Interreg Sudoe

ADDISPACE

# OUTCOME OF THE SURVEY ON METALLIC ADDITIVE MANUFACTURING (MAM) FOR AEROSPACE SECTOR

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# 1 INTRODUCTION

This survey aims at finding the requirements and needs of the Aerospace sector for producing components using Metallic Additive Manufacturing (MAM).

It is targeting both MAM providers and suppliers and Aerospace sector companies.

This survey takes place in the framework of ADDISPACE project (www.addispace.eu), financed by the European Regional Development Fund (ERDF) through INTERREG SUDOE programme (www.interreg-sudoe.eu).

ADDISPACE is born as a platform for the dissemination and transfer of MAM technologies to the aerospace sector in South West Europe. The outcome of this survey will help the ADDISPACE project to plan and run 4 pilots projects to leading to the development and transfer of MAM technologies better suited to answer the MAM and Aerospace sector needs.

If you want to keep informed about ADDISPACE you can register to receive our newsletter on www.addispace.eu

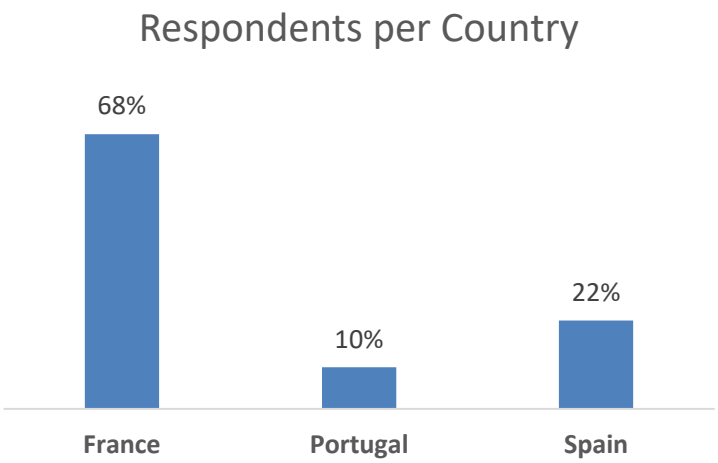
We thank you for your contribution to the survey that will take around 10 minutes of your time.

Information you provide when filling in the survey will be confidential, stored on Portuguese Aerospace Industry Association (PEMAS, www.pemas.pt) secure server. Information will not be treated on an individual basis and will not be forwarded to any Third Parties outside the ADDISPACE consortium.

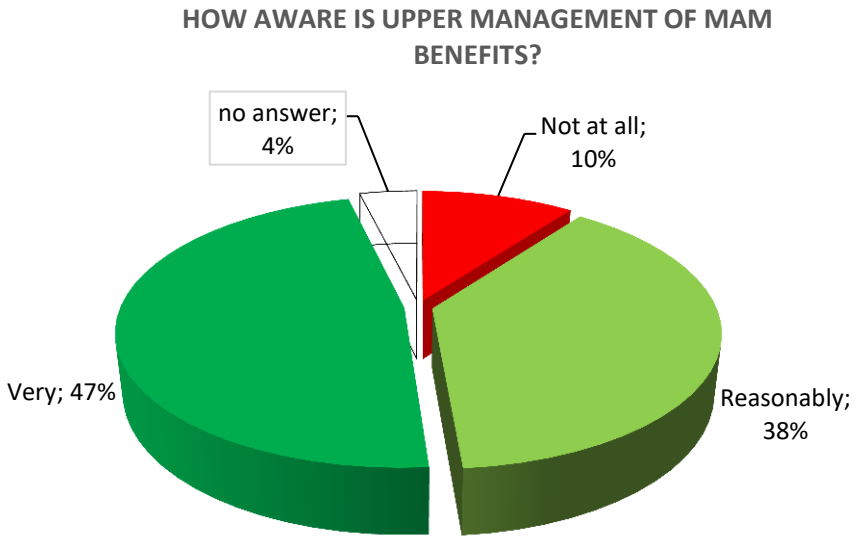
# 2 THE RESPONDENTS

The first part of the survey was aiming at identifying the respondents base and defining the border conditions to confirm the respondent's base.

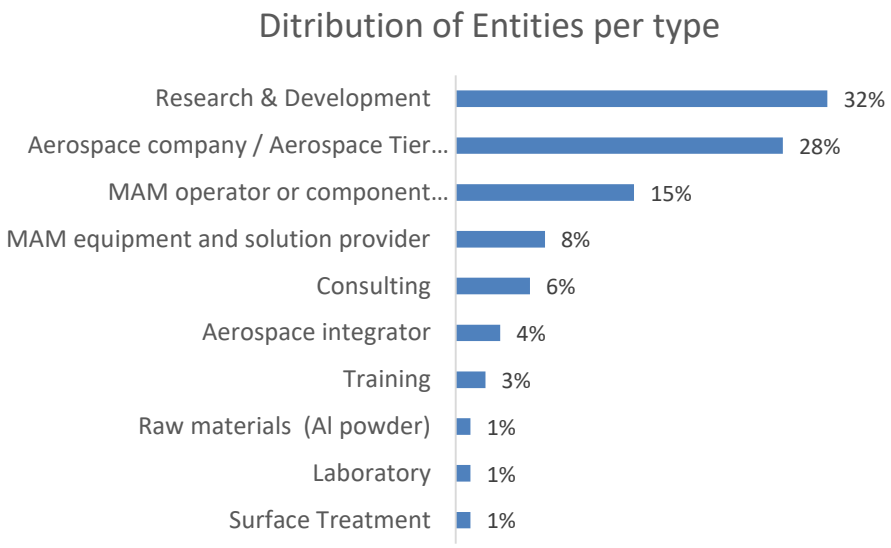
A total of 78 entities from the Aerospace community in the SUDOE region, encompassing Portugal, Spain and France have answered this survey.




According to the outcome of the survey the internal awareness of the respondents and their Upper Management is higher than 85%, which set the ground for educated decisions on future MAM investments.

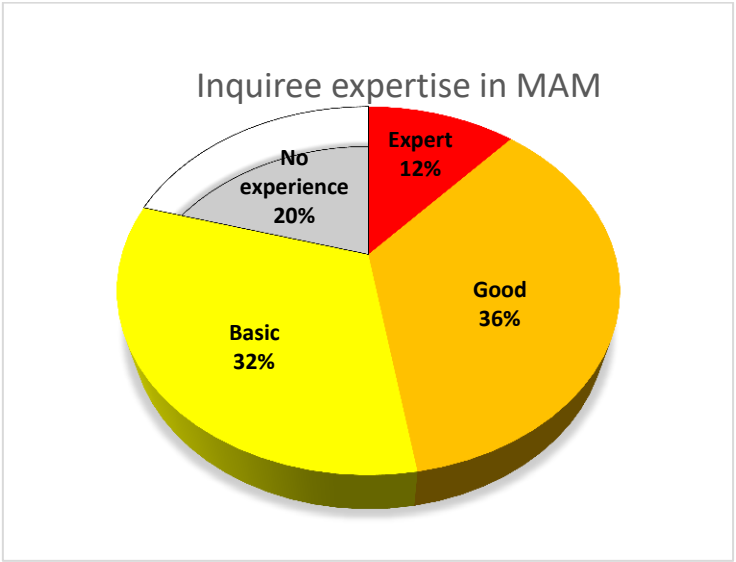


The distribution of entities that have participated in the survey reveals that R&D centres are strongly represented (33%), but industry altogether represents 2/3 of the respondents base. This confirms the strong interest industry is showing by this specific area.




In terms of profile base, 80% of the participants in this survey are aware of the features and informed about Metallic Additive Manufacturing, and 48% are on a very good condition to provide proper technical feedback and educated contributions.

These results show the respondents base is statistically relevant and has a good level of expertise in the specific MAM area.

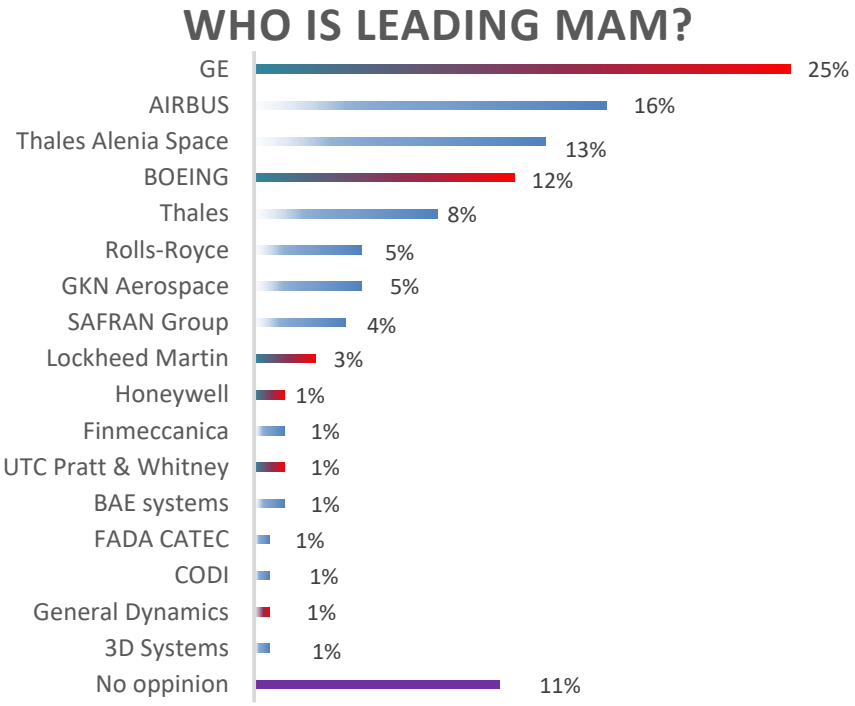


# 3 MAM FOR THE AEROSPACE SECTOR

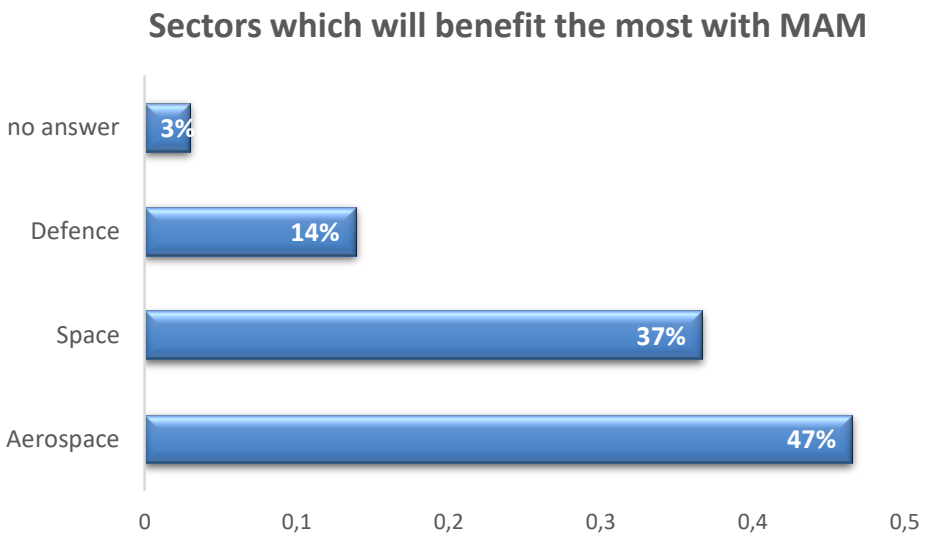
The second part of the survey aims at characterizing the applications of MAM to aerospace sector.

