Authorities. This council already has members from different countries, like Spain, France, Belgium, Germany, Italy, UK, Ireland and Portugal. However, SAM is working to have representatives from other European countries.

Observatory section: *AM Education and Training > IAMQS /> Training Offers*

A2.4: Promote European Qualifications in AM, through national events and through supporting activities focused on training centres (both VET and HE) events such as Train the trainers Workshops,

piloting events showcasing different training methods, or other events to present new or revised qualifications.

Observatory section: *Happening Now in AM > Events*

A2.5: Share data on AM Workforce Employability: implementation of an open group on LinkedIn to bridge interaction between job seekers and recruiters; and the provision of data regarding employment indicators in the AM Observatory. Part of this data will be coming from students that undergo a training course or qualification under the International AM qualifications system and that are compelled to use tracking tools designed to monitor employability of AM students or professionals that qualified or requalified in the system. Other than this, national statistics data could be initiated and reported in the AM Observatory.

Observatory section: *AM Market World > SKILLS /> Employability />Market Analysis*

6.3 Prepare European, National and Regional organizations to tackle the challenges of AM, in terms of Qualified personnel

A3.1 Engage industry, academia, training organizations and authorities in projects for collaborative implementation of AM training, supported by a Quality Assurance System:

The International Additive Manufacturing Qualification System (IAMQS) which is the first and only Qualification System currently active in the AM field was created by working groups consisting of industry, academia and training organizations.

Observatory section: *AM Education and Training > IAMQS /> Training Offers*

A3.2: Create a Network of AM Training providers (National and Transnational)

To promote the cooperation within a network of training centres the settlement of the rules for AM training Centres that belong the European Network is always helpful. These rules have already been defined and the procedures for constantly updating the AM Training offers within the Observatory. In order to make the network visible to interested parties the information about location and the training offers is mapped.

The implementation process follows a top-down approach, meaning that scope and curricula for AM are defined at European level through harmonised training guidelines and then up taken at the national level by the training centres, under supervision of the representative organisation in the AM field, but always ensuring that it is accessible to everyone.

During SAM, namely along the pilot courses, conditions will be established for the AM Observatory to implement the AM Qualification System through a network of AM training centres from Vocational Education and Training (VET) and Higher Education (HE) institutions., Contacts with National Qualification Agencies and European Policy Bodies will be thoroughly explored in order to promote the integration/recognition of the AM Qualifications in National VET and HE systems.

Observatory section: *AM Education and Training > IAMQS /> Training Offers*

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A 3.3 Funding for the "upskilling" of training centres with a focus in AM

The implementation of the AM skills forecast methodology through the Observatory and sustained by a dissemination campaign involving all relevant stakeholders will enable to define strategy for "counselling" funding programmes providing relevant data related with AM sector.

A 3.4 Support the development and implementation of Harmonized trans-national curricula

A series of dissemination and raise awareness events are planned to take place until 2022 to promote SAM outcomes and strategy, this includes the organization of National events to engage with industry and training providers interested in AM. The first two event will take place in Portugal, Poland and Romania but plans for Czech Republic and Hungary are already been made. The idea is to cover other countries.

Observatory section: *Happening Now in AM > Events*

A 3.5 Define training programmes for trainers

Along the project two train the trainers will take place to capacitate trainers towards innovative training methodologies used to deploy AM Training. Also, a set of new learning materials will be produced (e.g. Lessons plans, case studies, assessment questions among others) in order to ensure the availability and visibility of relevant AM teaching and training resources that can support bridging the gap between industry and education.

6.4 Tackle the diversity of sectors and applications of AM

A4.1: Engage with different sectorial organizations to allow a sectorial view on skills and qualifications for AM (sectors like Aerospace, Medical, Automotive, Maritime, etc)

- As part of the Observatory, SAM is creating an International Additive Manufacturing Industrial Council (IAMIC) involved in all industrial issues linked to the AM sector, which include the identification and validation of current and future skills needs, thus providing information on technological trends, as well as recommendations for the development of new products and required needs. The IAMIC is composed of relevant organisations representing the industrial view and needs in AM, which includes the suppliers, original equipment manufacturers (OEMs), end-users, human resources companies, certification bodies and research organisations.
- Along with Work package 8 "Dissemination and Exploitation", the engagement with Sectorial Organizations focusing on the following sectors is planned: Aerospace (NADCAP, FAA and EASA), Health (FDA), Automotive – Blueprint for automotive sector (DRIVES), Maritime – Blueprint for Maritime sector (MATES), Defence – Blueprint for Defence sector (Assets+)- Also non-sector specific organizations will be engaged, such as EIT Raw Materials, EIT Manufacturing, ISO, ASTM and ASME.
- Future sectors that will be engaged categorizing them based on two dimensions: first one being the industry: e.g. Automotive, Aeronautical and the second one being the stages in which they use the AM technology, e.g. product development phases, final production. Sectors to be addressed in the next 5 years will be the Construction and Energy sectors.

Observatory section: *Abouts Us > AM Observatory Structure*

A4.2: Use a modular approach in the development of the training with some sector/process specific modules

- The modular approach used to design qualifications and address skills development will allow a faster and flexible implementation of sector-specific requirements. An example of the modular approach is the division of IAMQS into several Units of Learning Outcomes/ Competence Units and courses to address the needs for different sectors and professional profiles. The definition

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of Professional Profiles Design & Review Process and AM Sectoral Framework to Sustain and Feed the AM Qualification System has also been carried out as part of Deliverable 3.1.

