Deliverable 3.5

Call FoF-05-2016

AM-motion

A STRATEGIC APPROACH TO INCREASING EUROPE'S VALUE PROPOSITION FOR ADDITIVE MANUFACTURING TECHNOLOGIES AND CAPABILITIES

Grant Agreement Nº 723560

D3.5 Training & Education: evaluation of employers needs

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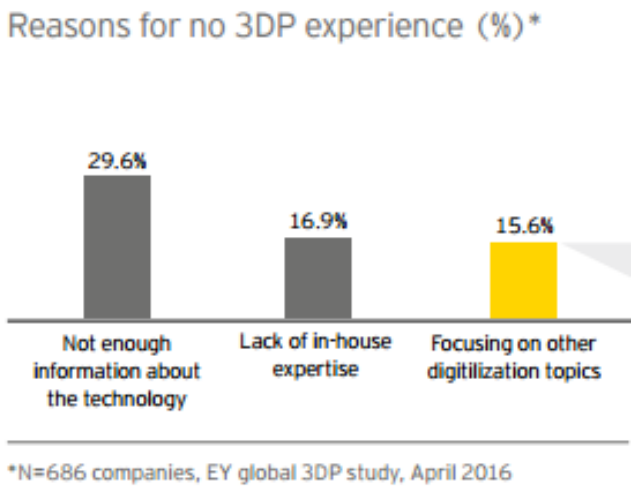
1. Background and objectives of the document

The present document constitutes Deliverable D3.5 in the framework of the AM-Motion project "*A strategic approach to increasing Europe's value proposition for Additive Manufacturing technologies and capabilities*" (Project Acronym: AM-motion; Contract No.: 723560). This document is the result of the activities performed within the framework of work package 3 (WP3): "*Analysis of non technological aspects*", and more specifically of Task 3.1 entitled "Training Education: evaluation of employers needs".

This deliverable contributes to meet the overall objective of WP3, which is to identify existing non-technological barriers that hold down the industrial deployment of additive technologies in Europe. Together with D.3.7 on Educational implementation model, D.3.5 addresses the skills dimension of the topic. The importance of this subject for the AM uptake should not be underestimated. Several sources acknowledged the potential impact of lacking skills throughout the company, from shopfloor to the boardroom.

A report commissioned by the EU[1] pointed to the lack of competences as one of the most relevant obstacles for AM growth in Europe. A recent global survey[2] among SMEs and large companies from a wide range of potential application industries indicated the lack of information on 3D Printing and that of in-house talent as the two biggest reasons for industry's limited attention on the technology (*graph on the left side*). In the UK, it is forecast manufacturers will need to train around 100 apprentices for a year in very near future. By 2025, their number will rise to a few hundred a year. Even larger figures are estimated for the training of existing manufacturing workforce, with figures ranging between 13,000 and 45,000.[3] Getting a sense of where AM skills



[1] Identifying current and future application areas, existing industrial value chains and missing competences in the EU, in the area of additive manufacturing (3D-printing)

[2] http://www.ey.com/Publication/vwLUAssets/ey-global-3d-printing-report-2016-full-report/$FILE/ey-global-3d-printing-report-2016-full-report.pdf

[3] http://www.ifm.eng.cam.ac.uk/uploads/Resources/Reports/AM_PUB_MTC_FINAL_FOR_PRINT_new_-_low_res.pdf

are really absent is therefore helpful not only for companies already in the market, but also for manufacturers willing to adopt additive techniques. D.3.5. is relevant, too, for policy-makers across Europe, in so far as its results can feed into skills-related policy-making, contribute to AM workforce development and thus help to better deploy additive technologies to address existing societal challenges. To this extent, as AM is employed in a growing range of applications, there is a clear rationale for understanding the type of skills that non AM industry-specific actors such as regulatory agencies need to have to support the growth of this technology.

2. Methodology and survey

In order to identify the needs by employers in terms of competences and knowledge of workforce in AM space, a survey was designed, placed on the web site or hand-delivered was circulated by AM-Motion partners between October 2017 and March 2018. The following sub-sections illustrate the main characteristics of the selected sample of respondents.

Sectors

In line with what planned in the project's Description of Work, the survey has been sent out to advanced manufacturing companies, including those already part of the European AM ecosystem. Both SMEs and large firms were considered. Regarding the industrial end-user sectors, the survey considered fields previously identified in the project (D.2.1), which are:

- Healthcare
- Aerospace
- Automotive
- Consumer Goods / Electronics
- Energy
- Industrial Equipment and Tooling
- Construction

It was opted to target actors from any of the above segments involved in AM production, without excluding any material today available in the market. The AM-motion version of the AM value chain is illustrated below in Figure 1. With regards to the additive technologies considered, no family identified by the ASTM F42 committee[4] was excluded.

Figure 1: *AM Value Chain*

Attention was given to avoid over-representation of one specific AM value chain segments or application area in the respondents' group. Partners also aimed to get a sufficient number of responses from each of the EU countries with a high manufacturing output.

Geographical representativeness

The pool of targeted respondents to the survey was geographically limited to personnel mainly focused on the European region. This was decided with a view to obtain relevant information specific to this geographical area, so as to deepen understanding of the AM challenges and issues particular of this region.

2.1 Survey design

The survey prepared is showed below. It contained three different sections:

- General data, where respondents were first asked a series of contextual questions. These pieces of information were used as a way to characterize further the respondent
- Information on AM, where companies were asked about their knowledge and expectations on AM
- Education and expertise, where questions referred to AM current and needed skills.

[4] http://www.lboro.ac.uk/research/amrg/about/the7categoriesofadditivemanufacturing/

With a view to boost the response rate, the consortium decided to keep the survey short. The questionnaire was uploaded within the AM-motion project website for facilitating its dissemination, industry participation and data collection. It was also further circulated by PRODINTEC, CECIMO and EPMA among their members, as well as among the European Additive Manufacturing Technology Platform" AM Platform" members.

I) General Company info

1. Organization name:

2. Contact email

3. Type of organisation:

- Large company (+250 employees)
- SME
- Spin-off
- Industry Association/Platform

4. What is the activity/sector of your company?

- Aerospace
- Electronics
- Automotive
- Health
- Construction
- Consumer goods
- Industrial Equipment & tooling
- Energy
- Other:

II) Additive Manufacturing section

5. Is your organisation currently using AM?

- Yes
- No

If you reply YES to question 5: What's the main role of your organization in AM? (more than one answer is possible)

- R&D
- Service Bureau
- Equipment provider
- Materials provider

- Software provider
- Design
- End user (Adopter)
- Other services (legal, consulting, Human resources...)

If you reply NO to question 5: If your organization is not using AM, what is the reason? (more than one answer is possible)

- Lack of quality of AM materials / processes
- Too expensive or costs
- Too low throughput
- Lack of knowledge in your organisation
- Setting of AM knowledge is still ongoing
- We don´t know why /No clear correlation possible
- No standards available
- Other:

6. What are your company expectations in 5 years with respect to AM? (more than one answer is possible)

- We will not use AM
- We will start using AM
- It will bring us new services/products
- It will bring us new knowledge
- It help us creating new jobs
- It will bring competitive advantage
- Other:

III) Education and expertise: Existing knowledge on AM in your organisation

7. In which field do the employees in your organisation have knowledge on AM? (more than one answer is possible)

- No Knowledge
- AM modelling
- AM design
- AM materials
- AM machines (including maintenance)
- AM process
- AM post-processing
- AM quality assurance and testing
- Standards, legislation, Health & Safety, IPRS,...