The respondents stated that in their educated opinion the world market will be 68% dominated by European based companies.

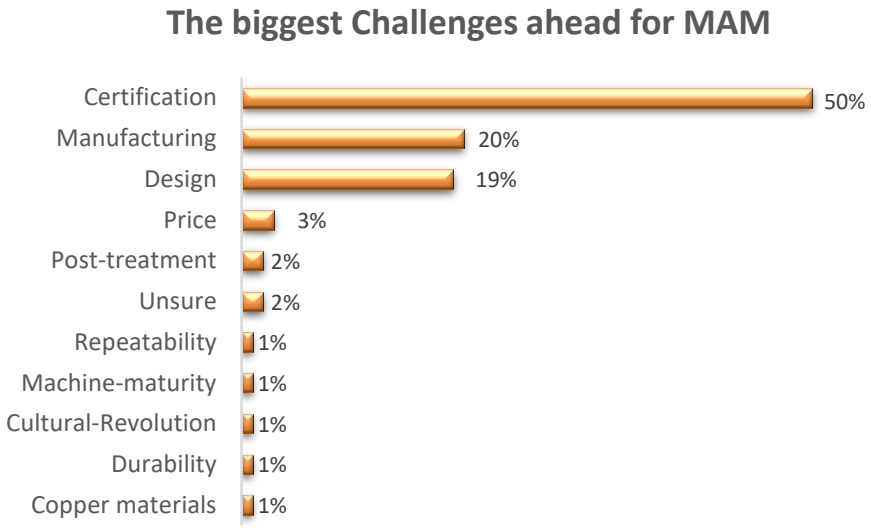
It also relevant the overall value of 5 largest integrators and manufacturers (GE, AIERBUS, BOEING and Thales and Thales Alenia Space) will by far dominate the MAM market worldwide by almost 75%. Interesting the fact only 10% of the respondents base showed "no opinion".



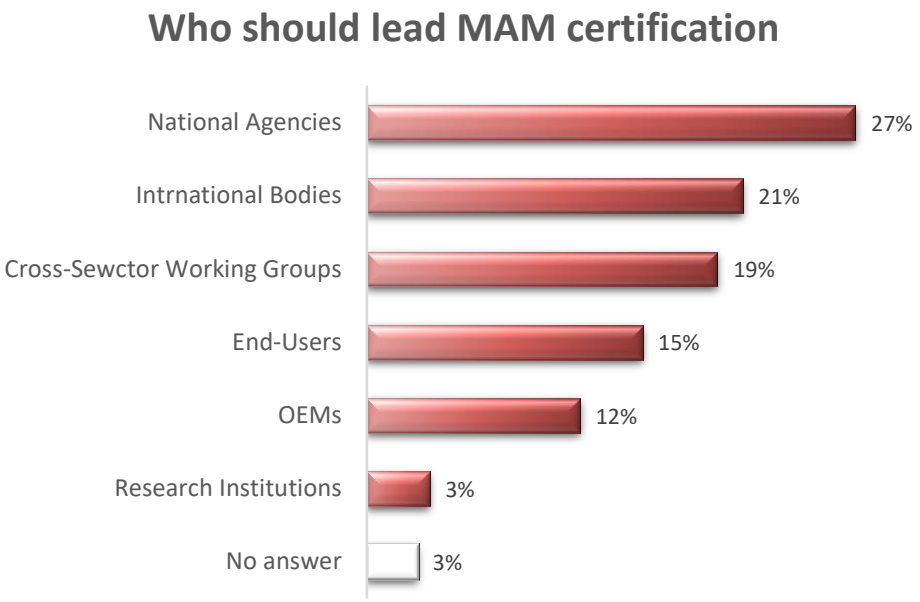

In terms of distribution of benefits per sector the outcome is also clear showing the aerospace and space sectors together will monopolize the benefits (84%), and not so much the Defence sector (14%)- Again only 3% of the respondents did not answer.



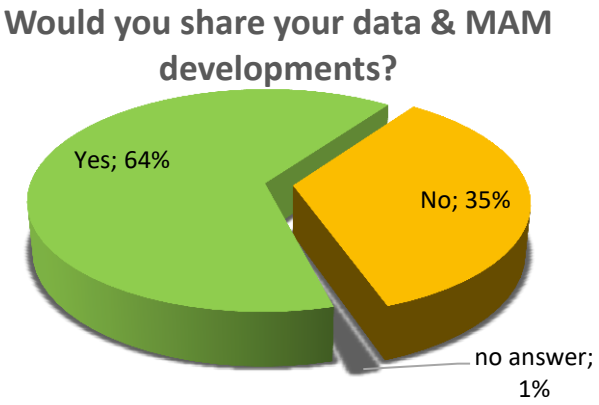

Among the several challenges ahead of MAM, the survey outcome has identified that 3 alone are in the back of the respondents concerns, with Certification being consensual in 50% of the answers. Manufacturing and Design share around 20% of the share of opinions. This is clear message for setting the priorities and the next support activities.



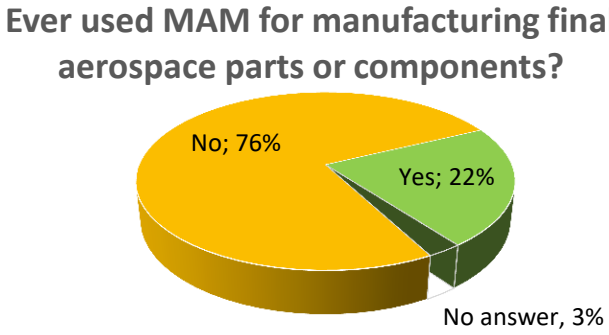

The respondents also stated clearly that Certification efforts should be led by National Agencies or International bodies (48%), with a clear articulation with cross sector working groups, end-user and OEM (56%). According to the outcome R&D institutions got a residual 3% should not contribute to this task.



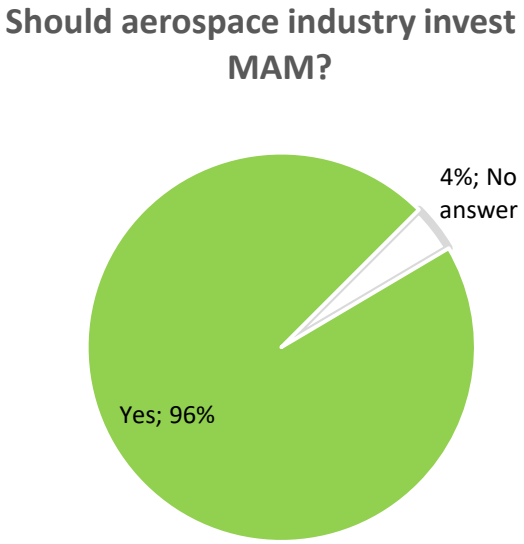

A very interesting outcome is the 64% willingness of the respondents to share data and developments, which is twice higher than the 32% R&D respondents base of this survey. Only 1% did not answer this question.




It was possible to identify a relative immaturity of the MAM sector reflected on the fact the large majority (76%) did not use MAM for manufacturing final aerospace components or parts, and this result is further validated by the fact only 3% did not answer.




If there were any doubts about the relevance of MAM to the Aerospace sector, the bulk 96% positive answer the respondents base gave to "should industry invest in MAM" said it all.



