EU Market for 3DP Demonstration Equipment and Services – Preliminary Report

Preliminary Report May 2021 (Final version expected October 2021)

Main Authors
Jean-François Romainville, IDEA Consult
Federico Bley, IDEA Consult

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This study is conducted by:

3DP Pan EU Consortium

Jozef II-straat 40 B1
1000 Brussel

T: +32 2 282 17 10
info@ideaconsult.be

www.ideaconsult.be

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Contents

0. General introduction and analytical scope

0.1. Objectives of the report

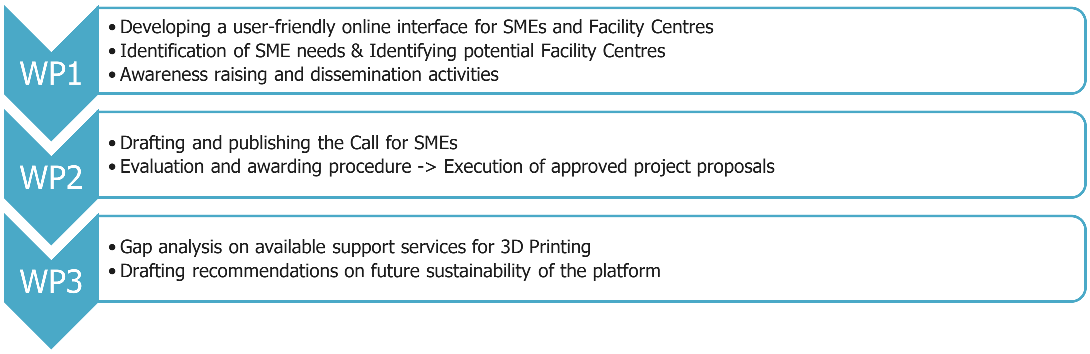
This report has been drafted in the context of the DG GROW 3DP Pan EU Project[1]. The report aims at conducting a 'gap analysis' of (demonstration) support services for 3D printing ('3DP'), relying (among others) upon insights derived from the data set complied in the context of the 3DP PAN EU project. More specifically, the report aims at further assessing the alignment of demand and supply of demonstration services now and in the near future as well as to assess how actors providing testing/validations-related services in Europe can, eventually, better serve/anticipate on the needs (current and expected) of the industry. Overall policy recommendations aimed at ensuring at better uptake of 3DP solutions are presented.

Going beyond the core focus of the 3DP Pan EU project (i.e., 3DP demonstration services), the present report also provides a general introduction/overview focusing on the EU '3D Printing Landscape' as a whole, which goes much beyond demonstration services and activities. This analysis highlights key market trends that will impact the 'demonstration'-related activities.

3DP Pan EU Project, In a nutshell

- European Parliament Pilot Action managed by the European Commission (DG GROW)
- Project length: 34 months (January 2019 – October 2021)
- Goals:
  - Fostering awareness, knowledge and uptake of 3DP
  - Promoting SME access to high quality equipment, services & infrastructure

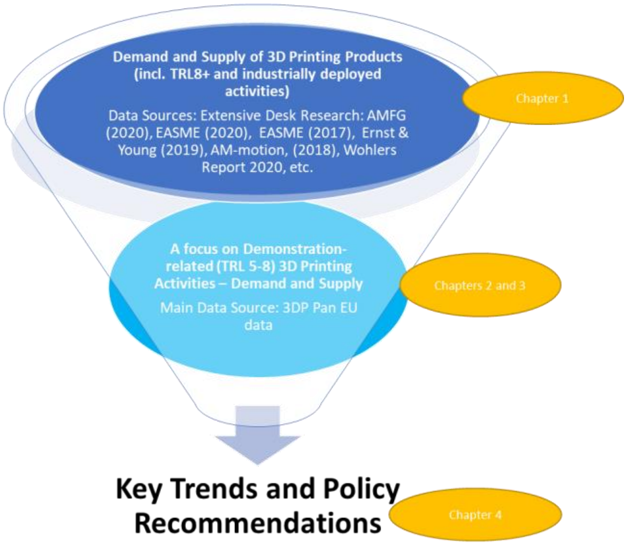
- Project structure:



[1] The 3DP Pan EU project is a European Parliament pilot action managed by the European Commission (DG GROW) and implemented by a consortium consisting of Brainport Development, IDEA Consult, ART-ER, CIVITTA and Asterion Europe.