- Business models 'creation
- Marketing and Sales
- Other:

8. What is the educational level of employees in your company with knowledge on AM? (more than one answer is possible)

- PhD
- Master
- Bachelor
- Vocational training/apprenticeship
- High School
- Other:

9. Through which route have your employees acquired knowledge on AM? (more than one answer is possible)

- In-house training
- Training provided by third party or in collaboration with third party (company, university, technology center)
- Directly from university: Phd
- Directly through university: Master degree
- Directly through university: Bachelor degree
- Through vocational and professional learning/apprenticeships
- Through high school
- Other:

10. In which fields does your organisation lack (still need) knowledge on AM and would like to obtain in? (more than one answer is possible)

- All
- AM modelling
- AM design
- AM materials
- AM machines (including maintenance)
- AM process
- AM post-processing
- AM quality assurance and testing
- Standards, legislation, education, Health & Safety, IPRs...
- Business models' creation

- Marketing and Sales
- Other:

11. Which is the route through which your organisation would acquire this lacking knowledge on AM?

- Employee's In-house training
- Employee's Training provided by third party or in collaboration with third party (company, university, technology center)
- Recruiting: Through university: Phd
- Recruiting: Through university: Bachelor degree
- Recruiting: Through vocational and professional learning/apprenticeships.
- Other:

12. Are you planning to hire AM qualified staff in the next 12 months?

- Yes
- Likely
- No

If done already in the past, did you have problems to hire AM qualified staff?

- Yes
- No
- If yes, please specify:

If answering yes to question 12, what kind of profile/s will you be interested in?

- Software expert
- Designer
- Materials 'expert
- Operator/Technician
- Engineer
- R&D
- Manager
- Commercial
- Other:

13. As a company, are you involved in AM educational and/or training programmes?

- Yes
- No

If yes, how?

- Company provides AM courses/training
- Company teaching at universities
- Company receiving students
- Other

2.2 Inputs from educational workshop

Adding to the survey circulation, a lively interactive workshop based on "Educational Needs & Opportunities in Additive Manufacturing" took place in Aachen, Germany, in the frame of a workshop held on 20th March 2018. Organized by AM-Motion together with AMable[5], ADMIRE[6] and CLLAIM[7] (all EU-funded initiatives focusing on AM), the event aimed to discuss the trajectory of AM skills evolution in the near future, the educational levels where focus is needed to avoid AM skills shortages, as well as the type of curricula and infrastructure necessary to support AM workforce development. In the roundtable, attended by more than 40 stakeholders from AM-focused research centres and companies, time was dedicated to the presentation of the initial findings from the AM-Motion survey. The roundtable was then followed by a world café exercise, where participants (companies among the others) had to give to AM-Motion partners feedback in a more interactive manner, filling in a "virtual" survey and give valuable insights from their experience as businesses. Part of the feedback received will be also considered for the AM roadmap on the educational and training gaps.

[5] https://www.amable.eu/
[6] http://admireproject.eu/
[7] http://www.cllaimprojectam.eu/

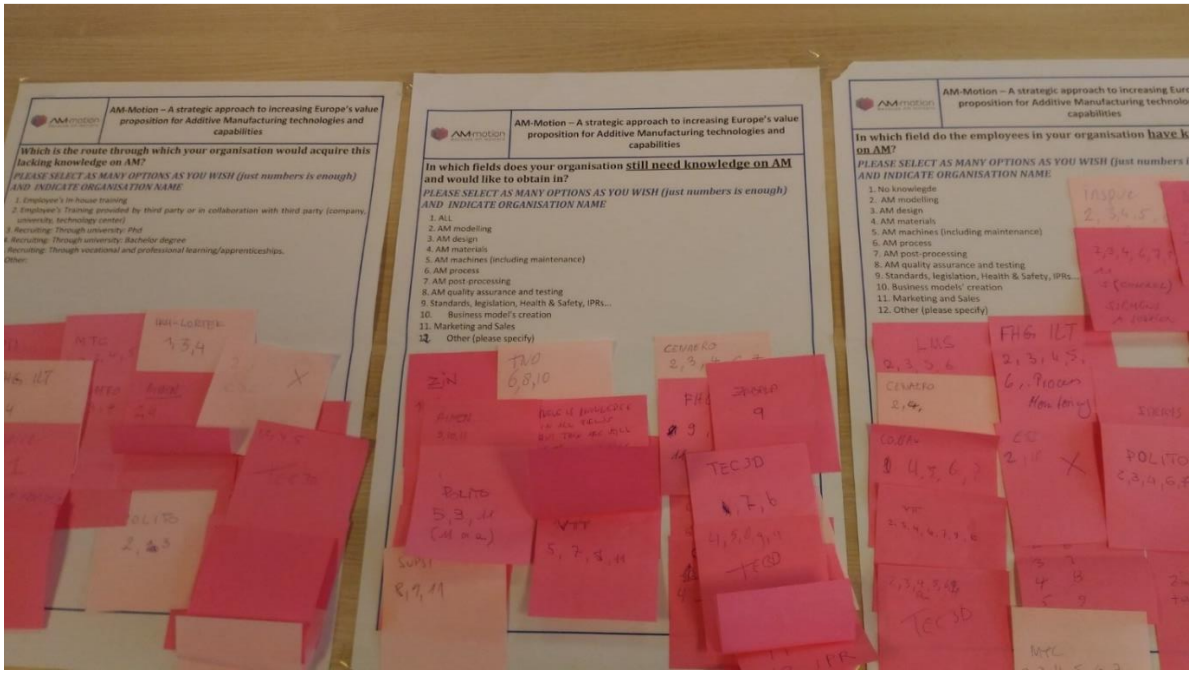


Figure 2. *AM-Motion survey interactive posters at the Educational workshop (Aachen, Germany, 2018)*

Figure 3. *Presentation of initial survey results at AM-Motion Educational workshop in Aachen, Germany*

3. Survey Results Analysis

A total of 65 responses were received.

3.1 Part I_ General Company info

Figure 4 below illustrates the number of responses by participating country. Germany was the country of business for most of respondents, followed by Spain and, more distantly, Italy and the United Kingdom.