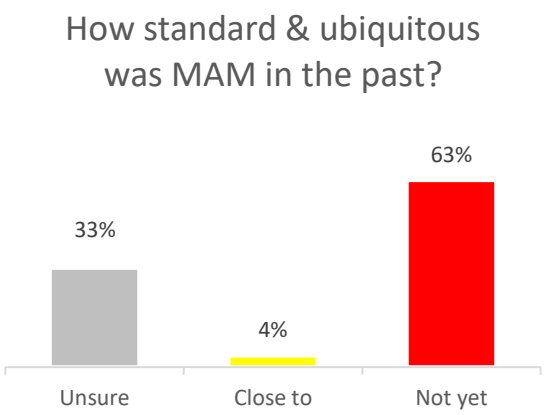

The reasons listed for "Why should the aerospace industry invest in MAM" gave an extensive list of arguments, among which:

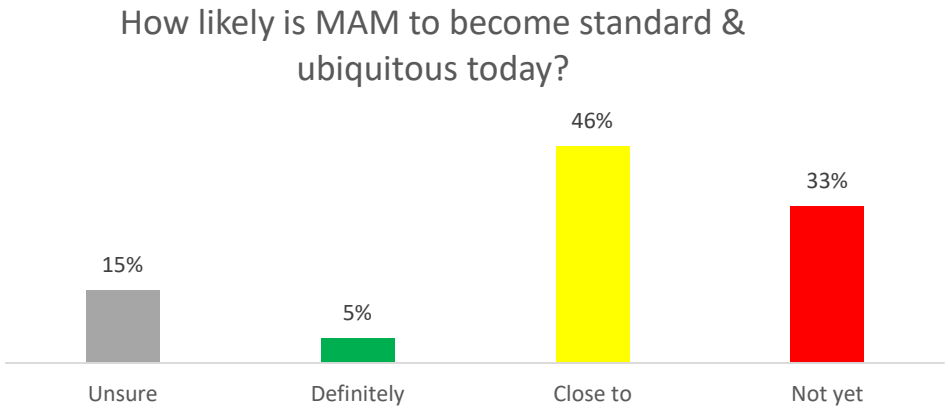
- Accelerate design changes, prototypes
- Act as a pilot industry
- Amount of investments
- Big possibility of evolution
- By the speed of manufacture and the versatility of forms
- Competitiveness vs conventional machining up
  Multidisciplinary production
- Disruptive technology in free form Design with great development possibilities in New processes and New materials.
- Flexibility and adaptability of production capacities for special products such as

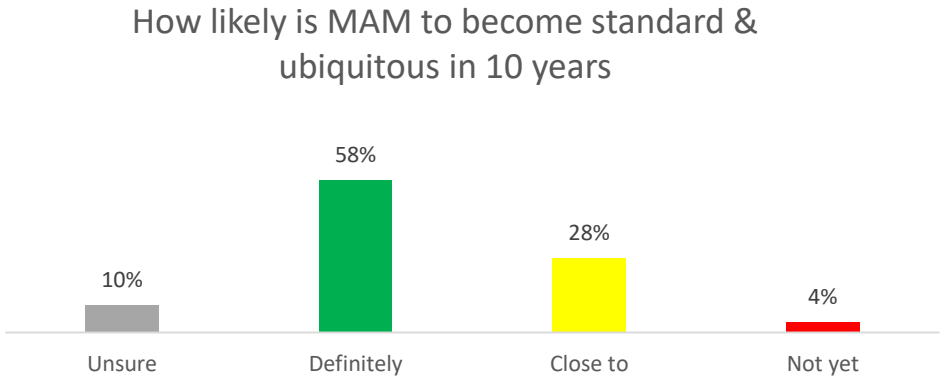
aircraft.
- For savings in cost and weight
- Future technology that will complement conventional manufacturing methods
- Little waste of material.
- Major benefits: Cycles, REX
- MAM techniques are still, in my opinion, at an undeveloped stage, especially in material studies and in the combination of various materials.
- Optimization and improvement of the product (more efficient products).
- Stability of optimized designs
- They must, together with other institutions, build and structure the additive subcontracting chain
- Time To Market reduction; Integration New functions; Relocation

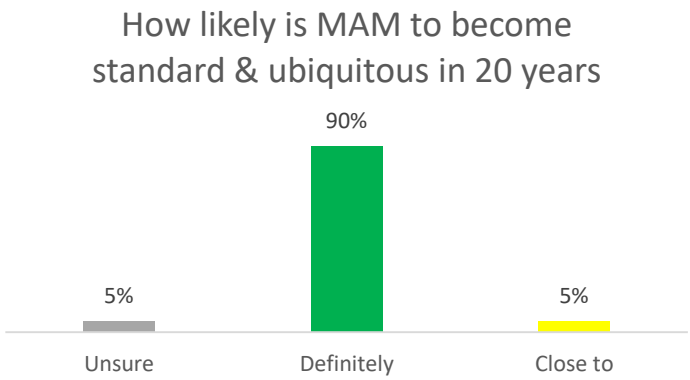
Given the relative immaturity of the MAM technology for aerospace applications, the respondents were asked to give a prospective view of how long will it take to MAM become an effective aerospace and used ubiquitously for industrial applications. A timeline was drawn from the past up to the next 20 years (see graphs below). The outcome shows a clear road to MAM becoming gradually standard and ubiquitous. The past has proven that MAM is "not yet" there by 63% but today there is a clear reduction to 33% and it is expected to vanish in 20 years.

The confirmation that MAM is walking to standardization is the behaviour of the bars "close to" and "definitely", showing that today almost 50% of the respondents know MAM is close to industrial application in aerospace, reducing to only 28% in 10 years and 5% in 20 years. This is followed by the increase of the confidence the MAM technology is only taken today by 5% but will definitely be there in 20 years by 90% of the respondents. Another interesting outcome is given by the number of "Unsure" answers which decreases from the present 33% to 5% in 20 years, reassuring the gradual acceptance of MAM technology in the next 2 decades.


How standard & ubiquitous was MAM in the past?
33%
4%
63%
Unsure
Close to
Not yet

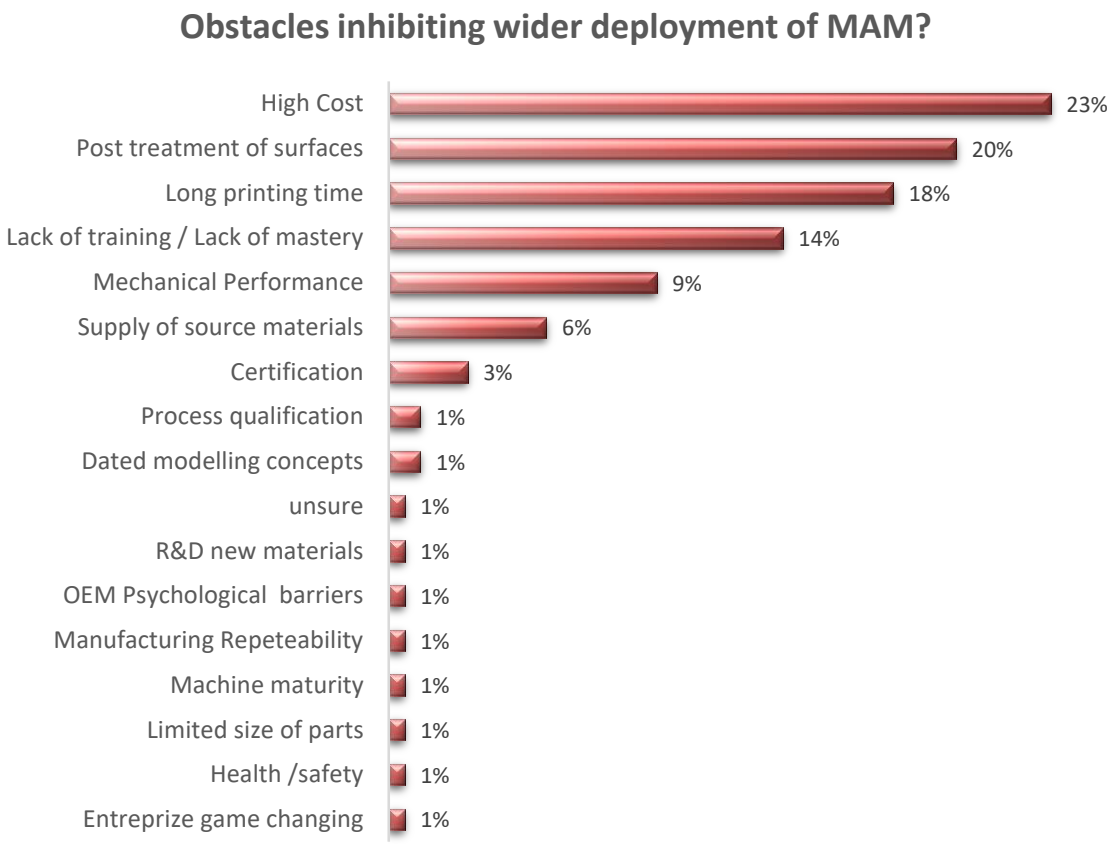

How likely is MAM to become standard & ubiquitous today?
15%
5%
46%
33%
Unsure
Definitely
Close to
Not yet


How likely is MAM to become standard & ubiquitous in 10 years
10%
58%
28%
4%
Unsure
Definitely
Close to
Not yet


How likely is MAM to become standard & ubiquitous in 20 years
5%
90%
5%
Unsure
Definitely
Close to

The respondents have also identified the main obstacles inhibiting a wider deployment of MAM to the Aerospace sector,. The outcome show the High Cost (23%) of production is the main factor, followed by the need for post surface treatment of surfaces (20%) and the long printing time (18%) it currently takes.

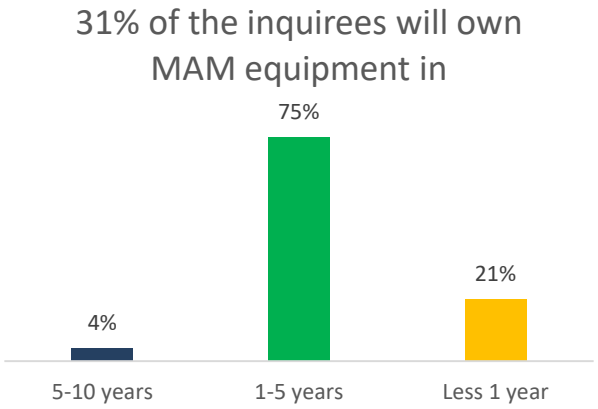
In terms of surprizing results one can point the fact "Lack of skills and training" (14%) coming before the technical concerns with mechanical performance (9%). Another interesting result is the fact "supply of source materials" now shows low impact (6%) reflecting the increase in the number of suppliers worldwide.



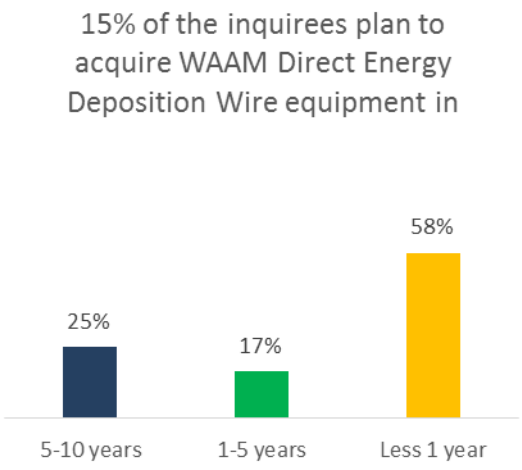

The inquiry tried to identify the prospective timeline for entities to start using MAM equipment and 31 of the respondents (40%) stated they are planning to use this technology. 85% of these entities will be using MAM within the next 5 years.