Observatory section: *AM Market World > Skills*

- In order to ensure that sector and /AM process specific skills/qualifications are identified and addressed, Surveys and workshops (e.g. Deliverable 4.5) have been organised with different stakeholders from educational and industry Councils to assess the needs, skills and knowledge required across different sectors including aerospace, medical, construction, etc. Also, more surveys and workshops will be organised over the course of the SAM Project, which will target several industries and sectors. More specifically, the mapping of current and emergent Professional Profiles in AM across different sectors was carried out in Deliverable 1.4, and a Global and Societal Milestones report (Deliverable 1.2) investigated global and societal developments across different sectors including health, energy, transportation sectors. These activities within the SAM Project will ensure the identification and solution to sector-specific skills and qualifications.

Observatory section: *Happening Now in AM > Open Surveys*

A4.3: Identify common requirements between the different sectors

- The competence units and courses (Work Package 5) embedded within the Qualification system have some cross-cutting modules (e.g. Introduction to Materials, Additive Manufacturing Process Overview) and shows the broader and common knowledge required by AM workers. The IAMQS developed within the SAM Project will also provide flexible training programmes, which will allow the mobility of AM workers and professionals between different sectors and countries. In addition, the qualifications, competence units and training modules being developed features the involvement and review from working groups that include standardisation/regulatory and industry experts (e.g. metal AM experts and polymer AM experts). Overall, this supporting action and activity during the development of these qualifications will foster mobility of AM workers between sectors and countries.

Observatory section: *Happening Now in AM > Open Surveys*

A4.4: Implement European Qualifications that are recognised by different sectors supported by a Quality Assurance System

- The IAMQS has been developed based on industry requirements and engagement/consultations with industry experts to address the needs of different sectors. Currently, the AM Qualification System comprises the skills and knowledge that the AM workers will develop and covers Metal AM Qualifications for Operators, Designers, Supervisor, Inspector, Coordinator and Engineers. Furthermore, there are plans to create new Professional Profiles/Qualifications and Competence Units/ Training Modules (Work Package 6), which will be implemented and recognised across different sectors.
- Within the **Quality Assurance System underpinning the IAMQS,** the scope and curricula for AM are defined at European level through harmonised training guidelines and then taken up at the national level by the training centres, under supervision of the representative organisation in the AM field. The existence of the organisation supervising both AM training and assessment activities at the national level is of utmost importance to ensure harmonisation and quality in the delivery of AM Qualifications. Making it possible to leverage a single syllabus for each level of Qualifications, resulting in the same qualification being awarded in Europe, regardless of the context in which the learning takes place.

A4.5: Organise events and disseminate the European AM Qualifications to different industrial sectors

Piloting of new and improved competence units (Work Package 5) within AM are currently being carried out, which promotes the IAMQS to participants from different industrial sectors. Also, there are engagements with different Associate Partners (e.g. 3D Printing Industry) and SAM, which promote the development of the IAMQS. There are two work packages (Work Package 7 and 8) specifically dedicated to Raising Awareness and Dissemination of AM to different stakeholders in many sectors. The activities within these work packages include events such as AM Open Day, webinars, workshops in different countries (e.g. UK, Greece, France, Germany, Italy). In addition, there are ongoing plans to develop online articles, papers, press releases addressing AM skills and qualifications, which will be promoted via different platforms, including SAM's website and social media channels. Overall, the implementations of defined activities will lead to an increased awareness of AM qualifications and speed up the industry-wide uptake of AM, alongside the creating of a wider pool of qualified personnel that can move between different countries and industrial sectors.

Observatory section: *Happening Now in AM > Events*

6.5 Constant update of the AM European workforce

A5.1 "Develop and promote skills mapping mechanisms and anticipation tools" during the course of action, SAM has worked on the improvement of kits` in order to determine the skills mismatches in the AM sector (WP2). Different forecast tools for data collection have been developed for different scenarios (real, short- and long-term). Furthermore, D2.6 should facilitate the integration and location of AM trainees, future employees and job seekers in AM. In D2.7 a feedback sheet has been developed to improve the offered piloting events. D2.8 helps for the organisation of workshops held during the analysis` and validation phases of industry needs concerning AM professional's skills development.

In WP4, the needs gathered in WP 2 will be analysed. The AM observatory serves as an overall watchtower.

Observatory section: *Happening Now in AM > Open Surveys*

A5.2 "Continuously update the learning modules related to advances in AM": this action is carried out in WP3 and WP5. In WP3, a methodology to revise and enhance the qualifications in the AM sector is developed. For this a critical literature review of current methodologies is carried out under close inspection of current AM EU frameworks. WP5 allows for the inspection of current professional profiles for two real term scenarios to inspect closely the adequacy of offered course material. Furthermore, close inspection of the real case scenarios allows to gather feedback and implementing of gathered needs into profiles.

Observatory section: *AM Education and Training > AM Qualifications /> Training Offers*

A5.3 "Carry out market research with focus on research organizations to identify new trends": in order to gather information about the current market situation with Research and Development Organisations and AM Technology Experts, using several surveys and interviews developed in WP2. These surveys focus on real case scenarios, short-term scenarios and long-term scenarios for the AM industry. Industry and research have been asked to give a short insight on what they think will be influencing the AM world next. WP 4 then deals with the review and analysis of the gathered information as well as the reporting of needs

in terms of upcoming AM trends. Hence, a feedback loop is created for constant observation of trends and analysis of possible gaps in current learning material.

Observatory section: *AM Market World >Market Analysis*

A.5.4 "Development of knowledge and skills in AM to keep up with the fast-evolving technology": again, in order to keep up with a fast-evolving technology, several rounds of pilots are foreseen during SAM to address real case and short-term needs (WP5). As a starting point, existing AM profiles have been selected to be piloted in various educational programs to track the status of the professional profiles. Single CU will be taught under real-life conditions and feedback will be gathered. With this SAM ensures to be able to act on missing needs in current professional profiles.