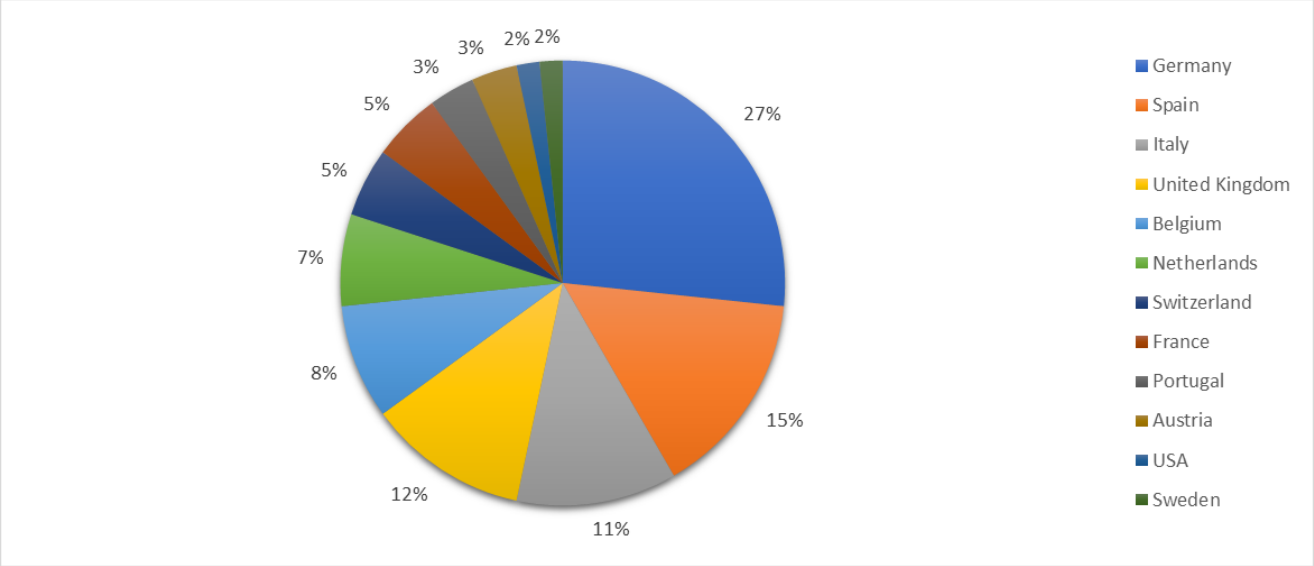


Figure 4. *Distribution per countries of respondents*

As it can be seen in Figure 5, **almost half of responses** (48,5%) **came from large companies**, which for the purpose of the survey were defined to be organisations with more than 250 staff headcount. Conversely, companies with 250 or less staff headcount were regarded as SMEs, and represented about 40% of respondents. Considerably smaller shares of responses came from spin-offs (7,6%), as well as industry groups and platforms (6,1%).

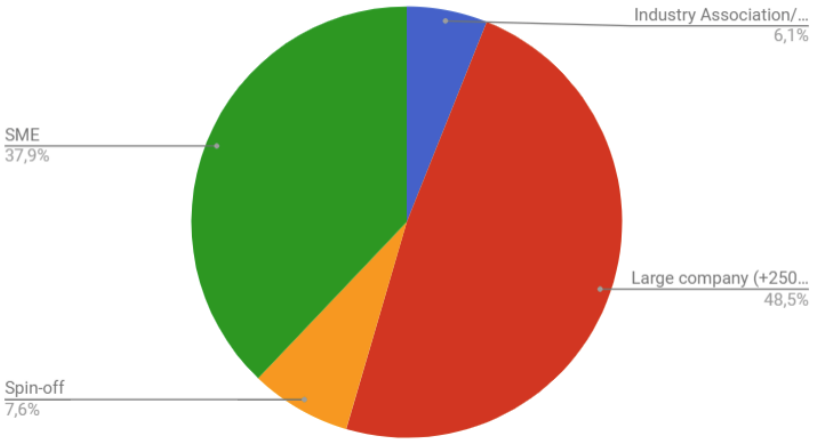


Figure 5. *Type of organisation*

With regards to the business sectors of respondents, **a clear majority of them (53%) was involved in the industrial equipment and tooling industry** as it can be seen in Figure 6.

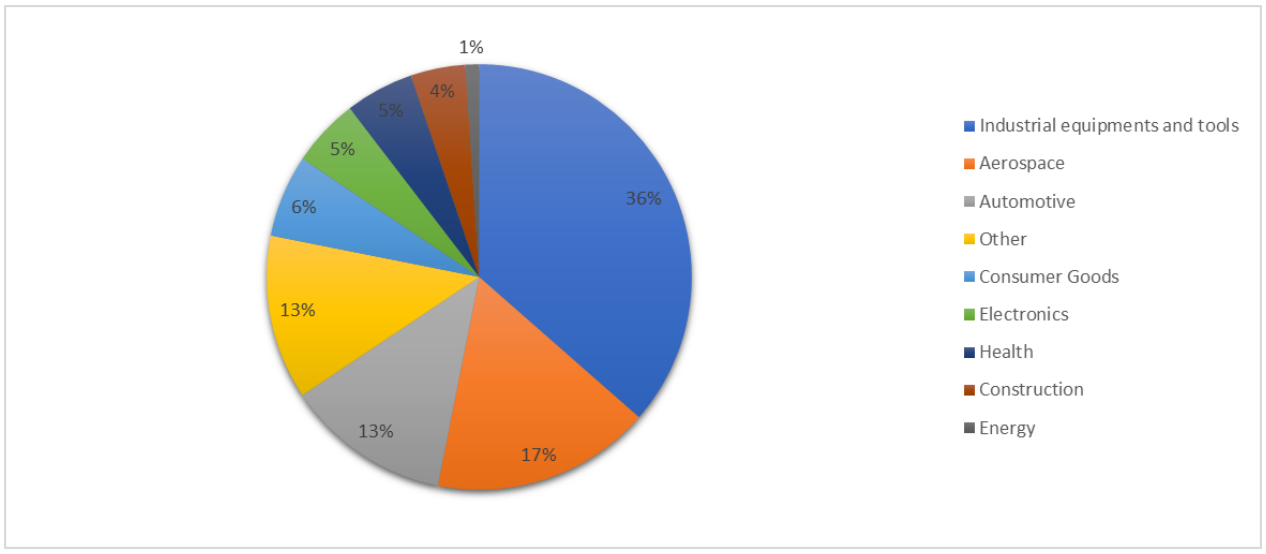


Figure 6. *Distribution by business sector of respondents*

As earlier analysed in the project[8], this sector presents today a number of key innovative AM products, including industrial equipment itself. About one quarter of respondents did business in the aerospace industry, which according to recent estimates is the second largest

[8] D2.1 on Selection of Key AM Sectors for Europe

sector for AM world-wide[9], and one in which additive technologies are being increasingly used for series production. 18% of surveyed businesses was engaged in the automotive sector, where AM is still mainly used for prototyping, tooling or short series.

3.2 Part II_ Additive Manufacturing section

The overwhelming majority of respondents to the survey, more than 8 out of 10 (83%) are **already using AM** at the time the questionnaire was being circulated (Figure 7).

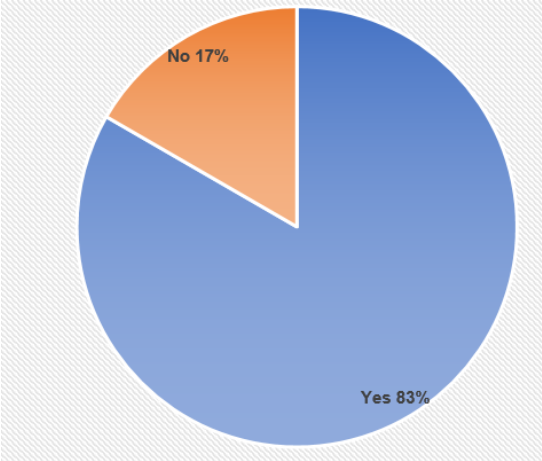


Figure 7. *Percentage of respondents on the current use of AM*

Almost one third of surveyed organisations was positioned in the AM ecosystem as an equipment provider. The second most represented sector was that of R&D with 21% of respondents involved in it. One fifth of companies indicated they were also (or solely) end-users of the technology.

[9] Wohlers, T. &. (2016). Wohlers Report. Colorado: Wohlers Associates Inc.