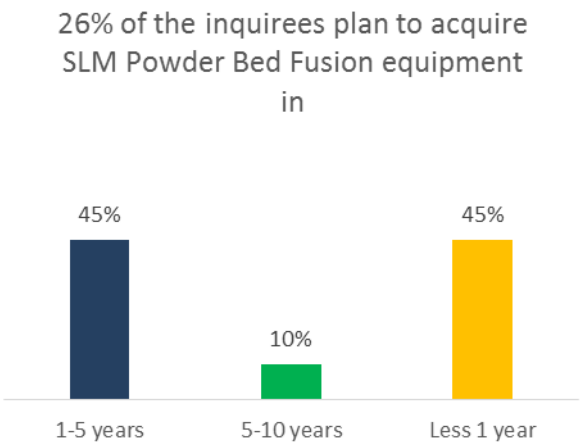

Furthermore, this survey tried to reveal the perspectives for MAM in terms of research and industrial activities, acquisition of equipment, subcontracting, prototyping and manufacturing of aerospace parts.

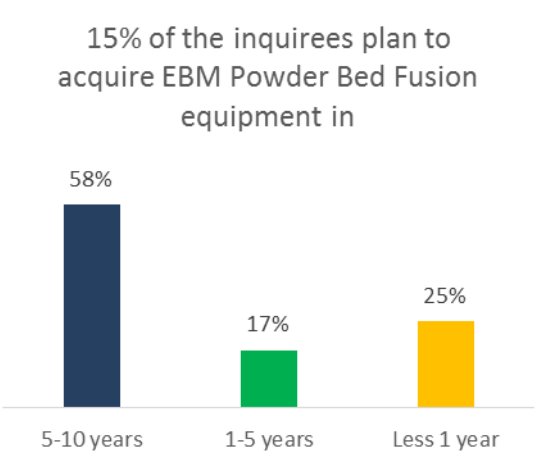
The outcome shows that 31% of the entities will own MAM equipment, and from these the large majority (96%) are planning to acquire equipment in less than 5 years.

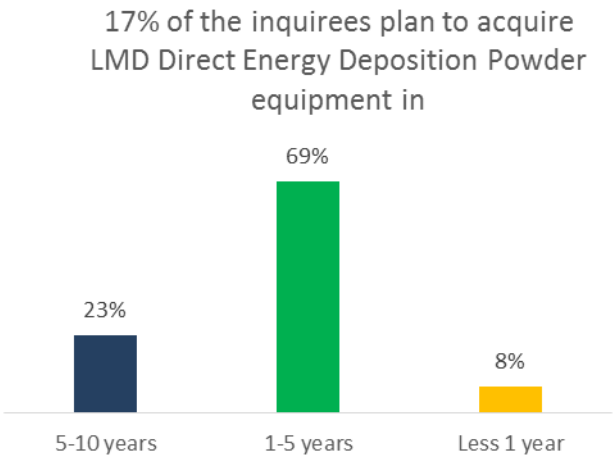


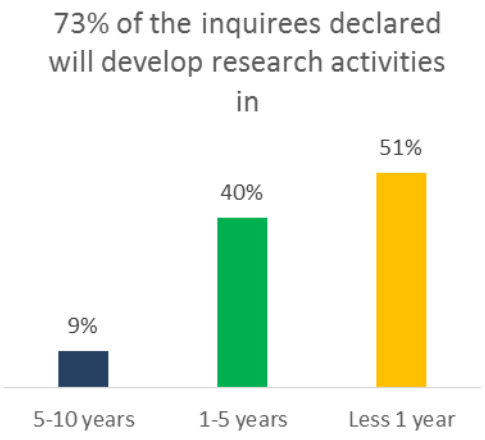

When asked about the type of MAM equipment to acquire the answers showed 26% prefer SLM Power Bed fusion, 15% EBM Power Bed fusion, 17% prefer LMD Direct Energy Deposition and 15% plan on WAAM Direct Energy Deposition. The time frame for acquisition strongly varies with the chosen technology as graphs show.

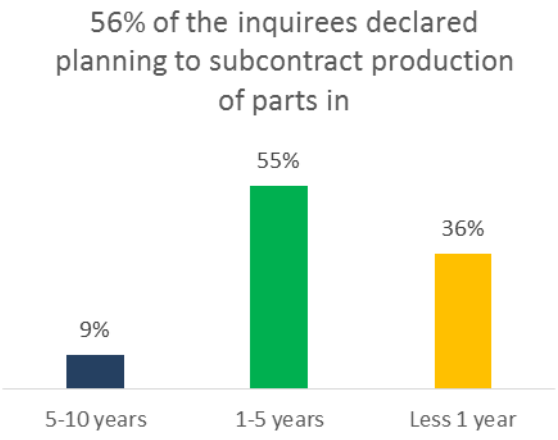


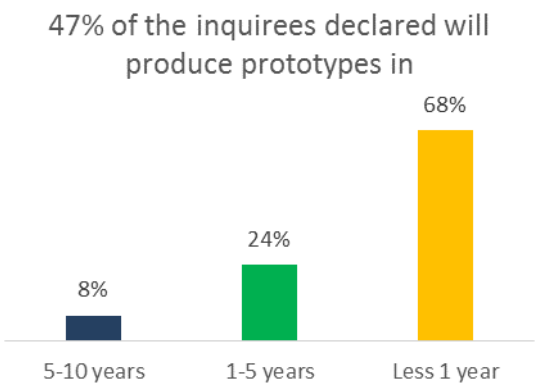



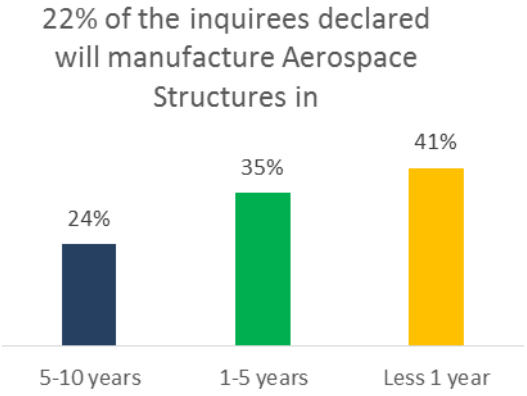



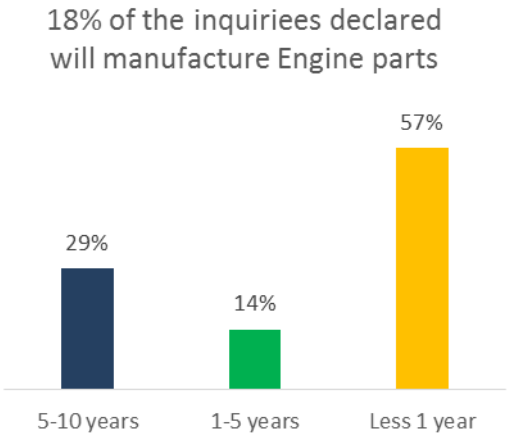



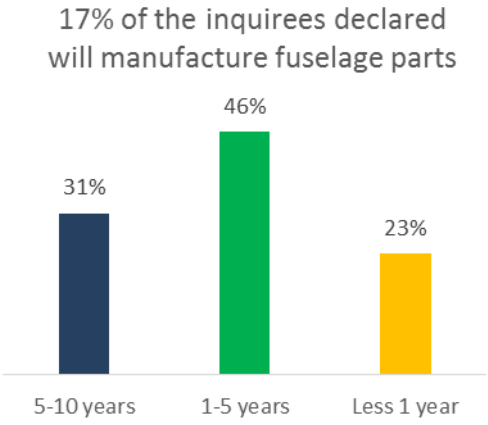




In terms of planned R&D activities, 90% of the enquiries stated they plan subcontracting MAM production or prototypes and 73% of the entities mentioned will invest in R&D activities within the next 5 years.