Observatory section: *AM Education and Training > AM Qualifications /> Training Offers*

6.6 Prepare the AM Future Workforce

A6.1: Raise Awareness campaign focused on different target groups and A6.4: Create AM awareness 'activities' that can be used by schools according to the age of students are currently being developed within the dedicated Work Package 7 and 8. Three main target groups (according to age and stage of professional career) have been identified, to whom raising awareness activities are addressed:

- **Children and Youngster (age 6 to 16)**

  The focus of the activities addressed to this specific audience is both on introducing with simple concepts and concrete examples what is Additive Manufacturing and stressing the creativity potential that such technology may enable, as kids are more interested in dynamic and creative activities. SAM project has developed a specific name used to label all the activities performed in this context: the Tech4Kids series, which see as a protagonist an animated mascot to catch the interest of little children.

- **Students (Secondary, upper secondary, and higher education level)**

  For students still enrolled in educational programmes, the activities made to raise awareness on AM focus more on technicalities and introduction to some processes, such as in the first free project course *'Introduction to materials: metals and alloys'*, but at same time trying to keep an eye on the creative potential of AM, especially when talking with secondary students. In the choice of the university, in fact, students who are most likely prone to choose creative disciplines, may also consider an AM specialized course, besides the traditional ones, such as design, architecture, etc.

  Moreover, additional activities are being foreseen as part of the raise awareness campaign addressed to students. Besides the traditional campaign materials made of informative posters, leaflets, and brochures, animated infographics with introduction on AM processes and podcasts on the technology and Industry 4.0 in general are being developed in the attempt of engaging with this particular target audience using tools they are more familiar with. In this context, an animated series has been developed with a female protagonist used in an effort to tackle the big gender gap among students studying STEM (Science, Technology, Engineering and Math) subjects in some EU countries.

  Ultimately, students can also join the SAM community on LinkedIn, where partners and senior professionals post informative material, as well as studies or AM market trends, giving the opportunity to students to deep their knowledge in the AM particular field of their interest.

- **Professionals (Job seekers or employed at early career stages)**

As professionals have already experience with AM, the content of the activities addressed to this category is more specific and requires previous knowledge of the basics of AM; they are more oriented to re-skilling or up-skilling, and consider future trends in AM. Workshops, seminars, and events open to professionals aim at validating results of the surveys, as well as creating a discussion towards the latest trends.

In a further effort to tackle the particular training needs of this category, the SAM consortium has developed two rounds of surveys targeting AM workers, where they have the opportunities to express which professional needs they perceive as more urgent to tackle. The survey results are then elaborated and used to address the content of both raise awareness material and trainings.

Additionally, professionals looking for a career in AM, as well as students at their latest stage of education, can join the dedicated LinkedIn group, created and managed by the SAM consortium, where AM provider facilities, companies, and HR agencies can post job openings related to AM and help the matching with professionals aiming to work with AM technology. The group serves also a second scope, as it allows to gather additional data on the current market needs.

Observatory section: *Happening Now in AM > Events*

A6.2: Organize events to raise awareness of AM and its capabilities, focusing on creativity, for young student is part of the overall scope of enlarging and differentiating the pool of suitable AM workforce. In the choice of the university, in fact, students who are most likely prone to choose creative disciplines, may also consider an AM specialized course, besides the traditional ones, such as design, architecture, etc., Opening up a sector traditionally considered as a *niche* will eventually result in an increase of the general employment rate.

However, events in general are being organized in a joint bid to engage directly with the different target audiences. Although the pandemic of SARS-CoV-2 has endangered the chance of in-person discussions, a series of Webinars is tackling the absence of networking activities. The webinars' content varies according to the target group they want to address. The latest event of the series: *'A career in AM: opportunities and obstacles for students and young professionals'* has not only presented to this specific audience with the latest trends and the professional figures that will be most needed in the future, but also with the opportunities that AM can offer in terms of creativity.

Webinars directed to industrial stakeholders and policy makers are also being organized, by presenting the results collected with the surveys and validated by the pool of experts that will constitute the IAMIC, with the scope of aligning the policies framework, the industry needs and the training provided.

Observatory section: *Happening Now in AM > Events*

A parallel activity following the deployment of the raise awareness campaign is defined in **A6.3: Relate European AM Qualifications with NQF (National Qualifications Framework) using European tools, such as EQF, ECTS, ECVET, and EQAVET.** In fact, creating a harmonized European system for AM skills recognition in favour of the whole European AM sector means that all the training material, developed both within the project and by external stakeholders, have to be equally recognized in 27 different countries. Alignment of the European Qualifications System with the National one becomes therefore essential, to ensure that a learning outcome achieved in one country can be recognized, and applied, in other countries.

In this framework, SAM coordinator EWF, thanks to its longstanding experience in delivering trainings aligned with international standards, is currently managing the system for AM, which goes under the *IAMQS,* being the standards used in AM applicable internationally. It is composed by a set of qualifications for different proficiency levels in the field of AM technologies, grounded in industry requirements and validated by experts. The EAMIC will come, in fact, with the IAMQC* responsible to continuously revise

the qualifications. At present time, the AM Qualification System covers Metal AM Qualifications for Operators, Designers, Supervisor, Inspector, Coordinator and Engineers and it is being implemented through a network of AM training Centres from Vocational Education and Training (VET) and Higher Education (HE) institutions, both belonging to the public and private sectors.

Observatory section: *AM Education and Training > IAMQS /> Training Offers*

To achieve a broader engagement of as many training centres as possible, and to reach a homogenous European reference framework for AM qualification, two strategy of outreach are foreseen in the project:

- Promoting the AM Observatory and the advantages of being a training centre using an international recognized system, endorsed also by CEDEFOP and inviting training centres to start the accreditation process.
- Actions of direct engagement with National Agencies for VET to integrate the IAMQS in the national framework.

