SECTOR SKILLS STRATEGY
IN ADDITIVE MANUFACTURING

Visual timeline/milestones to include in the observatory (online)

Project No. 601217-EPP-1-2018-1-BE-EPPKA2-SSA-B

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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

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

Document Details

Deliverable Number:	1.5
Due Date :	December, 2019
Leading Organisation:	Materialise
Participating Orgnisations:	EWF, Lortek, CECIMO,EPMA, POLIMI, IDONIAL
Languages(s):	English
Dissemination level:	Public

Contents

1. Introduction

This report presents the first version of the timeline that will be used in the SAM-ERASMUS+ observatory. It is a prediction tool for the observatory. The goal is to be able to predict what the new evolutions will be in AM in order to be able to identify new gaps in skills before they will occur and provide the required educational solutions in time so the gaps can be avoided. The prediction period is ten years.

The focus for this report is on the **future developments and evolutions** that will have an impact on the required skills. This is a first version of the timeline. Reality will catch up with them and this needs to be updated. Furthermore, after a few years, the predictions should be made again for the following 10 years.

2. Timeline

The visual timeline is a graphical representation of (estimated) future trends that will impact the skills required for the implementation of Additive Manufacturing technologies in general (ranging from domestic use to industrial applications).

In the previous deliverables, namely D1.2 "**Global and Societal Milestone**", D1.3 "**Long term technological and industrial plan**" and D1.4 "**Professional Profiles/set of skill's roadmaps**", a wide variety of milestones with a different level of detail and accuracy were identified (exact timing connected to each milestone is difficult to determine). Apart from the deliverables mentioned (which have been finalised), deliverables that still to come in later stages of the project will also support the timeline (e.g.: D4.5.2, D4.5.7, D4.5.4, among others).

For the above-mentioned reasons, the timeline will be constantly updated along the project duration and after its end to avoid mis-leading information. To support the idea of a **"live timeline"** the consortium partners agreed to present it in a **Prezi format.**

Prezi allows to have the timeline divided into different levels of detail ("skins") providing, at the same time, a user experience. At an initial implementation stage of the timeline, SAM's website visitors will be able to interact with the timeline according to their interests. For example, if someone from the health sector wants to know about the major trends related to AM, they select **Global and Societal** as the first skin and then, move into the **Health** sector, being able to navigate through the different scenarios: "**Real Case (2019)**", "**Short Term (2020-2021)**" and "**Foresight (2022-2030)**". The timeline is currently hosted in: http://www.skills4am.eu/amtrends.html and available through the link https://prezi.com/view/45TZMR9wh5woSYPv3NC3/ .

With the progress of the AM observatory, the visual timeline will be migrated there.

3. Milestones

The deliverables mentioned in the chapter 2 of this report have provided the relevant milestones to feed the timeline, and are summarized below.

3.1. Global and Societal Milestones

From D1.2 "Global and Societal Milestone", the identified Milestones were:

1) Health:

- 2019-2022
  - Modelling methods of interaction between materials and living tissue
  - Bio-materials applicable to AM
  - Large production at lower costs
  - Validation of mechanical and thermal properties of existing materials
- 2022-2030
  - Studying and modelling of the whole human body and its evolution over time
  - Printing human body parts in bio-tissues
  - Recycling, reuse of precious materials and use of sustainable ones
  - Multi-material products with improved functionalities
  - Novel skeletons

2) Energy:

- 2019-2022
  - Development and industrialization of more efficient small and complex components
  - Repair of components
  - On-site Production of small size parts
- 2022-2030
  - Development and industrialization of more efficient large size components
  - On-site production of large size parts

3) Transport

- 2019-2022
  - Optimization modelling for the most used materials and processes
  - Design optimization in the assembly of complex parts with main used processes
  - Identification of feedstock properties to achieve powder production quality and consistency
  - Reliability of produced parts linked to new sustainable materials, processes, multifunctional materials, multi-materials with highly improved functionalities
  - Development of control mechanisms for optimized performance of the AM processes
  - Characterization on dynamic properties and residual stresses
  - Design capability of complex structures using "common" AM processes
  - Automation of repair processes through integration of AM robotics
  - Post-processing of AM parts
  - Cost effective printing assemblies linked to the design of parts
  - Development and validation of small and simple hybrid manufacturing systems
- 2022-2030
  - Development and optimization for other materials and processes reaching the market and industry
  - Design optimization in the assembly of complex parts with all used processes
  - Testing and validation criteria of feedstock properties to ensure part quality
  - Reliability of produced parts during their lifetime and in accordance to different sectors requirements linked to new sustainable materials, processes and related characterization in the field of multifunctional materials, multi-materials with highly improved functionalities
  - Sustainability and recyclability of AM parts
  - Development of processes to manage graded materials and to overcome the need of joining/Welding parts

- Development of real time control systems and data for improved repeatability, reproductivity and performance of AM processes
- Design capability of complex structures using all the AM processes
- Automation of repair of complex parts/structures
- Combined post-processing, including subtractive manufacturing with AM
- Production of larger AM airframe structures
- Higher rates and cheaper systems linked to the production of larger AM parts
- Cost effective printing assemblies linked to new design methodologies that align materials with functionality
- Industrially relevant larger certified build envelopes
- Optimization of larger and more advanced manufacturing systems