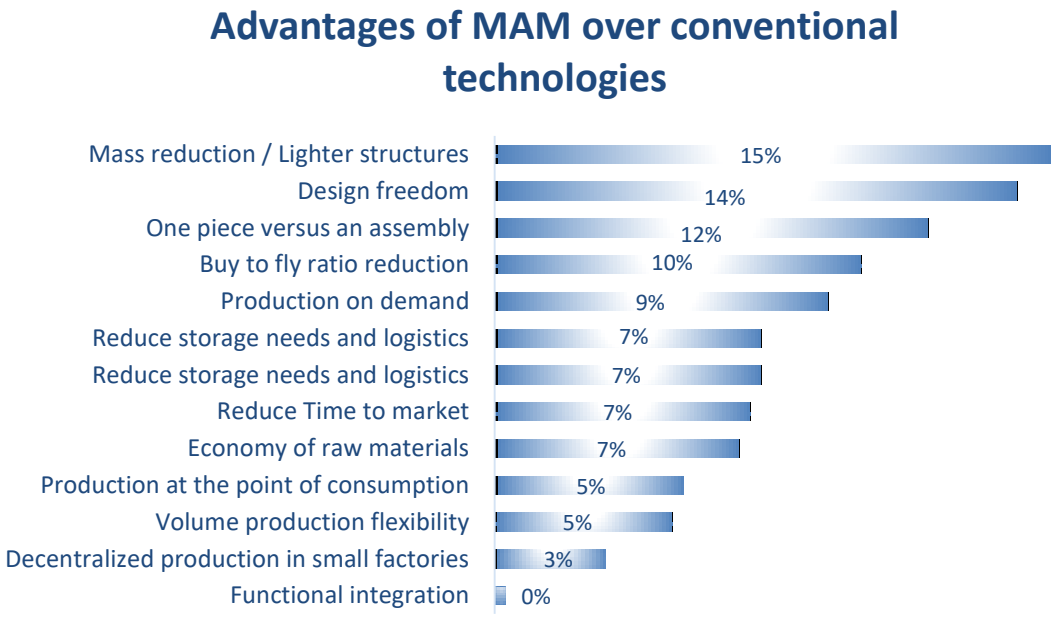



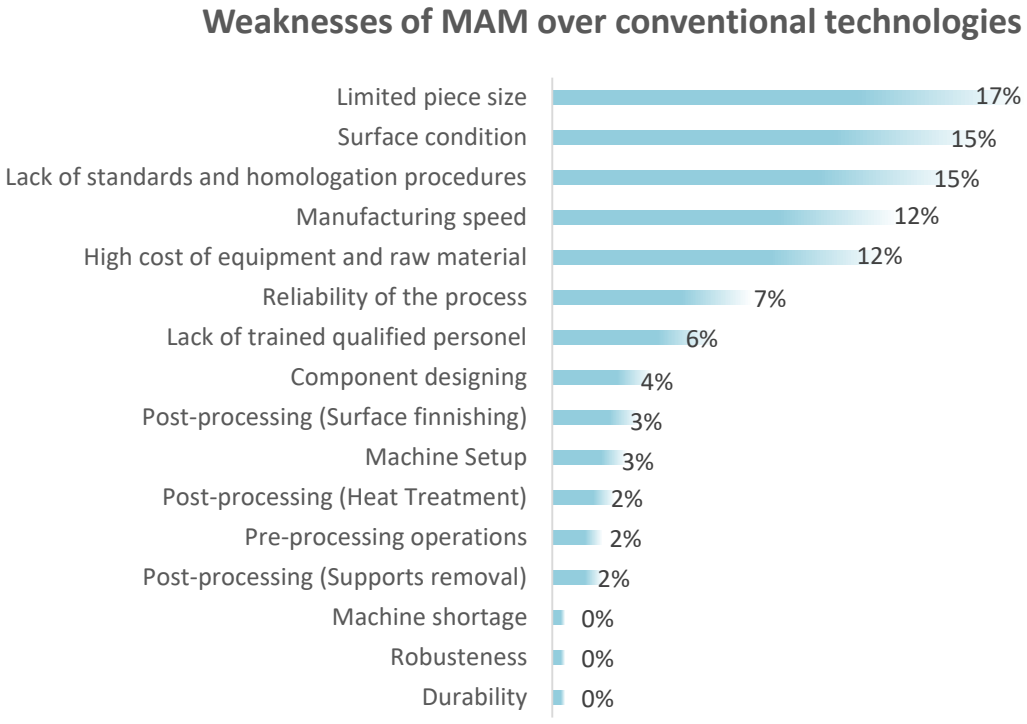




In what concerns industrial activities 47% will very soon producing prototypes, and from these 22% will focus on manufacturing aero structures parts, 18% engine parts and 17% fuselage parts..

The search for the reasons why MAM is so appealing led to the question on advantages over conventional subtractive technologies. The respondents have selected as top five advantages for preferring MAM, the reduction of mass possible with MAM, the freedom of design in conceiving the parts, the possibility to print directly from CAD in one single piece instead of an assembly of many parts, the Buy to Fly ratio clearly favourable to MAM and the production on demand. All these 5 top reasons show similar importance (between 10-15%).



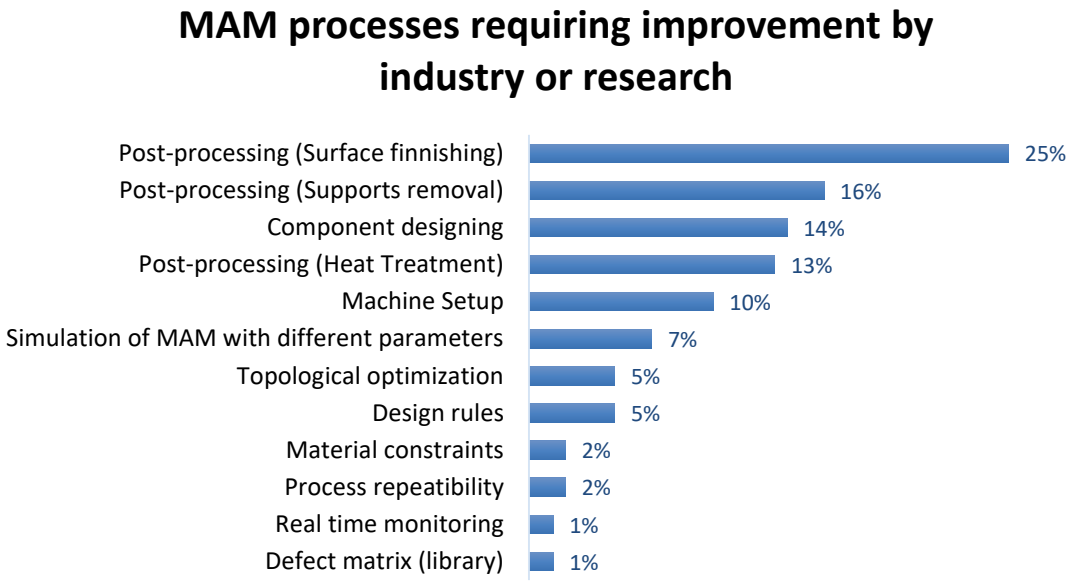

But MAM also has its share of weaknesses. The respondents have mentioned the top five weaknesses to be the current maximum size limits (100cm x 50cm) of parts, the surface condition of the printed MAM parts which requires finishing, the lack of standards and homologation procedures for MAM, the low manufacturing speed of current machines and the relative high cost of equipment and raw material.



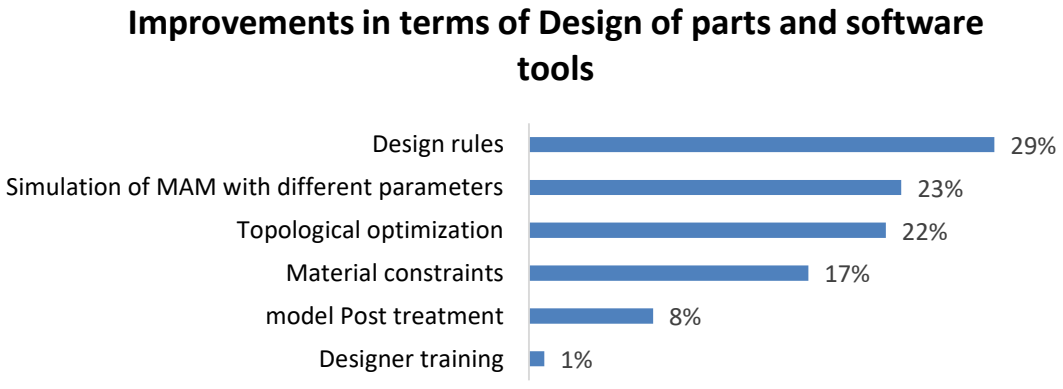
# 4 MAM TECHNOLOGIES FOR AEROSPACE

Respondents were also asked to specify the improvements required for MAM in terms of processes, technologies, design and integration with other technologies or processes.

According to the survey outcome, the processes that require close attention and improvement are post processing (surface finishing, support removal and heat treatment), part design and machine setup. Together these processes gather 68% of the answers.



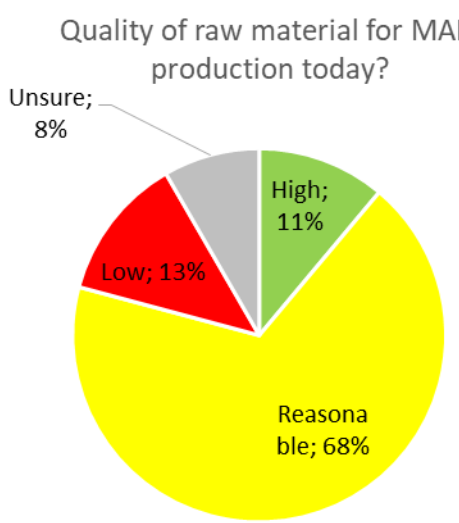

In what concerns design of parts and software tools, the respondents mentioned improvements are needed mainly for setting rules, simulation of MAM, topological optimization and material constraints.

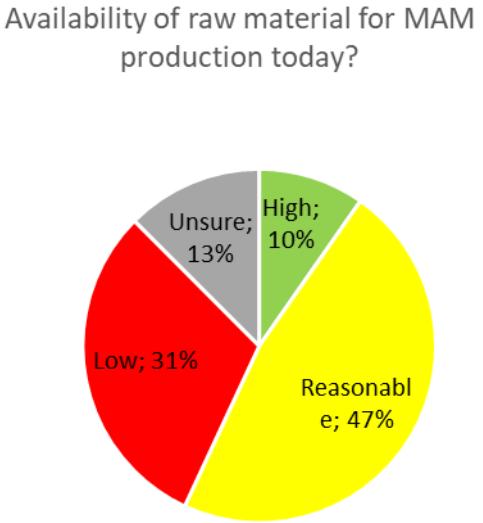


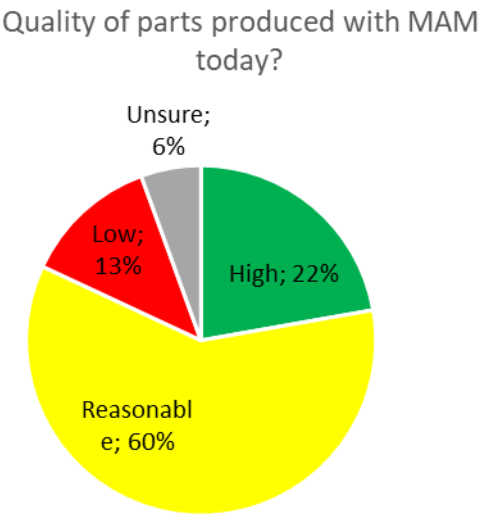

The respondents have also listed their perspectives and suggestions for integrating MAM technologies with other manufacturing processes, namely:

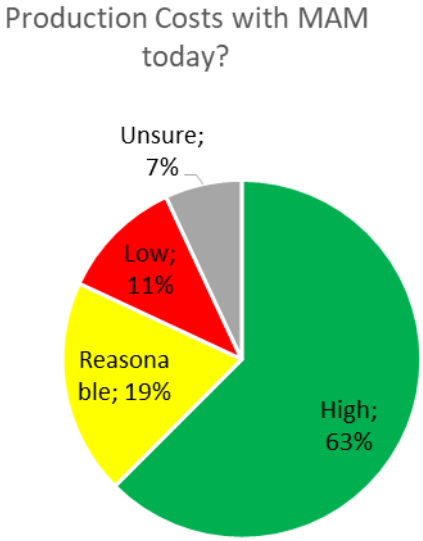
- MAM and subtractive manufacturing are complementary given the different parts and topology requirements
- Integration critical in the future
- Hybrid machines for niche markets
- MAM development time is lower than in other technologies
- Traditional technologies are complementary to MAM as they are needed for surface treatment and support removal

Raw material is seldom referred as a huge constraint either for quality, availability or costs. The inquiry tried to identify the situation of raw material from the different perspectives and describe the problems or defects, benefits and issues with inspection.