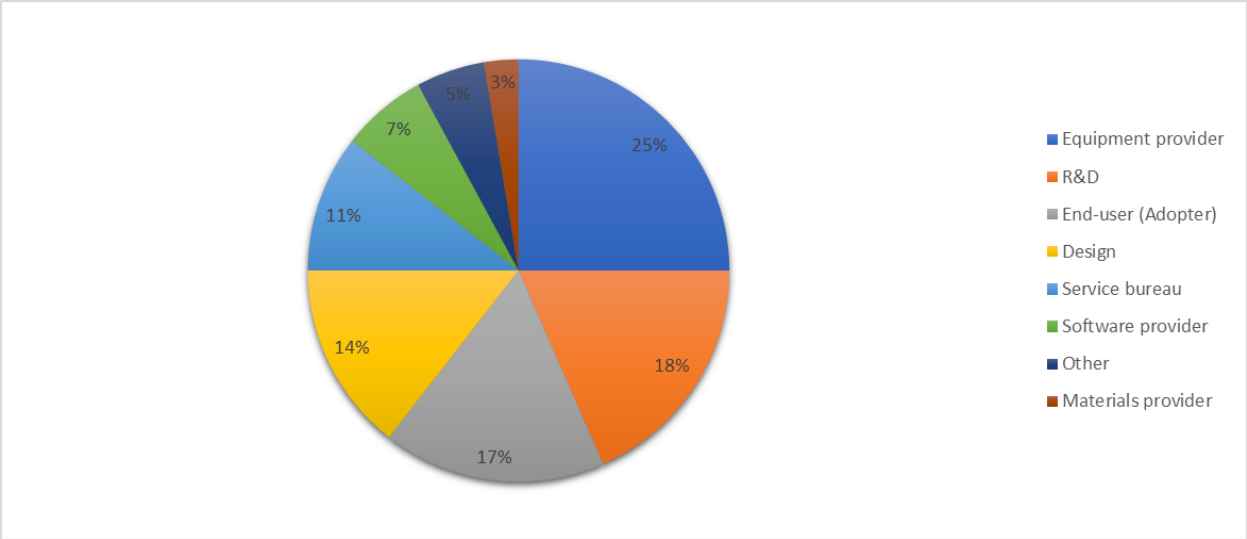


Figure 8. *Position in the value chain*

Asked about what they expected from AM over the next five years (multiple answers were possible), companies indicated a boost in competitiveness as their main expectation (33%), suggesting the technology may be increasingly embedded into the existing production environment. As figure six shows, this preference narrowly outranked a prediction in the expansion of the portfolio or services and/or products offered by industry players (31%). If only replies from large companies are to be considered, the diversification of products and services brought to the market emerged as the single most indicated expectation. 73% of them did so.

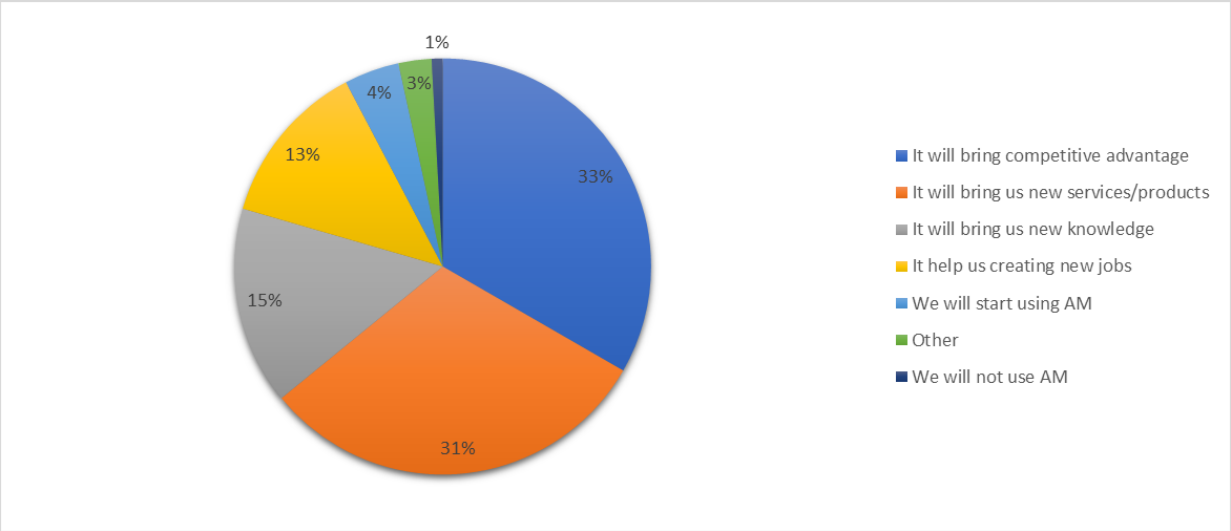


Figure 9. *Expectations over AM*

3.3 Part III_ Education and expertise section

Concerning the specific existing AM knowledge within the firm (multiple answers possible), survey results in Figure 10 below pointed to **a relative concentration of expertise in the areas of AM machine (including maintenance operations) and process** (13% both). Knowledge of post-processing operations, together with that of AM design, followed closely (11% both). Among those firms with expertise in AM design, it is relevant to highlight that 70% of them were large companies, 55% of which sharing the fact they are end-users in the AM ecosystem.

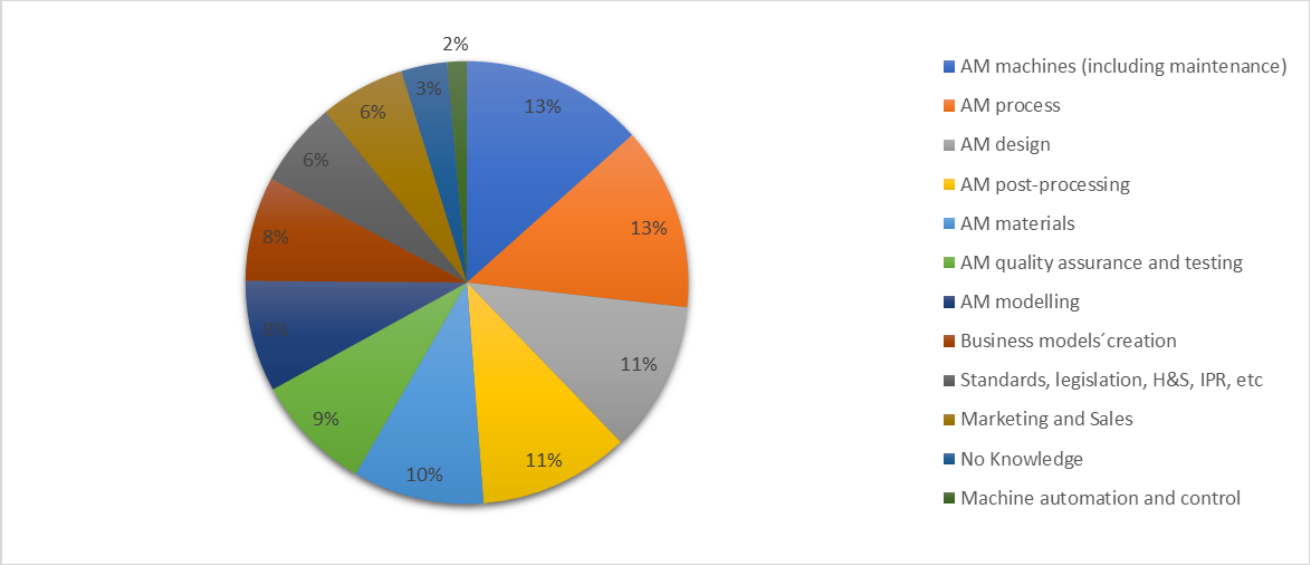


Figure 10. *Existing AM knowledge within the organisation*

Responses from SMEs and other smaller actors, instead, revealed a pattern of results generally similar to that of the overall breakdown illustrated in Figure 10, with knowledge of AM machines and process accounting for the largest shares. Considering all replies, expertise in non-purely production stage issues, such as in the regulatory and standardization framework applied to the technology, ranked instead lowly in terms of AM knowledge possessed in-house by respondents (6%).