4) Consumer Goods

- 2019-2022
- Multi-material parts
- Mass customization of existing products
- Improved aesthetics and surface quality linked to low post-processing
- 2022-2030
- Smart/4D multi-material parts
- Mass customization, co-creation and fabrication platforms for new product-services
- Improved aesthetics and surface quality linked to no post-processing
- Predictive, self-learning and holistic multi-physical modelling approaches
- 3D capturing geometry/technologies

5) Environment & Efficient Resources

- 2019-2022
- Identifying the advantages in terms of quality and durability of manufactured products with established AM technologies
- Impact of different established AM technology in the sustainability ratios
- Studying life cycle analyses redesign processes for established AM technologies
- Analysis of the impact of distributed production business models for established AM technologies
- Development of design rules for sustainability for established AM technologies
- 2022-2030
- Identifying the advantages in terms of quality and durability of manufactured products with emergent AM technologies
- Impact of different emergent AM technology in the sustainability ratios
- Studying life cycle analyses redesign processes for emergent AM technologies
- Analysis of the impact of distributed production business models for emergent AM technologies
- Development of design rules for sustainability for emergent AM technologies

6) Citizens Security

- 2019-2022
- Identification of reliable 3D printed solutions expressly created for use in humanitarian crises
- Using SAM blueprint for future AM-related on-site efforts
- Improve process security and reduction of any possible malicious actions
- 2022-2030
- Integration of resilient, reliable 3D printer for on-site use in humanitarian crises
- Using new blueprint for future AM-related on-site efforts
- Global implementation of process security for the prevention of malicious actions

3.2. Long term technological Trends

From D1.3 "Long term technological and industrial plan", the identified Milestones (and related trends) were associated to 4 main technological pillars: Materials; Process & Manufacturing; Post Processing and Quality.

This segment of the timeline is also fed by the main initiatives and policies within the Additive Manufacturing sector. This allows to ensure a European and Industrial perspectives on the long-term technological and industrial plan. Specifically, at the moment, SAM project has already analysed a set of 84 initiatives, encompassing networks, platforms and research programmes at International, European, National and Regional levels. The aim is to clearly understand which areas/topics are common, how they can promote new offerings and allow employees, students and society in general to progress together with technological evolution.

Within the 4 above mentioned pillars, there are more detailed milestones (with associated timings), which are represented in the tables below.

		Short term: 2020-2021				Foresight 2022-2030			
	Materials								
M1	Implementation to new applications and products (polymers, metals, composites and ceramics)								
M2	Development and standardisation of new materials								
M3	Conventional materials (wires, pellets, sand, wax) for AM applications								
M4	Thermo-mechanical modelling for validation of the mechanical and thermal properties of existing materials and AM technologies								
M5	LCA and circular economy								
M6	Fit-for-purpose materials								
M7	Multi-material parts								
M8	Bioprinting (tissue printing)								
M9	Materials for 4D printing (incl. memory shape alloys)								

		Short term: 2020-2021				Foresight 2022-2030			
	Processing								
PR1	Software interoperability (all-in-one SW)								
PR2	More agile DfAM development frameworks								
PR3	Multiscale and Multiphysics AM modelling								
PR4	Massive use of desktop and benchtop AM machines								
PR5	Faster metal AM machines								
PR6	New automation concepts at machine level								
PR7	Hybrid machines								
PR8	AM machines for multi-materials								
PR9	Multi-functional parts including parts with embedded sensors								
PR10	Advanced monitoring and data acquisition systems								
PR11	Advanced data analytics based on AI								
PR12	Advanced close-loop controls for automated adaptation								
PR13	Connected modular printers operated by robots								
PR14	Market uptake of new AM technologies and downfall of existing AM technologies								

		Short term: 2020-2021				Foresight 2022-2030			
	Post processing								
PP1	Automation of support removal (metal PBF, MEX)								
PP2	Improved and new heat treatments (sintering, HIP, heat treatment)								
PP3	Debinding process								
PP4	Automation of surface finishing								
PP5	New surface finishing treatments								

PP6	Automation of resin removal (VAT)								
PP7	Automation of powder removal (PBF, BJ)								
PP8	New coating and drying treatments								
PP9	Design to minimize post processing								
PP10	New quality standards								

		Short term: 2020-2021				**Foresight 2022-2030**			
	Quality								
Q1	Integration of AM in TQM systems								
Q2	Improved AM-process control								
Q3	New inspection techniques								
Q4	Digital twin								

3.3. Professional Profiles / Sills Milestones

There are currently **Professional Profiles and Skills' Roadmaps** to identify the current professions working in the Additive Manufacturing Sector, present the new emergent Professional Profiles as well as identifying the related skills gaps and challenges in addressing AM skills. Moreover, the Professional Profiles and skills Roadmaps scope is extended to professionals from other disciplines which might be directly or indirectly linked to AM technology, thus progressing through upskilling[1]/*reskilling* pathways.

The SAM roadmap reflects the mid-point between existing skills and future ones, providing relevant findings and hypotheses to guide future work on the assessment of current and future skills in AM, which will take place in work package 2 "Forecast Methodology", as well as in other activities within the SAM project, that will then feed the timeline (as indicated in its structure – section 4 of the present report).

The skills gaps that will be fed into the timeline, are the results of the surveys already applied, both, to industry and RTDs, that will become available after the validation workshops.

[1] *Short-term targeted training typically provided following initial education or training, and aimed at supplementing, improving or updating knowledge, skills and/or competences acquired during previous training (Cedefop, 2004)*

4. Timeline Structure