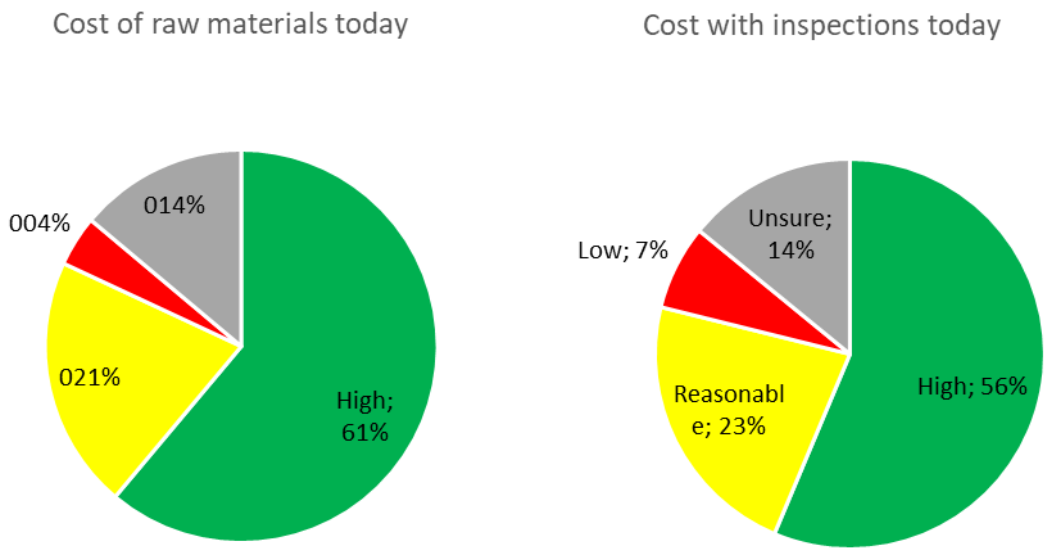


The outcome shows that raw material is nowadays well above reasonable both in terms of quality (79%) and availability (57%). Quality of parts currently produced with MAM is considered well above reasonable (82%) but production costs, raw material costs and inspection costs are clearly considered too high by the majority of the respondents (over 56%).




The respondents were asked to list and identify the main problems or defects with MAM and the result was the following:

- Variability of raw materials
- Availability
- Certification and control of parts
- Control defects in raw materials
- Control of distortions and material contamination
- Defects on parts submitted to stress conditions
- Deformation depends on heat treatment
  Post-processing (not mechanical surfaces)
- Lack of elasticity, lower conductivity and resistance to corrosion (lack of mechanical and dimensional reliability)
- Limited size of parts
- Monopoly of the powder and machine suppliers
- Need production capacity for Finishing
- No homogeneity of manufacturing processes
- Parts properties depend on the production environment
- Post-treatment cost too high
- Production costs too high
- Raw materials characteristics are not related with performance of parts
- Thermal exchanges
- Variability of the dynamic features

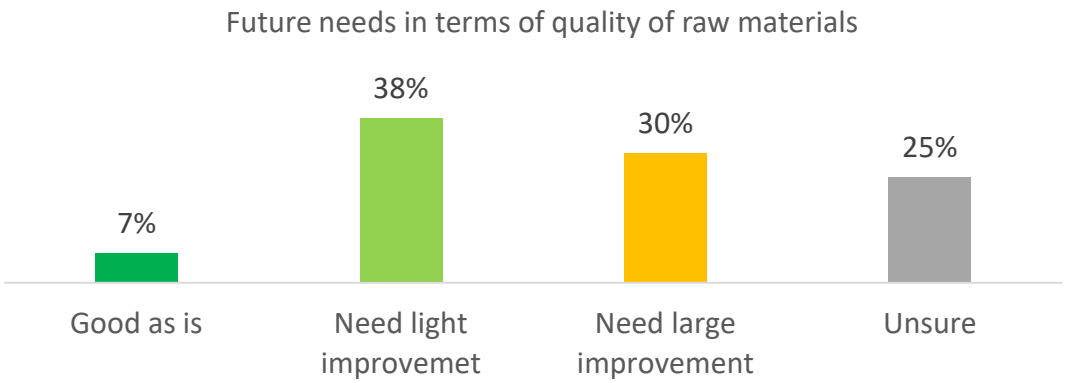
The respondents were asked to list and identify the main benefits of MAM both in materials and parts, and the result was the following:

- Reduction of the production cycle
- Complex geometry, fast implementation and low cost
- Creating complex parts
- Freedom of form, optimization
- Reduced weight, improved function and assembly.
- Speed of production
- Capacity to produce unique parts for specific requests
- No need to stock
- Reduce time to market
- Development of New Materials

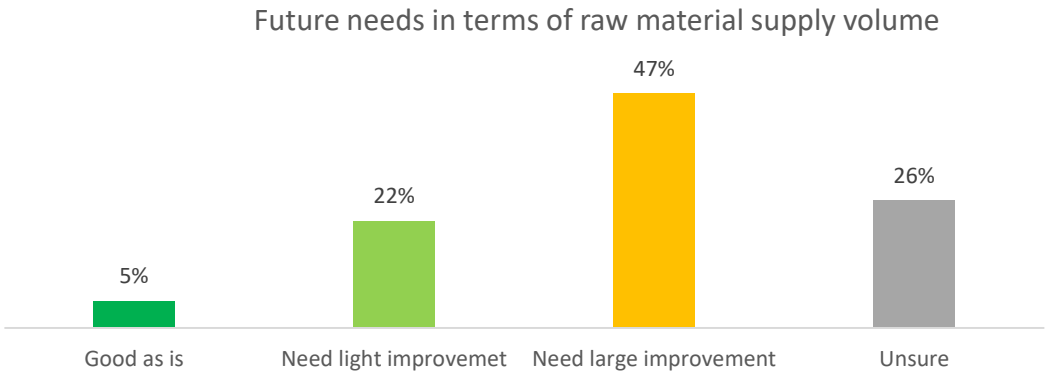
The respondents were asked to list and identify the issues with inspections, both in materials and parts, and the result was the following:

- Inability to measure due to geometric complexity
- Dificult to detect microporosities
- Certification is not defined
- Characterization of residual contraints, cracks or defects due to fabrication.
- Cost of materials and resources X Ray, Tomography, inspection)
- Defects depend on process and parameters
- Dimensional control using the 3D model. No Notion of 2D plan
- Inexperience of inspectors
- Inspection by sampling is not possible given the variability found under the same production conditions
- Inspections on parts depend on the system under which the part was produced and the level of criticity of the part
- Lack of industrial and material training
- Lack of inspection procedures
- Lack of library for calculations and supprt to manufacturing (abacus, statistical curves)
  Repeatability on series.
- Real time control during the production process is a must, allowing control and correction in real time for producing 100% defectless parts
- No feedback on the functioning of the controls

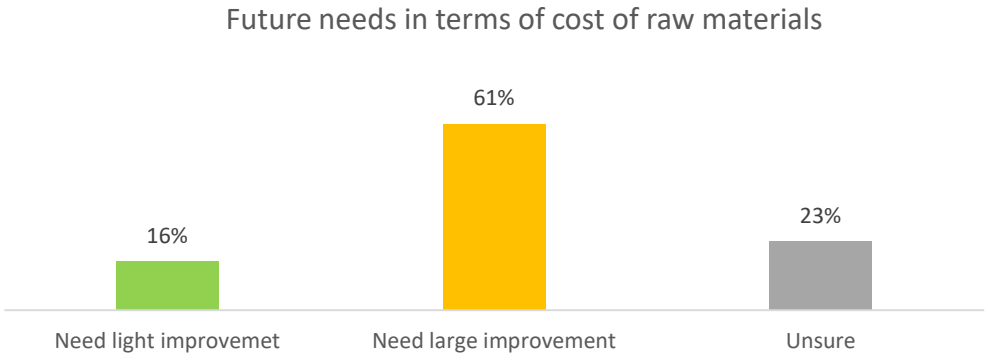
The MAM future needs in terms of raw material, was addressed by the survey. The outcome shows that quality of raw material isn´t good enough and requires improvement with experts divided almost equal parts between a large or sligh improvement.



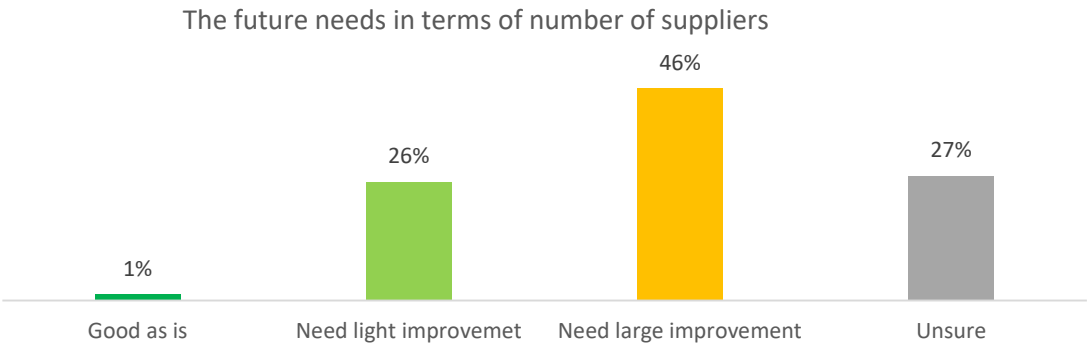

The future needs in terms of raw material supply volume also shows the situation isn´t good and requires improvement and mostly large improvements.