In terms of educational background of employees focused on AM within the company, Figure 11 below shows that 60% of firms relied on AM-oriented workers possessing a Master's Degree as highest educational qualification. Companies whose AM business had PhD graduates represented 20% of responses. They were therefore more common than Bachelor Degree's graduates, who were the AM-oriented employees with the highest educational qualification in 12% of cases. Finally, only 5% of companies possessed workers focused on AM whose education background was rooted into the non-academic context (vocational education and apprenticeships).

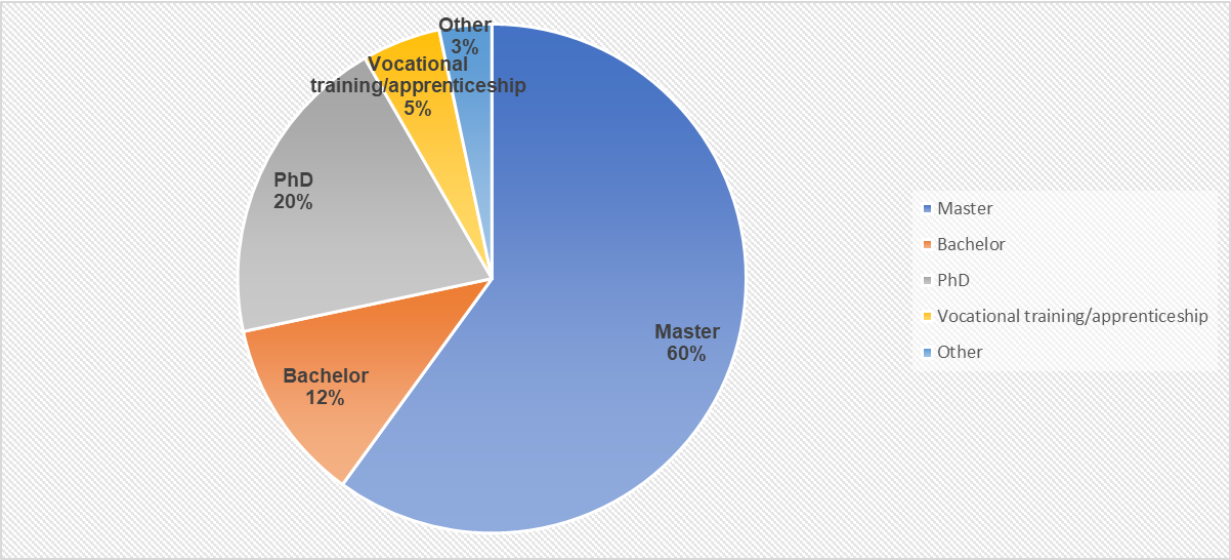


Figure 11. *AM Educational level within the organisation*

As Figure 12 below reveals, asked about the route of acquisition of AM knowledge within their organisation, **almost half of companies** (49%) **indicated in-house training and collaboration with a third party** (be it a company, an RTO or a university) **as their selected routes.** Considered together, in-house training and training-based collaborations with other actors accounted for the lion share of responses to this question.

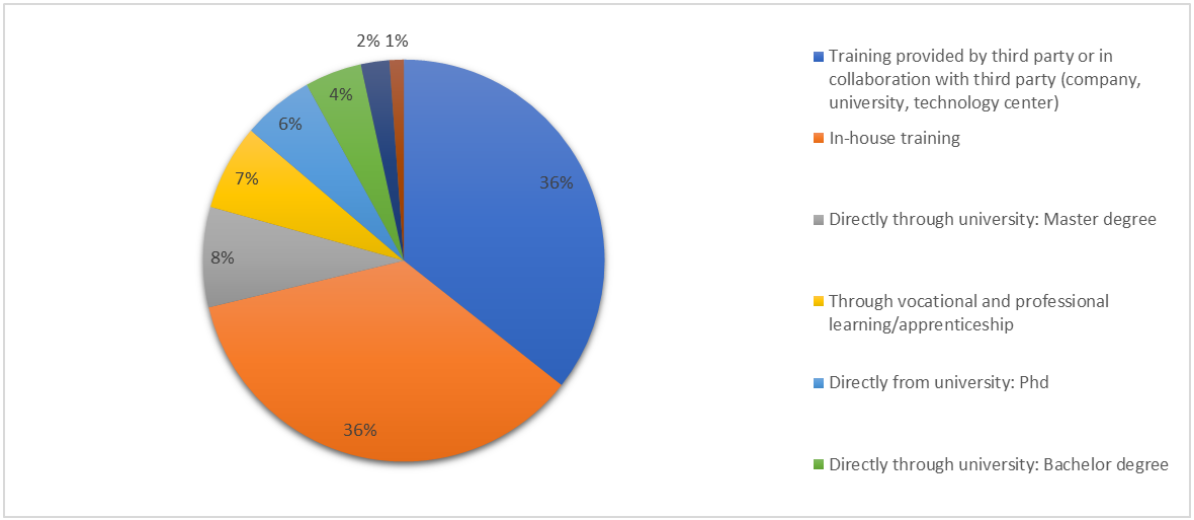


Figure 12 *Route for acquisition of AM knowledge*

Only a minor number of companies obtained AM knowledge directly through

recruitment of academic or vocational graduates. In just 11% of cases, respondents built up AM knowledge directly by hiring Master's Degree graduates. They did less so for what concerns other academic and vocational qualifications. Overall, this finding suggests that educational-level AM skills had rarely been considered ready to be employable into the AM businesses of the company. Rather, organisations may have felt as necessary some form of (post-graduation) additional training of workers in order to enable them to interact with additive technologies, training which happened either in-house or through partnerships with other entities in the ecosystem. Notably, the large majority of firms whose AM expertise was acquired through direct recruitment of academic graduates and/or apprentices were SMEs.

