**THE SAM PROJECT**

**Advanced Manufacturing** is one of the key enabling industries for sustainable economic growth, being Additive Manufacturing (AM), more commonly known as 3D printing, widely used in a wide range of Manufacturing processes or technologies applications.

As Europe seeks to retain its leading position in industrial competitiveness, there is an urgent need to establish a platform for AM skills at European, National and Regional levels. To meet this challenge the project Sector Skills Strategy in Additive Manufacturing (SAM) started in January 2019 and will run for 4 Years.

**SAM’S MAIN OBJECTIVES ARE:**

A Skills Strategy in Additive Manufacturing providing solutions capable to foster and support the growth, the innovation and competitiveness of the AM sector;

A methodology for a sustainable and continuous assessment of current and future skills needs in AM through the establishment of the Observatory in Additive Manufacturing;

Design, review and deployment of relevant qualifications in the AM sector, built with a learning outcomes approach and linked with EU Frameworks and Tools such as the EQF, e-CF, EntreComp, ECVET and ECTS;

Promotion of the attractiveness of the AM sector as a career choice for primary, general education, Vocational Education and Training (VET) and university’s students through a awareness campaign in the field of AM;

One online Qualifications Catalogue to continuously update and enlarge the European AM Qualification System, integrating all the developed and to be developed sectoral qualifications.

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INTRODUCTION

Welcome to the Skills Strategy Roadmap.

This Roadmap is 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.

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.
This Skills Strategy 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

This is a short version of the Roadmap, the full Skills Strategy Roadmap is available online: [www.skills4am.eu](http://www.skills4am.eu)
HOW DOES IT WORK?

1. Strengthen the collaboration between industry and training organisations

About this challenge:

- AM sector growth and development happens more quickly than the adaptation of the educational system (learning pace);
- Companies are increasingly demanding talented professionals that can work with and optimise the whole AM process and part production;
- 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.

Implementing Actions

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

Figure 1 - Timeline for the Implementation of Actions to Strengthen the Collaboration between Industry and Education
Mismatch between industry needs and educational/training offer

**GAP DRIVER:**

Strengthen the collaboration between industry and training organizations.

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

Supporting Actions

- 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

Expected Impact

- Reduce the skills gaps and ensure alignment between the training offers and the industry needs.

**Implementing Activities**

- A1.1: Engage industry in the validation and identification of skills and training programmes
- A1.2: Create an open platform for industries to provide their inputs on skills and qualifications for AM
- A1.3: Define a joint skills strategy with the main industrial partners
- A1.4: Implementation of Mainstreaming Steering Committees

Figure 2 - Actions to strengthen collaboration between industry and training organizations
2. Tackle the lack of AM personnel at the European level

About this challenge:

- The growing use of AM technology in industry is increasing the demand for AM workers, but the offer doesn’t match the existing need, thus generating high competition for skilled AM workforce.

- Absence of concerted actions in terms of possible synergies between institutions to overcome the lack of equipment in training institutions;

- Lack of data regarding the 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.

<table>
<thead>
<tr>
<th>Strategic Objective</th>
<th>2: Tackle the lack of AM personnel at the European Level</th>
<th>Short term scenario</th>
<th>Foresight term scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2.1: A2.2: A2.3: A2.4: A2.5: A2.6:</td>
<td>IMPLEMENTING ACTIONS</td>
<td></td>
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</tr>
</tbody>
</table>

Figure 3 - Timeline for Implementation of Actions to Tackle the Lack of AM Personnel
### GAP DRIVER:

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

#### Strategy

- **Tackle the lack of AM personnel at the European level.**

#### Implementing Activities

1. **A2.1** Implement the International AM Qualification System
2. **A2.2** Funding for the preparation of training centres.
3. **A2.3** Create an open platform for AM training providers to provide information on skills and qualifications for AM they can offer.
4. **A2.4** Promote International Qualification System in AM, through national events and through supporting activities focused on training centres (both VET and HE)
5. **A2.5** Establish mutual recognition protocols between training providers
6. **A2.6** Share data on AM Workforce Employability