0.2. Analytical scope, associated data sources and structure of the report

As mentioned in the figure on the right, the core of the report lies on the analysis of the (current and expected) Demand and Supply of **demonstration services**. Such analysis is based on data gathered in the context of the **3DP Pan EU Project** (see table below for a brief overview of the data, which are presented and analysed more in details in chapters 2, 3 and 4). To identify and assess current and upcoming industrial trends influencing the demonstration-related activities, the present report starts with a global/overall analysis of the 3D Printing landscape in Europe. Such analysis is based on extensive desk research[2]. Finally, the report concludes with a list of key trends and policy recommendations for an adequate 3D Printing demonstration-services landscape.



Below, more information about the 3DP Pan EU Data Base is briefly provided.

Table 1: 3DP Pan EU data base – Brief overview

<table>
<tr><th colspan="2">3DP Pan EU Data Base – In a nutshell</th></tr>
<tr><td>

380 Facility Centres (i.e. public or private organisations providing demonstration services (and associated equip.) to SMEs;
1.300 pieces of Equipment listed and described;
1.087 services listed and described;
3.500 searches between March – October 2020, using available matching tools (i.e. connecting demand and supply of demonstration services).

</td><td>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</table>

[2] AMFG, (2020), The Additive Manufacturing Landscape Report 2020; EASME (2020). Advanced Technologies for Industry – Product Watch. 3D printing of hybrid components; EASME (2017). Advanced Technologies for Industry – Technology Watch. The disruptive nature of 3D Printing.; Ernst & Young, (2019), 3D printing: hype or game changer?; AM-motion, (2018), AM-motion Roadmap; Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry

The present report is structured as follows:

- 1 - General overview of the 3D Printing Industry

The concept of 3D Printing, the value chain structure and key overall evolutions are presented.

- 2 - Demand of demonstration services - Current and future areas

Current AM technologies, use cases and applications are presented in this section together with emerging trends and indications of how 3DP will be used in the future. An analysis of the requests made on the 3DP PAN EU Platform and potential barriers to 3DP uptake in Europe further highlights what manufacturing stakeholders are expecting in the near and mid-term future from 3DP technologies.

- 3 - Supply of Demonstration services – Equipment, expertise, and services

An overview of manufacturing equipment on large and small scale in Europe and beyond provides an understanding of what equipment is currently available while an analysis of the 3DP Pan EU Platform data highlights what technical capabilities exist in Europe.

- 4 - Conclusions and Recommendations for AM uptake and deployment in Europe

Concluding the report, a first section provided a demonstration-focused analysis of the gaps between the expected demand and supply of demonstration services. Going beyond the demonstration activities, a SWOT analysis then present the overall main strengths of the European market. Finally this report concludes with policy recommendations to support the further uptake of 3DP in Europe.

This preliminary report will be developed over the coming months. The final report will be published in October 2021. If you have any questions/or remarks, please contact jean-francois.romainville@ideaconsult.be

1 / 3D Printing Industry – General Overview

In this section an overview of the 3DP landscape globally and in Europe is set out. Firstly, the concept of "3D Printing" is very briefly described. Then, the value chain is analysed based on its structure, key actors and application areas that have emerged or proven resilient over time.