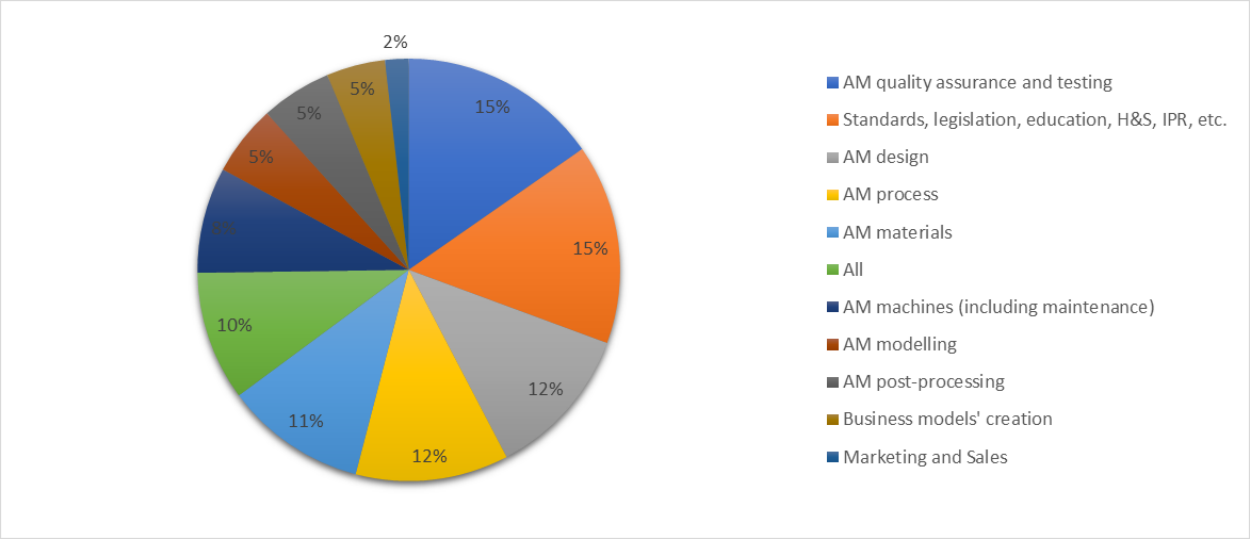


Figure 13. *Missing AM knowledge within the organisation*

Figure 13 above displays that **AM quality assurance and testing, as well as knowledge of regulatory standards, H&S rules applicable to AM and of IPRs emerged as the two most indicated areas where companies intended to beef up their AM expertise** (15% both). As Figure 10 previously showed, those of quality assurance/testing and of the regulatory framework applicable to additive production also emerged as two topics with relatively little company expertise. The intention of respondents to increase knowledge on both aspects may be linked to the growing industrialization of the technology in production, and the fact that today AM finds most applications in highly regulated industries. In these environments, ensuring a consistent and repeatable production process is key for series production, alongside a need to thoroughly understand applicable standards

and regulations. Indeed, knowledge of issues such as process qualification and regulatory standards for the certification of processes were voiced among the examples of skills' needs in this respect. A relatable problem consisted, in eyes of some respondents, in the difficulty to stay up-to-date with all new standard and regulation developments. With regards to the capabilities in understanding the patchwork of rules applicable to industrial AM, it is also of relevance to highlight that small businesses emerged to be particularly in demand of them. 32% of SMEs indicated appetite to boost AM regulation-related expertise, comparing to 22% of large firms.

About the reminder of the results, about 1 in 5 replies pointed to AM design and AM process as areas where further expertise was required (12% both). On design for AM, organisations put specific emphasis on the completely different mindset that design for AM requires when compared to conventional design. They raised, too, issues such as the lack of workforce capabilities in simulation and control software for AM. The presence of a limited pool of specialized designers in this field was also indicated as a problem adding further urgency to this issue. Finally, a note must be spent on the fact 10% of companies underlined their intention to acquire AM expertise in all the fields illustrated above.

Importantly, asked about their intended route to acquire the missing knowledge indicated, there was a clear indication that **businesses planned to acquire missing by collaborating with third parties** (42%). Figure 14 on the left gives an overview of all replies. Only 23% of companies expected to plug their skills' gaps by relying on in-house training. Similarly, just 27% of replies in total planned to acquire missing needed knowledge directly by drawing from the pool of AM labour market entrants. To this extent, recruitment of Bachelor's Degree graduates represented the way forward for just 18% of respondents, that of PhD graduates even less (just 9%). This result appears to be aligned with that shown in Figure 12, which addressed existing AM skills within the organisation. Although the percentage of companies willing to plug expertise gaps through hiring graduates is slightly higher than those that did acquire AM knowledge in this way (18% of respondents in Figure 12, vs 27% in this Figure 14), this solution overall appears to be generally uncommon among respondents. Much higher is instead the propensity of companies for ad-hoc training (either conducted alone or in cooperation with other players). This may therefore indicate that the AM industry does not see graduates as work-ready yet.

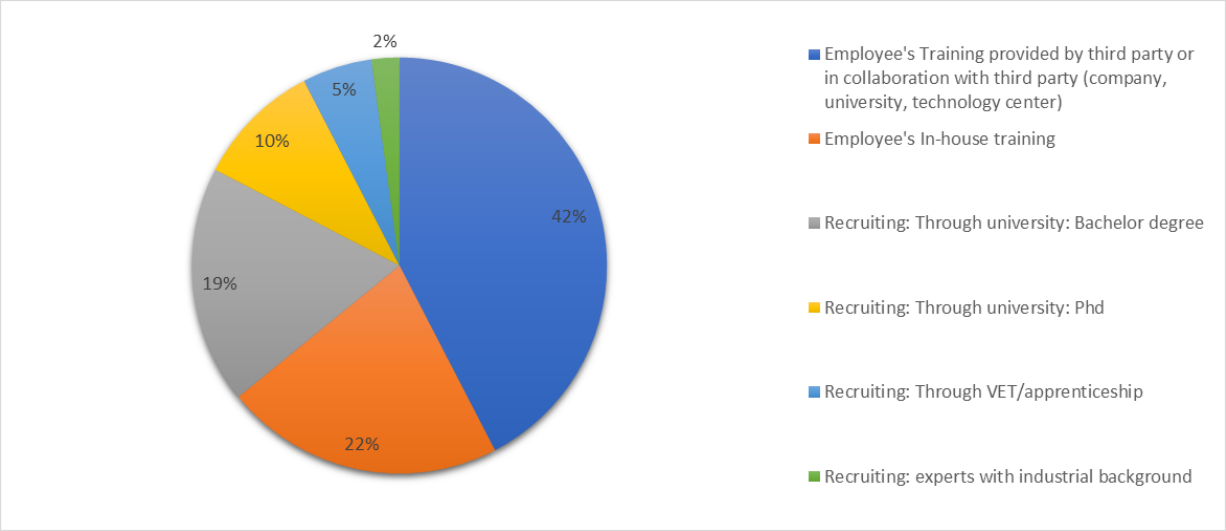


Figure 14. *Intended route of acquisition of missing AM within the organisation*

Respondents were mostly optimistic regarding their hiring plans, though with some reservations. As showed in Figure 15a, about one third of companies had already set out plans to hire AM workers over the next twelve months (32%), while another 37% was likely to do so. A sizeable minority of replies (31%), though, indicated no plans to recruit AM talent in the upcoming year.

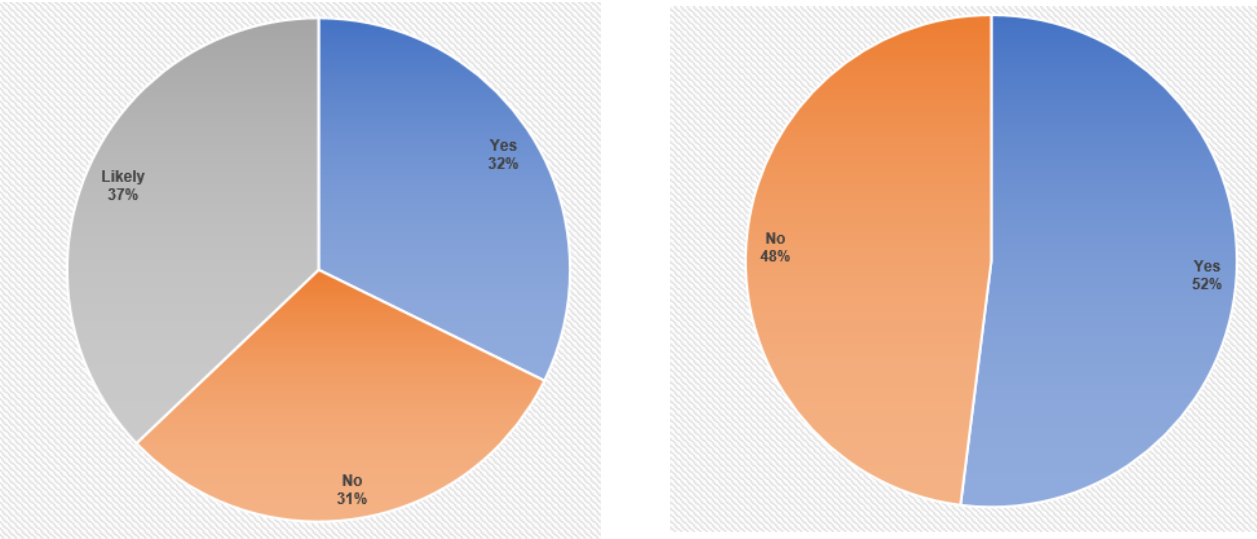


Figure 15. a) *Organisation's hiring prospects and* **b)** *Easiness in recruitment of AM talent (data in %)*