#### Supporting Actions

- **SA2.1** Facilitate access to AM-relevant vocational, educational training and higher education.
- **SA2.2** Support the implementation of different training methods and contexts for qualifications in AM
- **SA2.3** Support the implementation of upskilling, reskilling, RPL, I-VET, C-VET pathways.
- **SA2.4** Facilitate continued European collaboration between training providers.
- **SA2.5** Support the implementation of employability mechanisms in the AM sector.
- **SA2.6** Develop a recognised EU-level qualifications and training supported by a harmonized accreditation system at both VET and HE level.

#### Expected Impact

- Increase the number of AM Qualified personnel, being by re-skilling, up-skilling of by training the “new” workforce.

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**Figure 4 - Actions to tackle the lack of AM personnel at European level**
3. **Prepare European, National and Regional organisations to tackle the challenges of AM, in terms of Qualified personnel**

About this challenge:

- AM educational provision focus on higher qualification levels (e.g. EQF levels 6 to 8), with very few training offers at vocational level for EQF levels 4 and 5;

- The lack of training facilities with ready access to AM equipment is hampering the provision of education and up-skilling;

- The lack of competence and knowledge of the training staff also influences why training centres cannot provide training.

<table>
<thead>
<tr>
<th>Strategic Objective</th>
<th>3. Prepare European, National and Regional organizations to tackle the challenges of AM, in terms of Qualified personnel</th>
<th>Short term scenario</th>
<th>Foresight term scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>A3.1: Engage industry, academia, training organizations and authorities in projects for collaborative implementation of AM training, supported by a Quality Assurance System</td>
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<tr>
<td>A3.2: Create a Network of AM Training providers (National and Transnational)</td>
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<tr>
<td>A3.3: Funding for the “upskilling” of training centres with a focus in AM</td>
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<tr>
<td>SA3.4: Support the development and implementation of Harmonized trans-national curricula</td>
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<tr>
<td>SA3.5: Define training programmes for trainers (VET teachers,…)</td>
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</tbody>
</table>

Figure 5 - Timeline for the Implementation of the Actions to Prepare Organisations to tackle AM Challenges
Prepare European, National and Regional organizations to tackle the challenges of AM, in terms of Qualified personnel.

GAP DRIVER:
Shortage of training centres, specially at VET level, capable of delivering AM training.

Supporting Actions
- 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.

Implementing Activities
- A3.1: Engage industry, academia, training organizations and authorities in projects for collaborative implementation of AM training, supported by a Quality Assurance System.
- A3.2: Create a Network of AM Training providers (National and Transnational).
- A3.3: Funding for the “upskilling” of training centres with a focus in AM.
- A3.4: Support the development and implementation of Harmonized trans-national curricula.
- A3.5: Define training programmes for trainers (VET teachers,...).

Strategy
Facilitate the access of professionals, students and industry to AM training.

Figure 6 - Actions to prepare European and National organizations to tackle the challenge of AM in terms of Qualified Personnel.

WWW.SKILLS4AM.EU
SKILLS STRATEGY ROADMAP 2021

11 Co-funded by the Erasmus+ Programme of the European Union
4. Tackle the diversity of sectors and applications of AM

About this challenge:

- There is a lack of a harmonised approaches for training involving different sector stakeholders to address the skills development programmes focused on sector-specific needs in AM;

- There are not enough skilled professionals available to meet the demands, and especially to operate across sectors

- There is a lack of combined approaches involving stakeholders from different sectors including standardisation bodies, educational and industrial councils to develop relevant qualifications to educate the diverse workforce of AM professionals to meet sector-specific requirements.