1.1. The concept of 3D Printing, in a nutshell

3D Printing is an additive manufacturing process allowing for the production of three-dimensional solid objects based on digital blueprints. As an additive manufacturing process, 3D printing allows for the creation of objects by laying down layers of a specific material until the final product has been created. This is contrary to traditional subtractive methods in which a piece of material would be cut away until the final product is left as a result. *N.B.: In the present report, the terms 3D Printing (3DP) and Additive Manufacturing (AM) are used interchangeably.*

The benefits

Additive manufacturing has several benefits in comparison with traditional/subtractive manufacturing technologies. Here are a few illustrative examples:

- Less material waste: only the material needed to produce the product is being used rather than removing excess material which is not needed in the final component.
- Complex designs: by creating new objects from the ground-up through 3D printing, more intricate designs can be created compared to traditional methods, giving the user more versatility in the creation of new components or products.
- Lighter products: when 3D Printing, it is possible to create structures which are lighter by using less material, while at the same time retaining component strength due to the possibility to reinforce structures from the inside. This would previously not have been possible through subtractive manufacturing.
- Shorter time to market through rapid prototyping: 3D Printing allows for the design, from first idea to 3D model to printed prototype in less time than was previously possible. This also means that further prototyping and the production of new iterations can be faster and cheaper as there is no longer the need to work from molds or having high material costs for each new version of a product.
- Product strength for certain materials: when working with plastics or soft materials, products can be designed to be more resilient, durable and reliable.
- Hybrid manufacturing: Soft and hard materials can be printed in one go – no need for several production steps to get to your final product.

An illustrative list of 3D printing technologies

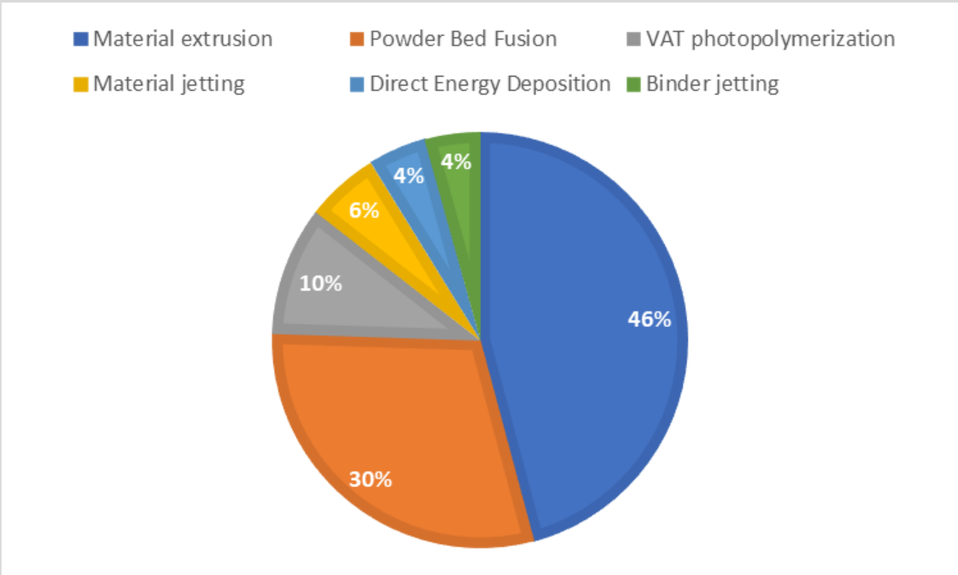
There are many different types of 3D printing and with the growth of the 3D printing industry, even more technologies will arise. Each type is based on the principal of building an object layer per layer, but the technology on how to do is may differ. On this platform a distinction is made between seven main categories. Each category consists of several subcategories.

- Material Extrusion: a process in which material is selectively dispensed through a nozzle. Subcategories are among others: Fused Deposition Melting, Fused Filament Fabrication, FlashFuse, Continuous Filament Fabrication.
- Material Jetting: a process in which droplets of material are jetted onto a build platform and solidify to form a layer. Subcategories are among others: PolyJet, Material Jetting Process, Solidscape Process.
- Binder Jetting: a process in which a binder material is deposited on top of powder material and serves as an adhesive between the layers. Subcategories are among others: Color Jet Printing, Full Sinter Binder Jetting, Binder Jetting with Metal Infiltration, Nanoparticle Jetting, Multi Jet Fusion.
- Sheet Lamination: a process in which a sheet of material is bounded to the other layers through welding or adhesive. Subcategories are among others: Laminated Object Manufacturing, Selective Deposition Lamination, Ultrasonic Additive Manufacturing.