Last, but not least, the AM Observatory will contain information on the availability of **A6.5: funding to equip schools, fab labs or industrial experience accelerators and allow them to do AM related awareness activities.** The whole ecosystem, in fact, from creating AM awareness to reskilling or upskilling of the current workforce, needs a robust sustainability strategy. This is why the SAM project is creating a map of available funding opportunities –both private and public- at regional, national, and European level that will support those wishing to implement AM related awareness activities, being them schools or companies all over Europe.

Observatory section: *Happening Now in AM > Events*

6.7 Leverage on existing funding programmes and mechanisms

SAM addresses actions to leverage the **A7.1: Funding to equip training centres and schools with AM equipment and software** and **to A7.2: Map and promote funding relevant for AM skills and qualifications** as the main purpose is to follow a methodology for a sustainable and continuous assessment of current and future skills needs in AM through an observatory for AM which provides mapping and monitoring of the AM industry technological trends, skills shortages and mismatches, policies and figures.

Observatory section: *Happening Now in AM > External Initiatives*

SAM Work Package 4 defines the skills strategy, where specifically a systematic approach to the development and implementation of the European Observatory, together with its unique collection of rules and operational procedures, has been followed. As already mentioned, the *Observatory in Additive Manufacturing*, collects inputs based on figures and patterns on AM skills and shortages as an interactive online tool, through data collected from various sources, then analysed and validated at project workshops. The Observatory is putting into practice the continuous forecast methodology, providing real-time mapping and monitoring of industry needs, technological trends, skills shortages and mismatches which will feed to **A7.3: Recommend calls for AM-specific activities.**

Finally, SAM will **A7.4: Organise events to facilitate networking and collaboration in EU and National calls for AM**. Within Work Package 8 dissemination and exploitation action plan are developed to ensure the sustainability of SAM outcomes after the project end as well as the diffusion of SAM project results at European and National levels. The Deliverables of Work Package 8 firstly include information and evidences about the effects of the activities carried out by each participant in order to communicate with external stakeholders during the project and offers also knowledge and data on the effect of each partner's activities.

Observatory section: *Happening Now in AM > Events*

7. TIMELINE FOR THE IMPLEMENTATION OF THE SKILLS STRATEGY ROADMAP

Table 2 illustrates the expected period of implementation of the AM Skills Strategy Roadmap from 2021 to 2030, showing which Initiatives and actors will be involved in the identified actions. Finally, the focus of implementation is given to the ones considered as a priority by industry during specific validation events, such as workshops with manufactures and/or AM equipment manufacturers some of those already taken place in 2020.

Strategic Objective	1: Straighten the collaboration between industry and training organisations	Short term scenario		Foresight term scenario	
		2021	2022		2030
IMPLEMENTING ACTIONS	A1.1 Identify and anticipate skills needs in the AM sector	SAM		✎	
	A1.2: Engage industry in the identification of skills and validation of training programmes	SAM		✎	
	A1.3: Create an open platform for industries to provide their inputs on skills and qualifications for AM	SAM		✎	
	A1.4: Define a joint skills strategy with the main industrial partners		SAM		
	A1.5 Implementation of Mainstreaming Steering Committees	SAM		✎	

Strategic Objective	2: Tackle the lack of AM personnel at the European Level	Short term scenario		Foresight term scenario	
		2021	2022		2030
IMPLEMENTING ACTIONS	A2.1: Implement the International AM Qualification System	SAM		IAMQS	
	A2.2: Funding for the preparation of training centres	SAM			
	A2.3: Create an open platform for AM training providers to provide information on skills and qualifications for AM they can offer	SAM		✎	
	A2.4: Promote International Qualifications in AM, through national events and through supporting activities focused on training centres (both VET and HE)	SAM			
	A2.5: Establish mutual recognition protocols between training providers	SAM		✎	
	A2.6: Share data on AM Workforce Employability	SAM		✎	

Strategic Objective	3: Prepare European, National and Regional organizations to tackle the challenges of AM, in terms of Qualified personnel	Short term scenario		Foresight term scenario	
		2021	2022		2030
IMPLEMENTING ACTIONS	A3.1: Engage industry, academia, training organizations and authorities in projects for collaborative implementation of AM training, supported by a Quality Assurance System	SAM		IAMQS	
	A3.2: Create a Network of AM Training providers (National and Transnational)	SAM		IAMQS	
	A3.3: Funding for the "upskilling" of training centres with a focus in AM	SAM			
	SA3.4: Support the development and implementation of Harmonized trans-national curricula	SAM		✎ IAMQS	
	SA3.5: Define training programmes for trainers (VET teachers,…)	SAM		✎	

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Strategic Objective	4: Tackle the diversity of sectors and applications of AM	Short term scenario		Foresight term scenario	
		2021	2022		2030
IMPLEMENTING ACTIONS	A4.1: Engage with different sectoral organizations to allow a sectoral view on skills and qualifications for AM (sectors like Aerospace, Medical, Automotive, Maritime, etc)	SAM			
	A4.2: Use a modular approach in the development of the training with some sector/process specific modules	SAM		IAMQS	
	A4.3: Identify common requirements between the different sectors	SAM			
	A4.4: Implement International Qualifications that are recognised by different sectors supported by a Quality Assurance System	SAM			
	A4.5: Organise events and disseminate the International AM Qualifications to different industrial sectors	SAM			