### IMPLEMENTING ACTIONS

<table>
<thead>
<tr>
<th>Strategic Objective</th>
<th>4: Tackle the diversity of sectors and applications of AM</th>
<th>Short term scenario</th>
<th>Foresight term scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>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)</td>
<td>2021</td>
<td>2022</td>
<td></td>
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<tr>
<td>A4.2: Use a modular approach in the development of the training with some sector/process specific modules</td>
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<tr>
<td>A4.3: Identify common requirements between the different sectors</td>
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<tr>
<td>A4.4: Implement International Qualifications that are recognised by different sectors supported by a Quality Assurance System</td>
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</tr>
<tr>
<td>A4.5: Organise events and disseminate the International AM Qualifications to different industrial sectors</td>
<td></td>
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</tbody>
</table>

Figure 7 - Timeline for the Implementation of the Actions to Tackle the diversity of AM Sectors and Applications
Sector and process specific requirements for AM, that are also reflected on the qualifications of professionals.

**GAP DRIVER:**

1. **Tackle the diversity of sectors and applications of AM.**

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

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

   **Identify common requirements between the different sectors.**

   **Implement International Qualifications that are recognised by different sectors supported by a Quality Assurance System.**

   **Organise events and disseminate the International AM Qualifications to different industrial sectors.**

   **Support the creation of International Qualifications/modules focused on a specific industrial sector.**

   **Ensure that sector and/or AM process specific skills/qualifications are identified and addressed.**

   **Ensure a common base for the Qualifications to allow mobility of the workers between sectors and countries.**

   **Wider pool of qualified personnel that can "move" between different countries and industrial sectors.**

**Figure 8 - Actions to tackle the diversity of sectors and applications of AM**
5. Constant update of the AM European workforce

About this challenge:

- There is a sharp rise of new processes or the evolvement of "old" processes, also the quick adaptation of needs in terms of automated post-processing technologies

- New topics will enter the market such as cybersecurity, multi-materials, machine learning and printed electronics.

- The continuous watching of the market while using a strategic approach to cover the most important trend is required.

<table>
<thead>
<tr>
<th>Strategic Objective</th>
<th>5: Constant update of the AM European workforce</th>
<th>Short term scenario</th>
<th>Foresight term scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5.1:</td>
<td>Develop and promote skills mapping mechanisms and anticipation tools</td>
<td>2021</td>
<td>2022</td>
</tr>
<tr>
<td>A5.2:</td>
<td>Develop and update, in a continuous way, modules related to new advances in AM</td>
<td>2021</td>
<td>2022</td>
</tr>
<tr>
<td>A5.3:</td>
<td>Carry out market searches, with a focus on Research Organizations, to identify new trends in AM</td>
<td>2021</td>
<td>2022</td>
</tr>
<tr>
<td>A5.4:</td>
<td>Development of knowledge and skills in AM to keep up with the fast-evolving technology</td>
<td>2021</td>
<td>2022</td>
</tr>
</tbody>
</table>

Figure 9 - Timeline for the Implementation of the Actions to Continuously Update the AM European Workforce
**GAP DRIVER:**

**Fast evolving technology and industry**

- **Constant update of the AM European workforce.**

**Supporting Actions**

- **Implementing Activities**
  - **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.

**Expected Impact**

- **Improved foresight of skills needs for the AM Sector.**

**Strategy**

- **A5.1** Develop and promote skills mapping mechanisms and anticipation tools.
- **A5.2** Develop and update, in a continuous way, modules related to new advances in AM.
- **A5.3** Carry out market searches, with a focus on Research Organizations, to identify new trends in AM.
- **A5.4** Development of knowledge and skills in AM to keep up with the fast-evolving technology.

**Figure 10 - Actions to guarantee the constant update of the AM European workforce**
6. Prepare the AM Future Workforce

About this challenge:

Combined factors are at the origin of the lack of AM awareness, such as the fast development of the technology, absence of a role-model industry in the sector able to create visibility and interest towards the technology, together with the lack of substantial promotion of AM courses in academia or professional trainings.

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

Figure 11 - Timeline for the Implementation of the Actions to Prepare the AM Future Workforce
Lack of AM awareness among the younger generations.