- VAT Photopolymerization: a process in which a resin is cured by ultraviolet light to form a layer. Subcategories are among others: Stereolithography, Digital Light Processing, Continuous Digital Light Processing, Selectively Spin, Scan and Photocure; Digital Light Synthesis, Low Force Stereolithography, Programmable Photopolymerization, DLP MovingLight Technology.
- Powder Bed Fusion: a process in which material in the form of powder is fused together using a laser or electron beam. Subcategories are among others: Selective Laser Sintering, Electron Beam Melting, Multi Jet Fusion, Direct Metal Laser Sintering, Selective Laser Melting, Direct Metal Printing, Selective Heat Sintering, Laser Beam Powder Bed Fusion Direct Metal Laser Melting.
- Direct energy deposition: a process in which material is deposited on top of an existing object by a nozzle and melted using a laser, electron beam or plasma arc. The material will solidify to form a layer. Subcategories are among others: Laser Engineered Net Shaping, Direct Metal Deposition, Electron Beam DED.

The 3DP Pan EU data allow for a comprehensive overview of the technologies used on the equipment of Facility Centres in Europe (see table below). While more detailed analysis is provided in chapter 3, Material Extrusion and Powder Bed Fusion turns out to be technologies most commonly used among facility centres.

Figure 1: Overview of technologies (% in total equipment registered on the 3DP Pan EU data base)



Source: IDEA Consult, based on 3D Pan EU data

In the subsequent sections, more details on the possible applications and industry impacts of 3DP are provided.

1.2. Value Chain Analysis

In this section the value chain structure of the overall 3D printing industry in Europe is laid out based on an extensive desk research using as main sources the 2021 Technological Roadmap on AM in the SUDOE region[3], the 2020 SAM long-term technological and industrial plan,[4] the 2020 AMFG Additive Manufacturing Landscape report[5], the 2021, 2020 and 2017 Product Watch reports on Advanced Technologies for Industry[6][7], the 2019 EY report 3D printing: hype or game changer?[8], the 2018 AM-Motion Roadmap[9] as well as the 2020 Wohlers report[10]. Additional scientific articles, industry articles and other resources (mentioned throughout the presented report) complete the overview of the 3D Printing Industry in Europe.