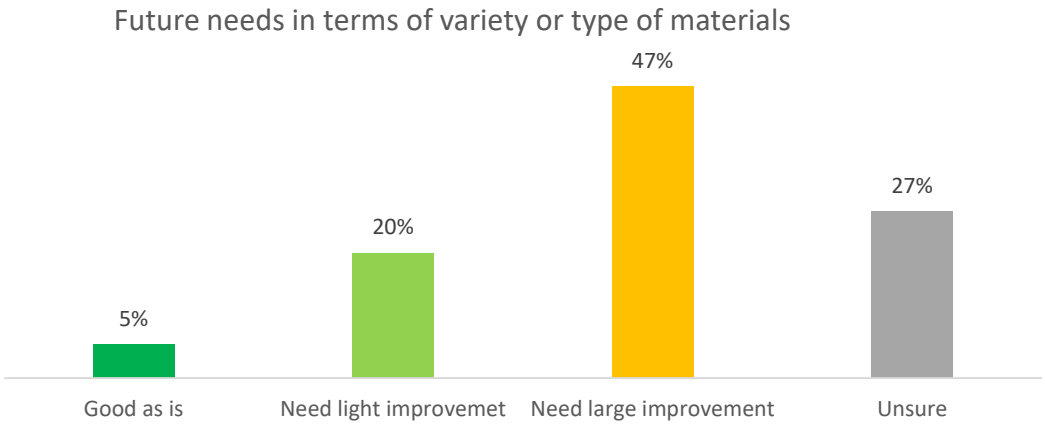

The need for future reduction of raw material's cost can clearly be deducted from the survey outcome with 77% of the respondents identifying the need for improvements.



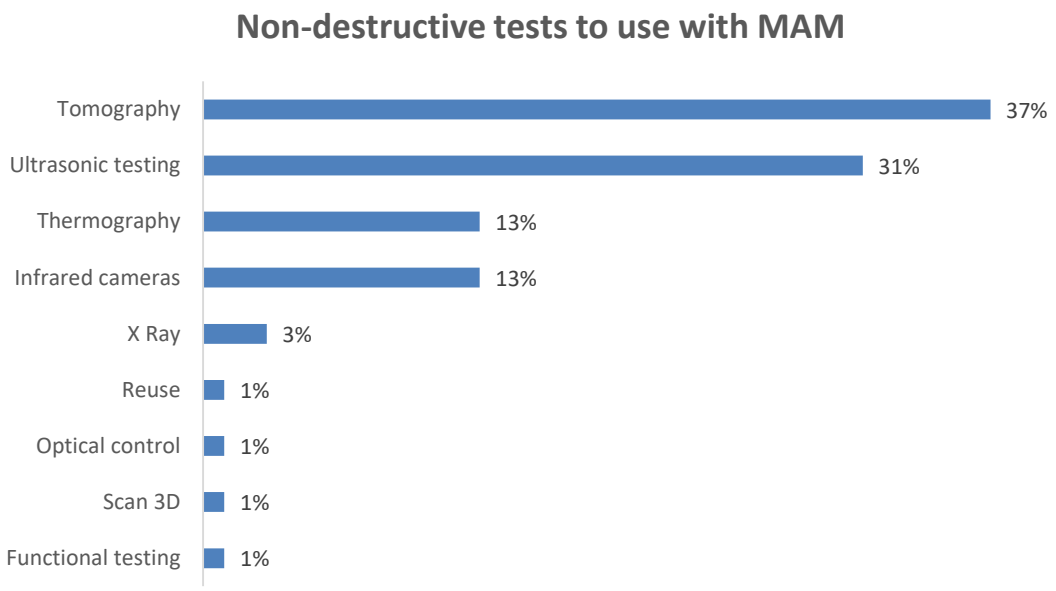

The need for future increase in the number of suppliers is clear from the results of the survey with 72% of the respondents referring the need for improvement.



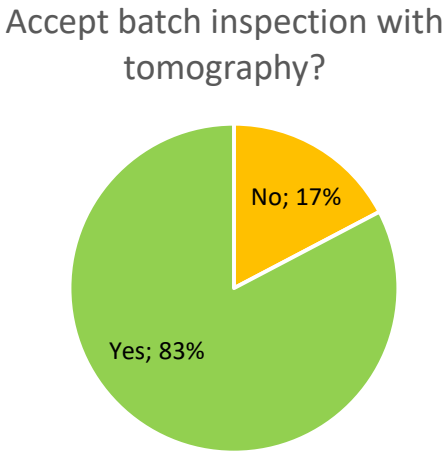

The need for future increase in variety (or type) of materials was also identified in the survey with 47% of the respondents referring the need for large improvement.




The respondents were asked to identify the non-destructive tests they suggest for MAM. The result shows Tomography, ultrasound, thermography and infrared cameras are clearly preferred over XRay.



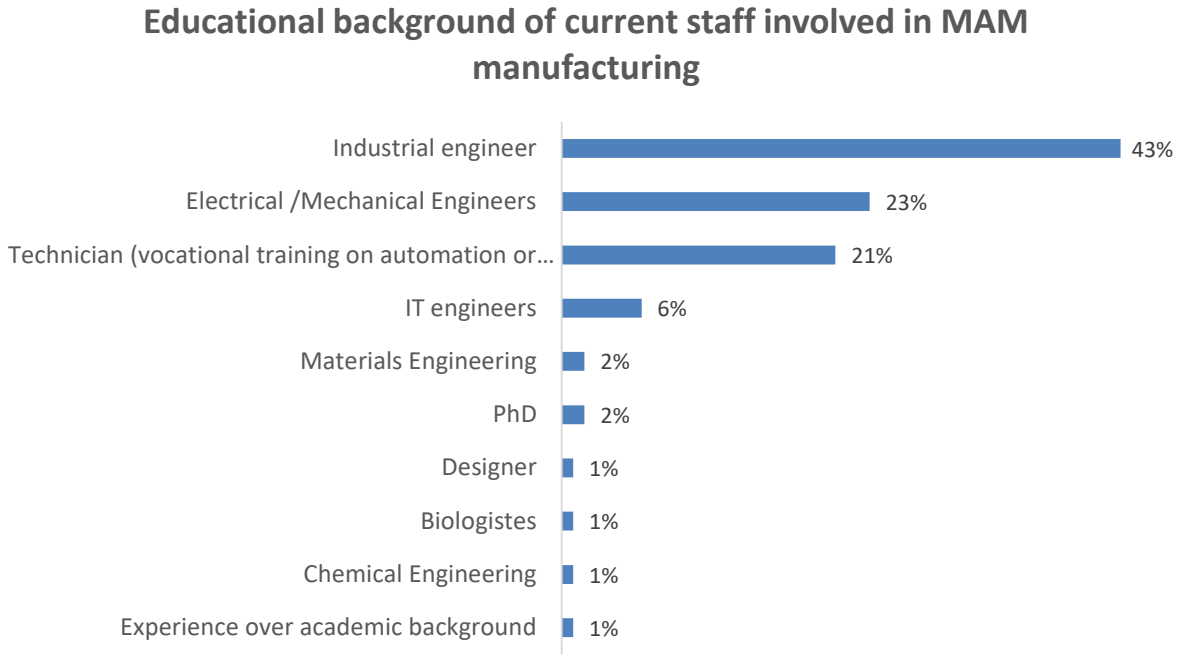

It is widely accepted that alternative processes such as Metallic Additive Manufacturing requires every part produced to be screened and tested. Yet 83% of the experts answering this survey agree that an inspection method based on batch tomography could well be used.



# 5 HUMAN RESOURCES AND TRAINING

HR is crucial for MAM, therefore the inquiry should focus on HR related issues.

The first HR related question aimed at identifying the educational background of current staff currently involved. The result shows that Industrial, electrical and mechanical engineers are clearly leading these positions in 66% of the respondents. Interesting the high number of Technicians (21%) involved.

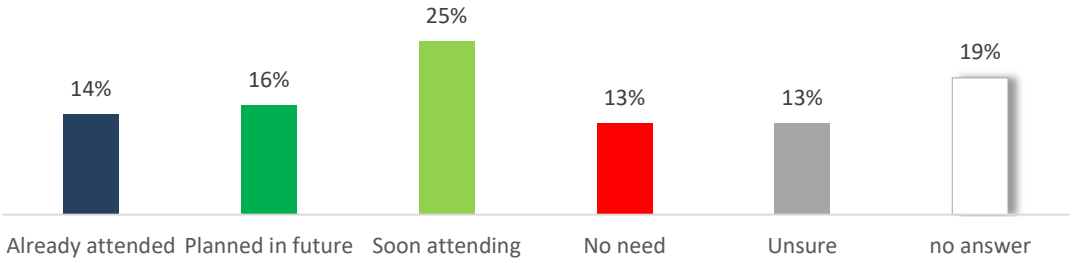



Current and future HR needs were also addressed by the survey. Such needs were considered in different areas and for different profiles.