Strategic Objective	6: Prepare the AM Future Workforce	Short term scenario		Foresight term scenario	
		2021	2022		2030
IMPLEMENTING ACTIONS	A6.1: Raise Awareness campaign focused on different target groups	SAM			
	A6.2: Organize events to raise awareness of AM and its capabilities, focusing on creativity, for young students	SAM			
	A6.3: Relate European AM Qualifications with NQF using European tools, such as EQF, ECTS, ECVET and EQAVET	SAM			
	A6.4: Create AM awareness "activities" that can be used by schools according to the age of the students	SAM			
	A6.5: Funding to equip schools, fab labs or industrial experience accelerators and allow them to do AM related awareness activities	SAM			

Strategic Objective	7: Leverage on existing funding programmes and mechanisms	Short term scenario		Foresight term scenario	
		2021	2022		2030
IMPLEMENTING ACTIONS	A7.1: Funding to equip training centres and schools with AM equipment and software	SAM			
	A7.2: Map and promote funding relevant for AM skills and qualifications	SAM			
	A7.3: Recommend calls for AM-specific activities	SAM			
	A7.4: Organise events to facilitate networking and collaboration in EU and National calls for AM	SAM			

Table 2 - Timeline for the Implementation of the Strategy

8. SKILLS ROADMAP

The mind map pathways for skills development in AM (see figure Figure 23) follows the AM Value chain flow, meaning that the set of skills required by each Professional Profile are grouped according to the specific AM value chain segments (e.g. Modelling & Design, Materials, AM Process, Post-Processing, Product and End of Life), see Figure 22.

The Skills Roadmap representation is inverse to the approach used to design AM Skills, which takes place per group of Material (e.g. Metal, Polymers, Composites among others) and AM Processes/Technology, using a functional analysis approach to define the Professional Profiles, Job Functions and Job Activities. While the Skills Roadmap shows where AM skills need to go, the methodology for designing AM Skills focus on how the industry is structured.

Prior findings, supported by ongoing validation sessions to align the Occupational Standards with industrial requirements, lead to the development of Metal AM Professional Profiles and skills for the AM Process Engineer, AM Designer, AM Inspector and AM Operator levels.

These AM Profiles and Skills for each Professional Profile and qualifications are composed by a set of Units of Learning Outcomes / Competence Units (CUs) which are **Functional,** when they imply the mobilization of skills concerning a specific job function and related activities or **Cross Cutting** when they imply the mobilization of several functions and activities. The CUs have also different proficiency levels (e.g. Independent, Specialised, Advanced and Expert) in alignment with the correspondent Professional Profile which enable the progress inside one or different qualifications, thus fostering up-skilling (improving existing skills) and re-skilling (training in new skills).
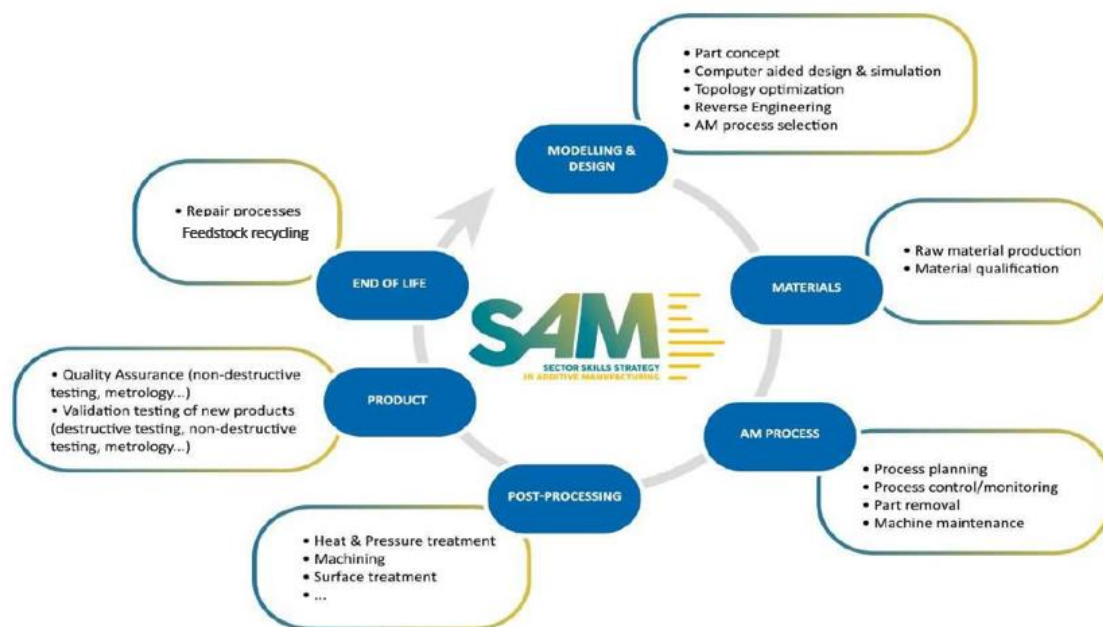

Figure 22 - AM Value Chain Segments

Co-funded by the
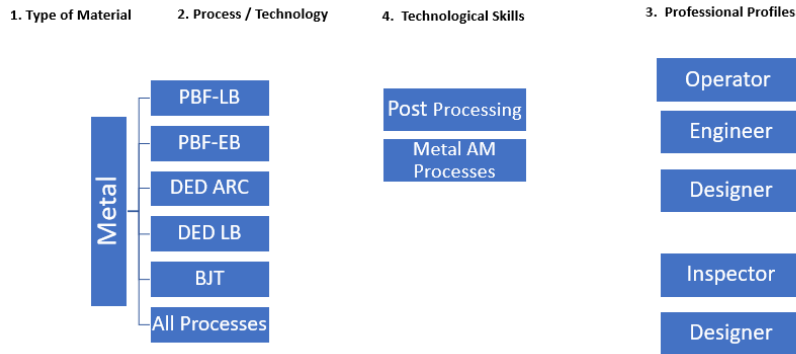Erasmus+ Programme
of the European Union

Figure 23 - Flowchart for AM Skills Development

At the same time that AM is reaching different sectors, it has become necessary to increase the "awareness" on AM among "non-manufacturing" professionals (e.g. Health Professionals) and potential 3D printing professionals (e.g. students both VET and HE), so that they can start embracing digital technologies and understanding the limitations and anticipate the growing challenges of an emerging technology such as AM. In addition to specific technological skills, a wide range non-technological skills are defined, which can be integrated within training in a transversal way for the different levels. These skills are categorized into Green, Digital and Entrepreneurship skills (see Table 3).