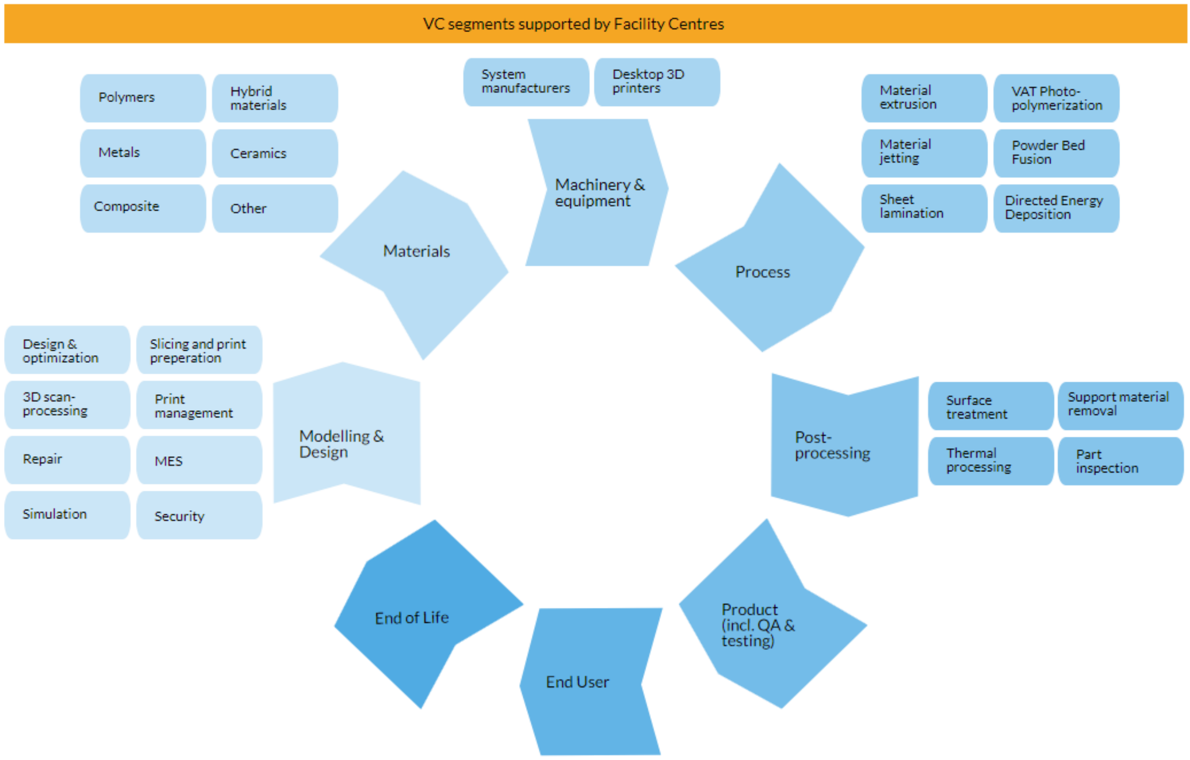
[3] CENTIMFE. (2018). Technological Roadmap on Additive Manufacturing and Advanced Materials in the SUDOE Region.
[4] Lortek. (2020). Long-term technological and industrial report.
[5] AMFG, (2020), The Additive Manufacturing Landscape Report 2020
[6] EASME (2020). Advanced Technologies for Industry – Product Watch. 3D printing of hybrid components.
[7] EASME (2017). Advanced Technologies for Industry – Technology Watch. The disruptive nature of 3D Printing.
[8] Ernst & Young, (2019), 3D printing: hype or game changer?
[9] AM-motion, (2018), AM-motion Roadmap
[10] Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry

The AM industry is **multi-disciplinary and cross-sectoral** by nature. It therefore engages with many different types of stakeholders from industry, government, academia and even civil society[11]. An overview of the most relevant trends and actors of the AM value chain is important. It allows for an understanding of what manufacturing will look like in the future and what impact it could potentially have on job markets, industries and ultimately organisations and individuals interacting with each other. The products that are created using AM technologies can be cutting-edge and revolutionise healthcare, construction, aviation and other sectors everyone relies on daily.

1.2.1 Structure of the Value Chain

The value chain structure of 3D Printing can be separated into eight key segments, going from modelling & design to end of life. As these segments are linked back to each other, the value chain is set out in a circular structure instead of a traditional linear structure. This structure is depicted in Figure 2, where each segment is expanded with underlying aspects.

Figure 2: The 3D printing value chain



Source: IDEA Consult, adapted from Wohlers report 2020 and European Commission, 2020, Advanced Technologies for Industry – Product Watch

Overall, the Value Chain dynamic is as follows. 3D Printing enables the **design, modelling** and production of complex parts. It also enables to offer custom or semi-custom parts for specific users or application areas. Modelling and design are considered as key steps in the additive manufacturing value chain. The different underlying aspects of modelling and design will determine which **materials** are needed. Subsequently, which **machinery and equipment**, which **process** and which **post-processing** techniques necessary are outlined. This results in a product that needs to undergo a specific **quality assessment and testing**, depending on the requirements of the **end user**. An important and not to be forgotten part of the value chain is **end of life**. What will happen at the end of the product's lifecycle is or should be decided at the beginning of the product development process, such as material choice and recyclability of the 3D printed product. Therefore these steps are linked back to each other.

[11] As the emergence of hobbyists and entrepreneurs have led to a strong desktop 3D printer industry proving how dynamic and flexible this industry is.