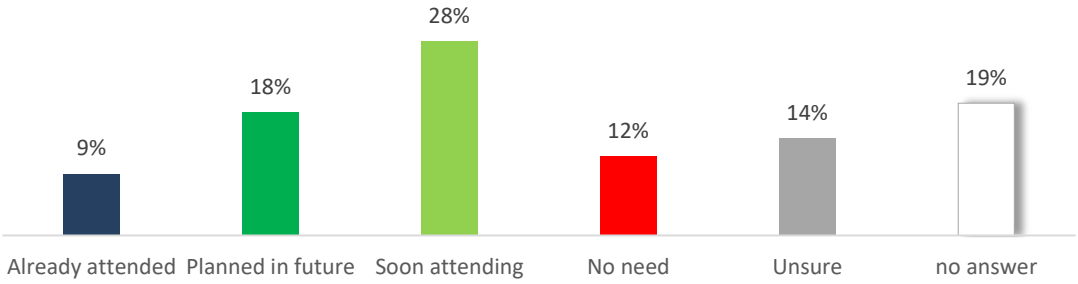
In terms of HR needs the areas considered were Topological optimization, Process & Regulation, Design rules, non-destructive control and surface finishing. The result of this inquiry per areas (below) shows that globally 81% of the respondents answered the questions but 14% in average were “unsure” about their training status or future training needs. Interesting to see that between 10 and 19% of the respondents have no future training needs on MAM. Interesting to conclude that between 9-18% of the respondents claim to have “already attended” specific training on those MAM areas.

In all other cases where training needs are identified, and across all areas, the highest rate always goes to “soon attending”.

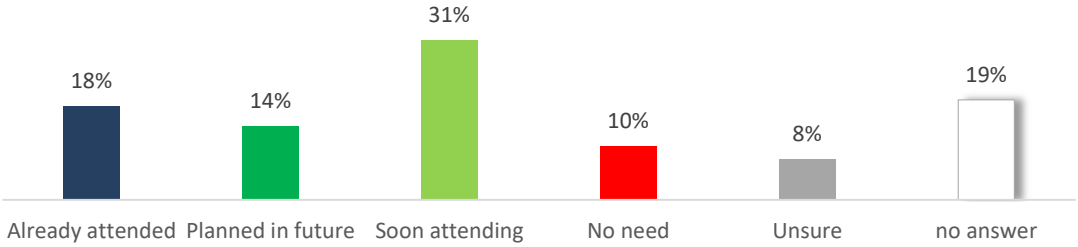
MAM current training status and future needs on Topological Optimization



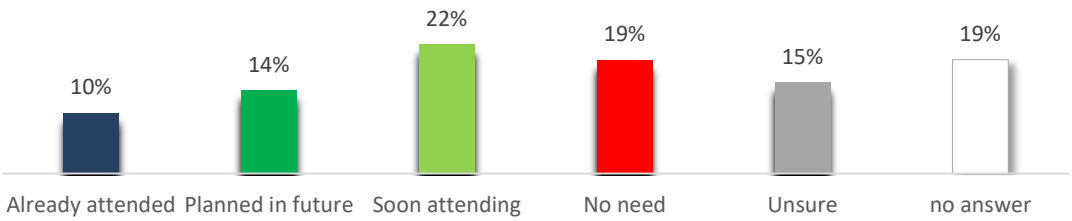

MAM current training status and future needs on Process & Regulation

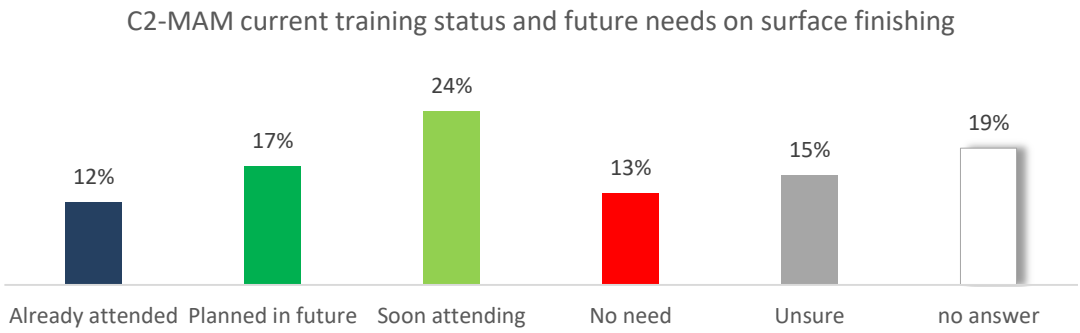


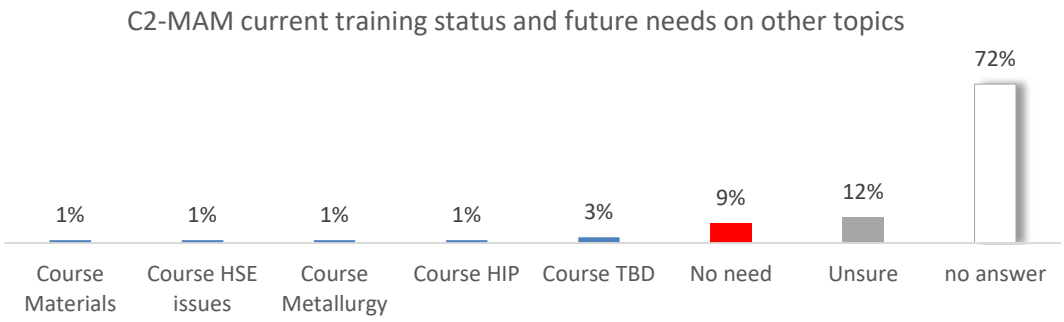

MAM current training status and future needs on Design Rules



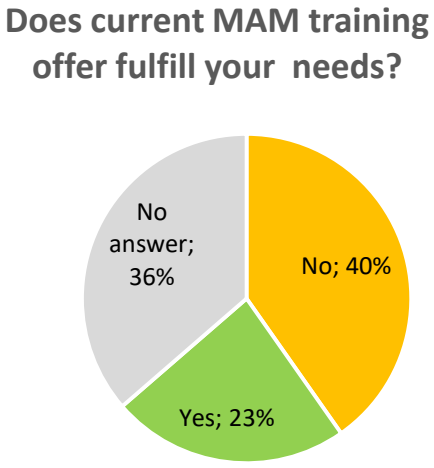

MAM current training status and future needs on Non Destructive Control



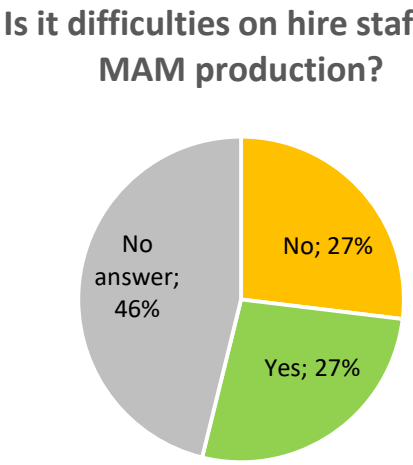



The answer to the question on available training offer has received a clear negative answer from the respondents (40%).

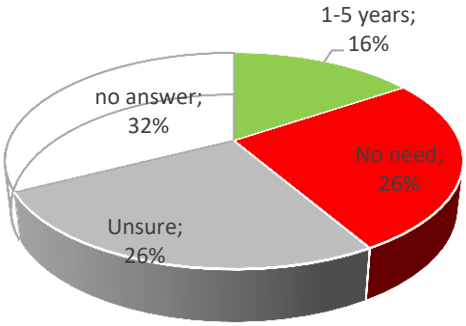



The question "How difficult it is to hire staff for MAM production" received from the respondents a balanced answer with both claiming 27%.

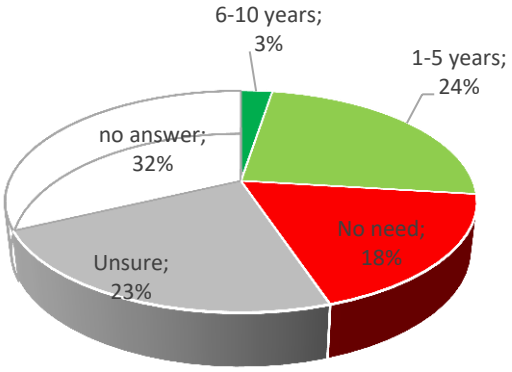



In terms of HR needs the profiles considered were Researchers, Designers, Controllers and Machine Operators. The result of this inquiry per profile (below) shows that globally 64% of the respondents answered the questions but 23% in average were “unsure” about their training status or future training needs. Interesting to see that between 18 and 27% of the respondents have no future training needs on MAM. Interesting to conclude that for all profiles there is intention to hire between 19-27% more staff in the next 10 years.

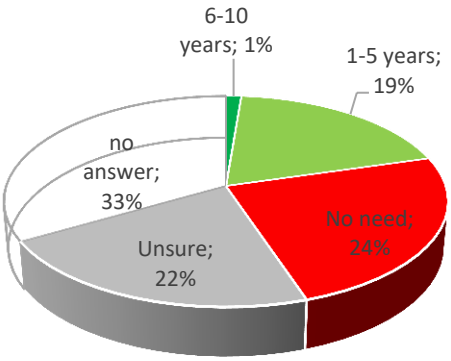
Plans to hire new staff - Researcher



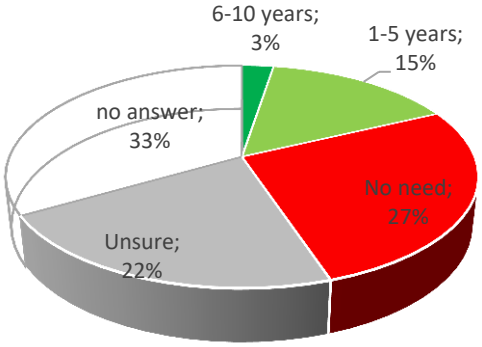

Plans to hire new staff - Designers



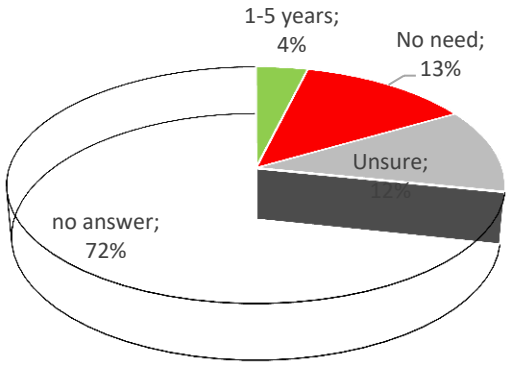

Plans to hire new staff - Controller




Plans to hire new staff - Machine Operator




Plans to hire new staff - Other



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