Non-technological Skills Classification		
Entrepreneurship *	Digital	Green
Spotting opportunities Creativity Vision Valuing ideas Ethical and sustainable thinking Self-awareness and self-efficacy Motivation and perseverance Mobilising resources Financial and economic literacy Mobilising others Taking the initiative Planning and management Coping with ambiguity, uncertainty and risk Working with others Learning through experience	Digital data analytics (Artificial intelligence, Machine learning) Digital data management (big data, statistics) Ability to think in 3D Cybersecurity Coding / programming	Resource efficiency management Green awareness LCA Eco-Design Circular economy Green resources Green products

Table 3 – Non-technological Skills Classification

9. CONCLUSIONS

This deliverable has outlined the complex challenges that the AM sector currently faces, in the form of "Gap drivers" between what the industry needs in terms of educational/training offer and what is currently available. If left unaddressed, this can have a serious detrimental effect in the European AM sector.

Through the consortium's expertise, this deliverable has put forward key strategic initiatives and concrete activities to address each of the seven Gap Drivers identified. Furthermore, SAM has also structured a "Roadmap" that will allow each strategic initiative (and their related activities) to be implemented in a realistic and measurable manner, so as to accurately assess how these have affected the AM industry and how they can still be assessed and adjusted, if required, to maximise their impact.

The identified Sector Skills Strategy is grounded in the AM Observatory and the deployment of the IAMQS through a network of training providers, which is sustained by industry and by strong connection between a wide range of industrial sectors, which are applying AM in their activity or intend to do so.

Table 4 summarizes each of the Gap drivers, together with their equivalent Strategic Objectives and Implementing Activities that will allow the sector to overcome them.

Gap driver	Mismatch between industry needs and educational/training offer	
Strategy Objectives	**1: Strengthen the collaboration between industry and training organizations**	
Supporting actions (SA)	**Implementing activities**	**SAM project tasks**
SA1.1: Ensure engagement of Industry in the identification and validation of the necessary skills and training programmes **SA1.2**: Support the link between training development and standardization activities (like CEN and ISO) **SA1.3**: Ensure a link between stakeholders of the AM value chain, in terms of skills needed	**A1.1** Identify and anticipate skills needs in the AM sector	WP1 – Review of global and societal challenges and technological trends and their influence within the AM skills needs. Skills roadmap; WP2 – Update of real case, short terms and foresight kits; WP4- Implementation of tools for skills identification ;
	A1.2: Engage industry in the identification of skills and validation of training programmes	WP2 - Update Real Case Scenarios' kit surveys and interviews for the annual surveys and industry rounds, to allow the identification of their needs (WP4- report on need analysis results should provide data for this update). WP2 - Update Short Term Scenarios' kit surveys and interviews for the annual surveys and industry rounds, to allow the identification of their needs. (WP4- report on need analysis results should provide data for this update). WP2 - Implement Foresight Scenarios' kit with industry experts – settle date for kick-off WP4 - Implement validation Workshops (training programs for skills development validation) with industry experts
	A1.3: Create an open platform for industries to provide their inputs on skills and qualifications for AM	WP4 - As part of the Observatory, SAM is creating a European Industrial Council that will be composed of industrial members. The initial plan is to have the machine manufacturer followed by some large end-users in that Council. This will be an activity that has already started but will carry on for the next years. WP5: Include online qualifications catalogue in the observatory. After the development and implementation phase had being completed (pilots) the Competence Units/Training Modules will be uploaded into an online catalogue
	A1.4: Define a joint skills strategy with the main industrial partners	WP4 - Organize a workshop with machine manufacturers to define a joint strategy for skills in AM. Negotiations are already in progress with the following machine manufacturers: - Renishaw - GE Additive - SLM Solutions

		- EOS - TRUPF - Prima Additive - 3DSystems - DMG Mori WP2 - Implement Foresight Scenarios' kit with industry experts – settle date for kick-off
	A1.5 Implementation of Mainstreaming Steering Committees	WP 8 – Define national Mainstreaming Steering Committees
Expected Impact	**Reduce the skills gaps and ensure alignment between the training offers and the industry needs**	

Table 4- Skills Strategy Summary Table

Gap driver	Competition for skilled AM workers and lack of knowledge of AM from existing workers/students	
Strategy Objectives	2: Tackle the lack of AM personnel at the European level	
Supporting actions (SA)	Implementing activities	SAM project tasks
SA2.1: Facilitate access to AM-relevant vocational educational training and higher education **SA2.2**: Develop a recognised EU-level qualifications and training supported by a harmonized accreditation system for training and educational organizations, at both VET and HE levels **SA2.3:** Support the implementation of different paths for qualifications in AM, e.g.:	**A2.1:** Implement the International AM Qualification System	WP3 – The review of existing qualifications in AM and development of new Units of Learning Outcomes and/or Qualifications WP8 - The implementation of a International AM Qualification System already started targeting organizations outside the consortium WP5 – Decide on which qualifications/Modules will be piloted by which partners WP6 – Develop and implement 4 new Qualifications/Units of Learning Outcomes WP4 – Integrate the rules for the Qualification system implementation
	A2.2: Funding for the preparation of training centres	WP6 – The development of 4 new Qualifications/Units of Learning Outcomes can become input for the necessary identification of funding for the training centres WP4 & WP8 – define strategy for "counselling" funding programmes providing relevant data related with AM sector WP5 – Organisation of two trainers workshop