Regarding the number of actors in general (more details are available in the next sections), EY puts the number of European AM (both large and small scale) companies overall at 722 in 2019, representing 55% of all AM firms worldwide (EY, 2019).[12] Crunchbase lists 878 organisations active in 3DP manufacturing in Europe. Their funding types are seed, venture, grants and private equity. 697 of these companies are for profit and 1% are public. By listing '3D printing' as industries (other 'industries can be added as well'), these companies indicate that they are capable of providing 3DP-related services, not necessarily 3D printing itself.[13] Regarding the 3DP Pan EU data base, which focuses (on the supply side) only on a subset of the overall AM market (i.e., facility centres), around 380 organisations (public or private) registered on the platform. When compared to the overall EY/Crunchbase numbers available, this highlights the extensive coverage of the 3DP Pan EU data base.

1.2.2 Key actors Concerned

Reflecting the Value Chain depicted above, we can group the key actors of additive manufacturing into these categories of actors:

- Software providers who sell programs on which AM equipment runs, and engineers design and test 3D models;
- Service providers who assist individuals, companies and organisations with 3D modelling, prototyping, and testing services;
- Facility centres who similarly to service providers assist organisations with 3D modelling, prototyping and testing services, but are further implicated in research, applied research and demonstration activities. Facility Centres were the core target group of the 3DP Pan EU Platform. The objective is to make their services and equipment visible to companies/end users looking for specific demonstration services.
- Software providers who sell the software used to create 3D models and create the bridge from virtual models to physical components;
- Material suppliers who mine, process and provide raw materials such as metal powders, thermoplastics filaments and ceramics to AM companies who produce prototypes and finished components;
- Machinery & equipment manufacturers, who also encompass post-processing manufacturers. These companies manufacture the industrial AM systems and desktop printers that manufacture components;
- Start-ups related to AM create a dynamic and innovating ecosystem that feeds into industry demand.

For illustrative purposed, a detailed overview of leading AM companies can be found in Annex 1.

In the subsequent sections, a detailed description of these key actors of the AM value chain. Information relating to market demand can be found in section 2 while more quantitative information on European manufacturers and equipment availability is presented in section 3 (supply side).

1.2.2.1 Software providers

Additive manufacturing is a digitally driven technology. Especially in the first phases of the product development process, different software products are used to design and model first prototypes. The use of suitable software can have a large sustainability impact on the product or application areas. It can help to increase material efficiency and efficiency of the manufacturing process, but also reduce the number of iterations during the development process or the energy needs during the lifetime of the product. Software vendors provide software tools for specific applications or integrate several functions in one software program. Examples of European software vendors are Materialise, Siemens, Additive Works and MeshLab. Most software vendors can be found in the field of design and simulation software.

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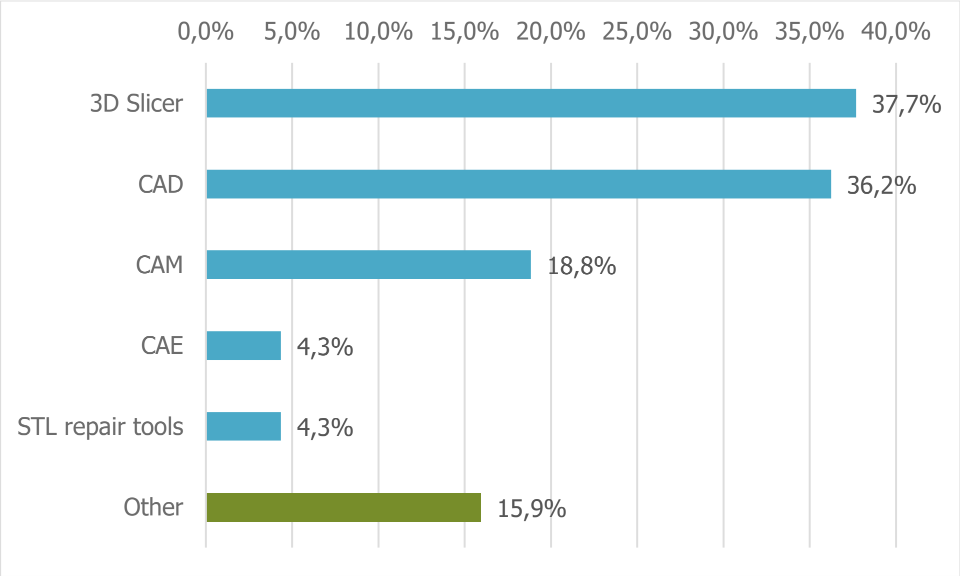
[12] EY, (2019), 3D printing: hype or game changer? consulted online: https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/advisory/ey-3d-printing-game-changer.pdf