Concerning previous hiring trends, overall replies in Figure 15b **points to a challenging AM labour market.** A thin majority of all surveyed firms (52%) struggled to recruit competent AM staff in recent times. This was especially true among SMEs (55,2% struggled to hire personnel), while slightly less among large companies (47,6% of them). One of the most mentioned reasons for this difficulty emerged to be the lack of qualified AM individuals, especially experienced ones. This shortage constrained employers in their recruitment operations. To cope with that, some respondents resorted to hiring fresh graduates, not necessarily on AM-specific subjects. They then had to train them on-the-job, in-house, to put them in the conditions of implementing successfully required activities. However, even the large amount of time needed to make recruited individuals "work-ready" was mentioned as a hindering factor in some replies. Related to this obstacle, businesses pointed out the limited availability of AM-specific focus in the teaching offerings of educational actors, which in turn impacted on the set of skills held by candidates. Other hindering factors cited were the shortage of available resources, which presumably influenced HR activities, as well as the difficulty to find talent with the sort of interdisciplinary range of skills needed in AM.

Figure 16 below illustrates that among those organisations planning to hire staff with AM knowledge in the next twelve months, the material's expert topped the list of the most sought-after job profiles by respondents in the AM business. Almost one third of organisations replied they were interested in this job profile. If producers of pure additive or hybrid manufacturing machines only are considered, this figure goes up to about 50%, implying around half of surveyed firms in this segment of the AM value chain are interested in materials' experts. A possible interpretation of this finding is that, in a highly fragmented market, machine manufacturers are looking for differentiation from competitors by exploring ways to increase the range of available materials and open new applications. Boosting personnel resources focusing on materials' development would enhance the impact of these efforts.

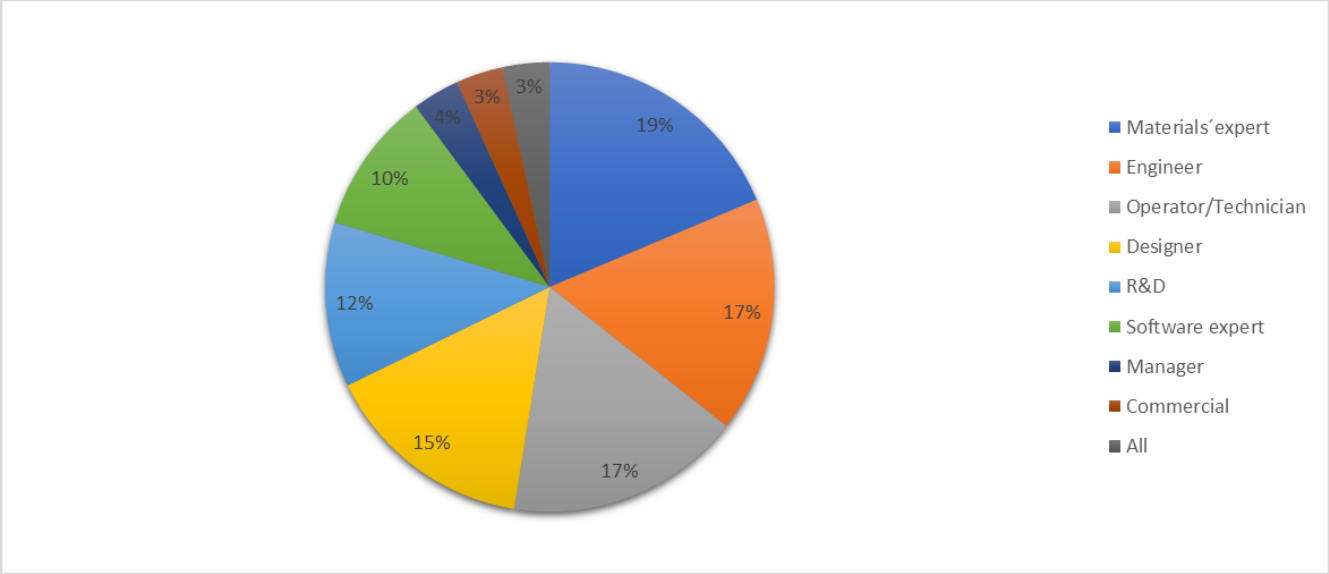


Figure 16. *Most demanded AM occupational profiles*

In terms of total replies, the AM engineer and operator/technician followed closely, with 27% of respondents looking to beef up their AM workforce with one (or both) position(s). The designer grabbed the interest of one quarter of surveyed organisations with hiring plans. Interestingly, 63% of those organisations indicating plans to hire designers were large companies. The opposite was true instead for the operator/technician. More than 60% of replies picking it came from SMEs. Finally, 5% of replies stated they intended to hire staff in all the positions listed for this question.

Asked if they were involved in AM educational and/or training programmes, the majority of respondents said they did so (figure 17). In this group, more than half of respondents had previously conducted in-house training on AM or built up expertise in this sector in partnership with third actors (universities, companies, research centres).