- Continuous education and training (C-VET) - Initial education and training (I-VET) - Recognition of Prior Learning (RPL) - Reskilling - Upskilling **SA2.4:** Support the implementation of different training methodologies for qualifications in AM, e.g.: - Work-based Learning - Project based learning - Distance Learning	**A2.3**: Create an open platform for AM training providers to provide information on skills and qualifications for AM they can offer	WP4 - As part of the Observatory, SAM is creating a European Educational Council that will be composed of VET and HE organisations. This will be an activity that has already started but will carry on for the next years. This council already has members from different countries, like Spain, France, Belgium, Germany, Italy, UK, Ireland and Portugal. However, SAM is working to have representatives from other European countries. WP4 – Develop a database with AM training offers to be published in the AM Observatory & settle procedures for updating training offers in the observatory WP5: Online qualifications catalogue to be included in observatory WP6 – develop/implement AM Training offers online catalogue
	A2.4: Promote International Qualifications in AM, through national events and through supporting activities focused on training centres (both VET and HE)	WP5 – Implement train the trainers Workshop WP5 – Implement Piloting events using different training methods (from revised and new Qualifications/Units of Learning Outcomes WP7 & WP8 – settle dates for events in 2020,2021,2022

- Lifelong Learning - Blended Learning **SA2.5**: Facilitate continued European collaboration between training providers **SA2.6:** Support the implementation of employability mechanisms in the AM sector	**A2.5:** Establish mutual recognition protocols between training providers	WP4 - Visibility of the existing network of training centres and protocols WP 5 - Implementation of mutual recognition protocols (Memorandum of Understanding) to foster the upskilling and reskilling of trainers, as well as for the mobility of trainees belonging to the network; WP 6 - Implementation of mutual recognition protocols (Memorandum of Understanding) to foster the upskilling and reskilling of trainers, as well as for the mobility of trainees belonging to the network;
	A2.6: Share data on AM Workforce Employability	WP4 - Implementation of an open group to bridge interaction between job seekers and recruiters WP4- Provide data regarding employment indicators
Expected Impact	**Increase the number of AM Qualified personnel, being by re-skilling, up-skilling of by training the "new" workforce**	

Gap driver	Shortage of training centres, specially at VET level, capable of delivering AM training (cost of the equipment/software, qualified personnel for delivering training)	
Strategy Objectives	**3: Prepare European, National and Regional organizations to tackle the challenges of AM, in terms of Qualified personnel**	
Supporting actions (SA)	**Implementing activities**	**SAM project tasks**
SA3.1: Support the development of National Cooperation Networks of accredited training centres in AM **SA3.2**: Include pathways for skills development and knowledge exchange in national and collaborative research, training and capacity building programmes **SA3.3:** Ensure the engagement of training organizations in the update and implementation of International AM Qualifications **SA3.4:** Support the development and implementation of Harmonized trans-national curricula	**A3.1**: Engage industry, academia, training organizations and authorities in projects for collaborative implementation of AM training, supported by a Quality Assurance System	WP4, WP6 & WP8
	A3.2: Create a Network of AM Training providers (National and Transnational)	WP4 – settle the rules for AM training Centres to belong the European Network. These rules have already been defined. WP4 – settle procedures for updating AM Training offers in the Observatory WP4 – mapping the AM Network with information about: location, training offers available, WP5 & 6 – start preparation of pilots: which partners will pilot which Units of Learning Outcomes
	A3.3: Funding for the "upskilling" of training centres with a focus in AM	WP4 & WP8 – define strategy for "counselling" funding programmes providing relevant data related with AM sector
	A3.4: Support the development and implementation of Harmonized trans-national curricula	WP7 & WP8 – define types of events and settle dates for 2020,2021,2022: SAM is organizing National events to engage with industry and training providers interested in AM. The first two event will take place in Poland and Romania but plans for Czech Republic and Hungary are already been made. The idea is to cover other countries.
	A3.5: Define training programmes for trainers (VET teachers,…)	WP5 – Implement train the trainers workshops WP5 - Ensure the availability and visibility of relevant AM teaching and training resources that can support bridging the gap between industry and education (New AM resources need to be developed for this purpose?)

Expected Impact	**Facilitate the access of professionals, students and industry to AM training**	

Gap driver	Sector and process specific requirements for AM, that are also reflected on the qualifications of professionals	
Strategy Objectives	4: Tackle the diversity of sectors and applications of AM	
Supporting actions (SA)	Implementing activities	SAM project tasks
SA4.1: Ensure the involvement of different sectoral stakeholders in the identification and validation of necessary skills/qualifications **SA4.2**: Ensure that sector and/or AM process specific skills/qualifications are identified and addressed **SA4.3**: Ensure a common base for the Qualifications to allow mobility of the workers between sectors and countries **SA4.4:** Support the creation of International Qualifications/modules focused on a specific industrial sector	**A4.1:** Engage with different sectoral organizations to allow a sectoral view on skills and qualifications for AM (sectors like Aerospace, Medical, Automotive, Maritime, etc)	WP4 – Ensure that sectoral organisation representation in both the Educational and Industry Councils WP8 - Engagement with Sectorial Organizations focusing on the following sectors: - Aerospace – NADCAP, FAA and EASA - Health– FDA - Automotive – Blueprint for automotive sector (DRIVES) - Maritime – Blueprint for Maritime sector (MATES) - Defence – Blueprint for Defence sector (Assets+) Non-sector specific organizations: - EIT Raw Materials - ISO - ASTM - ASME Future sectors that will be engaged categorizing them based on two dimensions: first one being the industry: e.g. Automotive, Aeronautical and the second one being the stages in which they use the AM technology e.g. product development phases, final production. Sectors to be addressed in the next 5 years will be Construction and Energy.
	A4.2: A4.2: Use a modular approach in the development of the training with some sector/process specific modules	WP3 - Action: using a modular approach will allow a faster deployment of the necessary sector skills requirements
	A4.3: Identify common requirements between the different sectors	WP3 – establish procedures for identifications of common requirements of the different sector in the methodology