[13] See online: https://www.crunchbase.com/hub/europe-3d-printing-companies#section-overview

The worldwide 3D printing software and services market revenue amounted to €1.62 billion in 2017 and is expected to grow to €3.97 billion by 2021.[14][15] Included in software sales are 3D design, simulation and machine control software while services considered primarily consist of print on demand and after sales and maintenance. Services considered alco cover different material types, technologies and applications.

3DP Pan EU Data provide in-depth information about the type of software being used be Facility Centres active in the AM market.

Figure 3: Main software used by facility centres registered on the 3DP PAN EU platform (% of Facility Centres)



Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

The **software** that is most used by the 380 Facility Centres registered on the 3DP Pan EU Platform is 3D Slicer, used by 37,7% of the facility centres having provided information on the software their equipment runs on. This is followed by CAD (36,2%), print and CAM (18.8%) software. 3D Slicer and CAD software are primarily used for Polymer Thermoset and Thermoplastics, while CAM software for working with ferrous and non-ferrous metals. CEA is a more generic type of software for 3D modelling while STL repair software is used to troubleshoot and repair virtual 3D models. These results show that plastics remain a main driver for 3D printing followed by resins and metals, as further outlined in the next sections.

1.2.2.2 Service providers

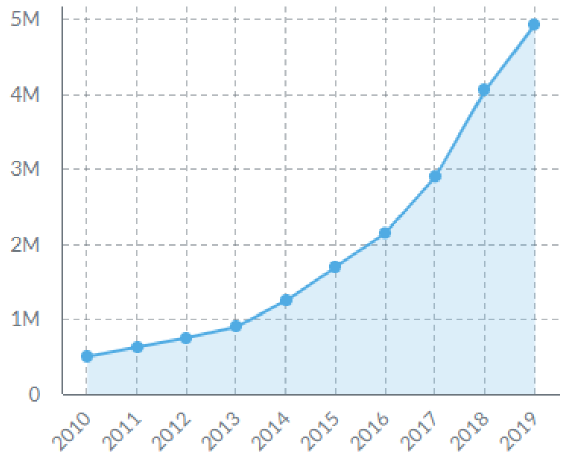
Service providers or service bureaus are companies that contribute to several segments of the 3DP value chain. They offer services such as modelling, design, or post-processing to other companies to support the development of 3D printed parts at the start of the value chain. They may also manufacture 3D printed parts on a contractual basis for other companies. The size of service provider companies ranges from a one-person company, to a large-scale company with different locations or online marketplaces. Examples of leading European service providers are Any-Shape (Belgium), Sculpteo (France) and Robert Hofmann (Germany).[16]

[14] Statista, (2020), 3D printing software and services market revenue worldwide in 2016, 2017 and 2021, consulted online: https://www.statista.com/statistics/828982/global-market-for-3d-printing-software-services/

[15] Average USD exchange rate for 2020: 0,877 EUR. Calculation: 1.85 billion USD * 0,877 = 1.62 billion EUR / 4.53 billion USD * 0,877 = 3.97 billion EUR

[16] Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry, p. 114.

Figure 4: 3D printed parts service provider revenue worldwide, in billion euros



Source: IDEA consult, adapted from Wohlers report 2020 (Wohlers Associates, 2020)

In 2019, independent service providers of 3D printed parts generated worldwide an estimated revenue of €4.4 billion. In comparison to 2010, the revenue has increased with 884%. These numbers only include revenues from additive manufacturing services and exclude other service revenues such as modelling and design or non-additive manufacturing services such as casting. The estimate also excludes revenues from service providers that are part of a bigger company, for example Stratasys. This means that the actual revenues for services provided in the additive manufacturing domain are even higher.