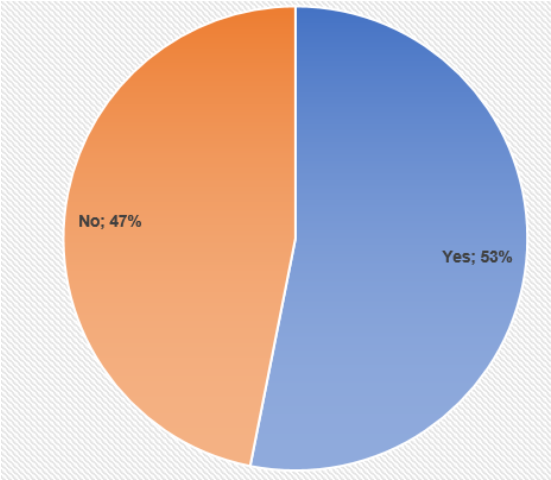


Figure 17. *Involvement in AM education/training*

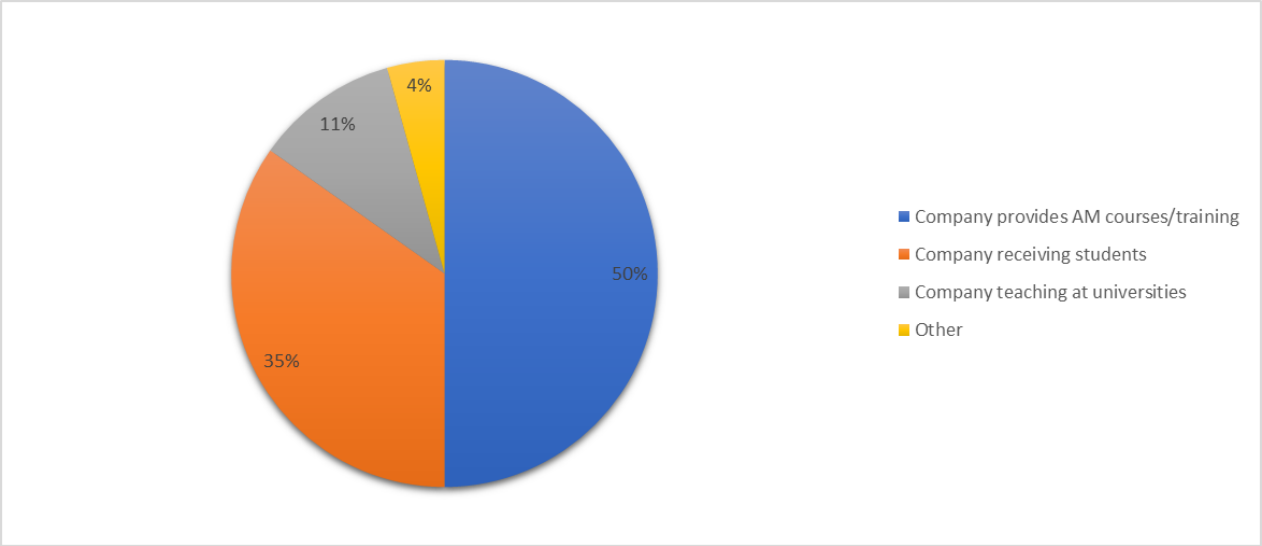


Figure 18. *Type of involvement in AM education/training*

More than 6 out 10 respondents involved in AM training did so by providing tailored AM courses, including to customers. Most of these respondents have expressed to have expertise especially in AM machines (including maintenance) and in the AM process. A considerable share of other replies (almost 50%) expressed to be involved in training by receiving students. More than 60% of surveyed organisations engaged into this type of training were SMEs. A smaller group of all respondents was focused (also) on teaching at universities. These were predominantly firms with an all-encompassing knowledge of AM,

that have trained workers in-house or in cooperation with other actors in the ecosystem, and that plan to scale up expertise in identified AM fields by partnering with a company, a research centre or indeed a university.

3.1 Synergies between survey results and further initiatives on the issue

Several initiatives are addressing the issue of competences for the use of AM technologies in Europe today. Synergies can thus be explored between this project and further initiatives in this field. An EU project in this respect appear to corroborate some of the findings illustrated above. As AM-Motion has done, also the EU-funded METALS[10] initiative investigated on key skills requirements in AM technologies. METALS put particular emphasis on the type of competences needed for workforce to transition successfully from interacting with conventional manufacturing technologies to interacting with additive manufacturing ones. Comparing to subtractive production methods, the initiative suggested how the need to observe norms, rules and standards during the production process will increase considerably. Such consideration goes in the direction of what shown in the previous Figure 10, in which organisations expressed intention to boost their knowledge of applicable standards and regulations. In METALS, research indicated in the framework of rules around safety in AM a key area where expertise will be much more in demand comparing to subtractive technologies. Stages such as operation are expected to be characterized by enhanced safety standards, where the AM operator is expected to be a safety-minded specialized worker with basic knowledge of materials, competent in emergency management and capable to handle minor deviations of the process parameters. Also maintenance will be a stage of the AM process where safety standards in the workplace will play a prominent role. Indeed, in the case of metal AM techniques, the risks linked to the use of powders, such as powder particles' inhalation and the reaction with oxygen and subsequent combustion of materials like titanium, are key issues. These will add a new specific dimension to the regular maintenance of machines, especially in tasks such as changing filters used during production, and carefully handling and storing feed materials. In the same vein, extraordinary maintenance of AM machines will require safety-oriented specialized skills by shop-floor technicians. To this extent, the end-user of the machine will need to rely on specialized AM maintenance personnel sent by the supplier to the manufacturing facility where the machine is located.

Concerning training issues in AM, survey results for Figure 11 earlier described emphasized how organisations predominantly see collaborations with third parties as a

[10] http://www.metalsalliance.eu/

planned way to plug their existing AM skills' shortages. In this sense, the European Welding Federation (EWF) has recently embarked on efforts to establish an international Additive Manufacturing qualification system under CLAIMM[11] project. The latter would provide the basis for a standardized training scheme, where authorized centres would provide training to individuals on the basis of a uniform, commonly-agreed set of AM-specific qualifications (and related tasks). As a step to advance on the establishment of this training system, ADMIRE project[12] launched a survey with the objective to identify skills needs in AM and prevalent tasks for five identified AM job profiles (operator, inspector, designer, supervisor and engineer). As possible skills AM processes, numerical modelling, design, post-processing, testing and costs were considered among others. Next step by this project is the further definition of the new job profiles characteristics. The results emerged from the AM-Motion skills survey reflecting the industry needs, therefore feed into the preparation of the qualifications' architecture underpinning this training system.

4. Conclusions

The AM-Motion survey consisted in an evaluation of employers needs in AM. Accordingly, it aimed to capture the state of play on AM skills in Europe and to better understand what are the needs of businesses implementing additive technologies. Concerning existing expertise in Europe, it emerged that competences in AM machine (including maintenance) and AM process are the most present among companies. AM design, arguably one of the most mentioned capabilities needed to reap the full benefits of additive technologies, came as third most cited reply. Together with it, there appear to be knowledge of post-processing operations, which may presumably be common with those for conventionally manufactured components (with a few exceptions). In terms of the highest educational level of AM workers within the organisation, Master's Degree graduates appear by far to be the largest group. PhD graduates, comparably much smaller, represent the second largest.

Companies acquired their AM expertise mainly through in-house training or collaborations with third actors. They were also much more willing to consider these routes to bridge existing AM competence gaps, which mostly revolve around skills for AM quality assurance and testing, as well as knowledge of regulatory standards, H&S rules applicable to AM and of IPR. The latter, in particular, was also among the least mentioned areas of knowledge possessed by companies at the time of survey compilation. The focus shown by

[11] http://www.cllaimprojectam.eu/
[12] http://admireproject.eu/

companies on boosting know-how in regulations and standards, together with strengthening capabilities in quality assurance, may be an indicator of growing attention to qualification and certification issues that are key for the broad adoption of AM.

Notably, the recruitment of academic or vocational graduates appeared to be much more rarely contemplated as a means to directly bridge current skills shortages. This result appeared to be common across the different educational qualifications included in the survey. Furthermore, when the survey asked how organisations got their AM knowledge, the hiring of Bachelor's, Master's, PhD or vocational graduates was not among the core routes selected either. Even for built-up capabilities, organisations prioritized in-house training and/or cooperation with external bodies. Some of the reasons provided by respondents help us in formulating a grounded justification as to why these dynamics emerged. Indeed, the general absence of work-ready graduates, able to smoothly settle into their company's new role, was voiced in the survey. A lack of sufficient AM-specific teaching within the educational context appeared to be a factor linked to this consideration. To deal with that, some of the organisations resorted to intensively training AM fresh graduates after having hired them, though the resources needed for this practice (especially in terms of time) were highlighted as considerable by some organisations. Further focus should then be dedicated on the real applicability, in a professional context, of the type of engineering and non-engineering knowledge acquired by students throughout their vocational or academic career.

To this extent, it must also be noted how Deliverable 3.6[13] "*Mapping of Educational activities*". of this project, while mapping existing AM-specific course offerings by European universities, highlighted the scarce availability of traditional post-graduate study programmes dedicated specifically to additive technologies, as well as the relative concentration of those few existing programmes in a very few countries only.

In light of the findings here presented, attention should be put by EU authorities on opportunities to support the development of an AM-specific, joint post-graduate programme encompassing several participating universities from a range of various European countries. The benefits of such a joint study course, which is already available in Europe for other subjects, lie in fostering cooperation between higher education institutions and researchers in an area — that of AM — where the AM-Motion consortium believes expertise is generally fragmented geographically.

[13] Deliverable 3.6 "*Mapping of Educational activities*"