	A4.4: Implement International Qualifications that are recognised by different sectors supported by a Quality Assurance System	WP5 & WP8 – engage with different sectors for piloting Units of Learning Outcomes WP6 – develop 4 new Qualifications/Units of Learning Outcomes
	A4.5: Organise events and disseminate the International AM Qualifications to different industrial sectors	WP7 & WP8 – define types of events and settle dates for 2020,2021,2022
Expected Impact	**Wider pool of qualified personnel that can "move" between different countries and industrial sectors**	

Gap driver	Fast evolving technology and industry	
Strategy Objectives	**5: Constant update of the AM European workforce**	
Supporting actions (SA)	**Implementing activities**	**SAM project tasks**
SA5.1: Ensure the identification of new trends in AM **SA5.2**: Continued monitoring of AM technology developments **SA5.3**: Investing in the continuing professional development of teachers and trainers **SA5.4**: Training provision for continuous professional development of the AM European workforce	**A5.1**: Develop and promote skills mapping mechanisms and anticipation tools	WP2& WP6 – Improvement of Kits WP4 - Reports on the Analysis and Validation of Needs (M13, M25; M37; M48)
	A5.2: Develop and update, in a continuous way, modules related to new advances in AM	WP3 – Implement methodology for design and review of professional profiles, qualifications and units of learning outcomes WP5 – Methodology piloting
	A5.3: Carry out market searches, with a focus on Research Organizations, to identify new trends in AM	WP2 & WP4 & WP8 – establish procedures for feedback loops between forecast (all 3 scenarios) & AM Observatory publication of data related with trends
	A5.4: Development of knowledge and skills in AM to keep up with the fast-evolving technology	WP2 – Implement Kit for tracking students, future employees and job seekers in AM WP2 – Implement Kit for collecting feedback on the qualifications and training modules WP5 & 6 – Implement pilots – start preparation of pilots: which partner will pilot which Qualifications/Units of Learning outcomes; Select CUs/Module close to trends in market to be piloted.
Expected Impact	**Improved foresight of skills needs for the AM Sector**	

Gap driver	Lack of AM awareness among the younger generations	
Strategy Objectives	**6: Prepare the AM Future Workforce**	
Supporting actions (SA)	**Implementing activities**	**SAM project tasks**
SA6.1: Formulate strategic and future-oriented visions for AM-related skills and their national roll-out SA6.2: Link European Qualifications with National Qualifications SA6.3: Develop the use of AM at different school levels	**A6.1:** Raise Awareness campaign focused on different target groups	WP7 - define types of events and settle dates for 2020,2021,2022
	A6.2: Organize events to raise awareness of AM and its capabilities, focusing on creativity, for young students	WP4 - Future Action: Area in the Observatory to publish AM skills relevant funding opportunities WP7 - define types of events and settle dates for 2020,2021,2022
	A6.3: Relate European AM Qualifications with NQF using European tools, such as EQF, ECTS, ECVET and EQAVET	Develop Alignment between European Quality Assurance Reference Framework: Quality Criteria and Indicative Descriptors & European AM System WP3 – Align AM Framework with EU tools: EQF, ECTS & ECVET WP8 – Engage with National Agencies for VET to integrate AM qualifications in national qualifications
	A6.4: Create AM awareness "activities" that can be used by schools according to the age of the students	WP7 - define types of events and settle dates for 2020,2021,2022
	A6.5: Funding to equip schools, fab labs or industrial experience accelerators and allow them to do AM related awareness activities	WP4 & WP8 – define strategy for "counselling" funding programmes providing relevant data related with AM sector WP8 – Action plan to guarantee the sustainability of the Project
Expected Impact	**Increase the number of people/students trained in AM in the short and long term across Europe**	

Gap driver	Necessity of more "infrastructures" for AM training	
Strategy Objectives	**7: Leverage on existing funding programmes and mechanisms**	
Supporting actions (SA)	**Implementing activities**	**SAM project tasks**
SA7.1: Guide the AM Sector to skills/training/qualification funding opportunities **SA7.2:** Mobilise skills-related programmes at EU and National level for AM specific needs	**A7.1:** Funding to equip training centres and schools with AM equipment and software	WP4 & WP8 – define strategy for "counselling" funding programmes providing relevant data related with AM sector
	A7.2: Map and promote funding relevant for AM skills and qualifications	WP4 & WP8 – define strategy for "counselling" funding programmes providing relevant data related with AM sector
	A7.3: Recommend calls for AM-specific activities	WP4 & WP8 – define strategy for "counselling" funding programmes providing relevant data related with AM sector
	A7.4: Organise events to facilitate networking and collaboration in EU and National calls for AM	WP4 & WP7 & WP8 - – define strategy for "counselling" funding programmes providing relevant data related with AM sector
Expected Impact	**Greater access to funding to support AM-related skills development and sustainment**	

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