**GAP DRIVER:**

- Prepare the AM Future Workforce.

**Supporting Actions**

- **A6.1** Formulate strategic and future-oriented visions for AM-related skills and their national roll-out.
- **A6.2** Ensure that sector and/or AM process specific skills/qualifications are identified and addressed.
- **A6.3** Develop the use of AM at different school levels.
- **A6.4** Create AM awareness “activities” that can be used by schools according to the age of the students.
- **A6.5** Increase the number of people/students trained in AM in the short and long term across Europe.

**Implementing Activities**

- **A6.1** Raise Awareness campaign focused on different target groups.
- **A6.2** Organize events to raise awareness of AM and its capabilities, focusing on creativity, for young students.
- **A6.3** Relate European AM Qualifications with NQF using European tools, such as EQF, ECTS, ECET, and EQAVET.
- **A6.4** Funding to equip schools, fab labs or industrial experience accelerators and allow them to do AM related awareness activities.

**Expected Impact**

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

**Figure 12 - Actions to prepare the future AM workforce**

[Image of a diagram related to the text]
7. Leverage on existing funding programmes and mechanisms

About this challenge:

- Mostly only big companies have the ability to invest in AM process awareness and training;

- Smaller companies face challenges with AM implementation and training, which hampers them to have a fair profit from the AM advantages in manufacturing and industrial lines.

<table>
<thead>
<tr>
<th>Strategic Objective</th>
<th>7: Leverage on existing funding programmes and mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMPLEMENTING ACTIONS</td>
<td>A7.1: Funding to equip training centres and schools with AM equipment and software</td>
</tr>
<tr>
<td></td>
<td>A7.2: Map and promote funding relevant for AM skills and qualifications</td>
</tr>
<tr>
<td></td>
<td>A7.3: Recommend calls for AM-specific activities</td>
</tr>
<tr>
<td></td>
<td>A7.4: Organise events to facilitate networking and collaboration in EU and National calls for AM</td>
</tr>
</tbody>
</table>

Figure 13 - Timeline for the Implementation of the Actions to Leverage on Existing Funding
GAP DRIVER:

Necessity of more “infrastructures” for AM training

Leverage on existing funding programmes and mechanisms.

Strategy

Implementing Activities

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

SA7.1

Funding to equip training centres and schools with AM equipment and software.

A7.1

Map and promote funding relevant for AM skills and qualifications.

A7.2

Recommend calls for AM - specific activities.

A7.3

Organise events to facilitate networking and collaboration in EU and National calls for AM.

A7.4

Supporting Actions

Expected Impact

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

Figure 14 - Actions to leverage existing programmes and mechanisms
The mind map pathways for skills development in AM 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 15.

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) with 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).
CONCLUSIONS

This Skills Roadmap has outlined the complex challenges that the AM sector currently faces, in the form of “Gap drivers” (challenges) between what the industry needs in terms of educational/training offer and what is currently available, thus placing forward key strategic initiatives and concrete activities to address each of the main seven strategic objectives:

• Strengthen the collaboration between industry and training organisations

• 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 16 - Strategic Objectives foreseen in the Strategy
SAM has structured a "Roadmap" that will allow each strategic initiative (and their related activities) to be implemented in a realistic and measurable manner grounded in the AM Observatory and the deployment of the International AM Qualification System (IAMQS) through a network of training providers, sustained by a robust Quality Assurance System and a strong connection between a wide range of industrial sectors, which are applying AM in their activity or intend to do so (see Figure 17).
The European Additive Manufacturing Skills Strategy and Roadmap is public and open to all organisations wishing to support it.

If you would like to be involved in the IAMQS or be part of the European AM Observatory, please contact us at ewf@ewf.be or follow the SAM Project www.skills4am.eu
SUPPORTING THE AM SKILLS STRATEGY

The Additive Manufacturing Skills Strategy is supported by:

Associated partners and other supporting entities:

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