1.2.2.3 Facility centres

Facility centres (FCs'), in comparison with service providers, provide support in the development and demonstration of technological solutions for additive manufacturing, i.e. activities at Technology Readiness Level of 5+ to 8. These are typically R&D&I organisations, such as universities and Research and Technology Organisations (RTOs). The aim of facility centres is to gain knowledge through research, demonstration and networking, and transfer this knowledge to companies. There are various leading facility centres in Europe that are active in 3D printing. Such actors cooperate, among others, in the context of the Vanguard Initiative 3DP pilot and most of these facility centres have registered to the 3DP Pan EU online platform, making their equipment and services more visible to SMEs. The table below provides more information about this key group actors in the 3D Printing Value Chain. A dedicated analysis of equipment and services of Facility Centres is provided in the chapter 3 of the present report.

Table 2: Facility Centres in Europe, an brief overview of equipment and services based on 3DP Pan EU Data

<table>
<tr><th>Dimension</th><th>Key Average Numbers</th><th>Specificities</th></tr>
<tr><td>Equipment – The FCs average</td><td>FCs have over 1300 machines available for demonstration purposes.
FCs have on average between 5-6 printers and/or AM systems.</td><td>11.6% are able to provide a sterile work environment
83% are able to manufacture small parts between 0 and 300mm and only 13% are able to manufacture large parts above 2.5m.
25% have equipment with multi-material capabilities</td></tr>
<tr><td>The Sector/ Material coverage by FCs (% of FCs covering a given segment)</td><td colspan="2">
<table>
<tr><th></th><th>Bio-materials</th><th>Composites</th><th>Ferrous metals</th><th>Hydrogels</th><th>Industrial ceramics</th><th>Natural Polymers</th><th>Non-ferrous metals</th><th>Polymer thermoplastic</th><th>Polymer Thermoset</th><th>Precious metals</th></tr>
<tr><td>Aeronautics & Space</td><td>1,8%</td><td>3,4%</td><td>18,4%</td><td>0,1%</td><td>1,0%</td><td>4,0%</td><td>20,7%</td><td>17,3%</td><td>14,8%</td><td>8,0%</td></tr>
<tr><td>Automotive & Transportation (excluding ships and boats)</td><td>4,9%</td><td>11,0%</td><td>17,5%</td><td>0,2%</td><td>1,9%</td><td>2,0%</td><td>17,3%</td><td>17,7%</td><td>14,0%</td><td>0,9%</td></tr>
<tr><td>Chemical Industry</td><td>5,7%</td><td>5,3%</td><td>20,1%</td><td>1,3%</td><td>9,1%</td><td>2,2%</td><td>21,1%</td><td>17,0%</td><td>8,2%</td><td>0,0%</td></tr>
<tr><td>Construction & Building sector</td><td>3,6%</td><td>7,3%</td><td>5,1%</td><td>0,0%</td><td>9,3%</td><td>9,7%</td><td>13,6%</td><td>17,2%</td><td>16,5%</td><td>0,1%</td></tr>
<tr><td>Consumer Goods & Products (excluding sporting goods, textile and furniture)</td><td>3,6%</td><td>17,9%</td><td>14,8%</td><td>0,3%</td><td>0,9%</td><td>3,8%</td><td>15,0%</td><td>22,2%</td><td>11,9%</td><td>0,5%</td></tr>
<tr><td>Energy</td><td>2,8%</td><td>3,8%</td><td>22,6%</td><td>0,0%</td><td>6,8%</td><td>3,1%</td><td>23,1%</td><td>11,1%</td><td>8,0%</td><td>0,7%</td></tr>
<tr><td>Environment</td><td>21,4%</td><td>14,3%</td><td>0,0%</td><td>3,6%</td><td>0,0%</td><td>17,9%</td><td>10,7%</td><td>10,7%</td><td>3,6%</td><td>0,0%</td></tr>
<tr><td>Food</td><td>0,1%</td><td>0,0%</td><td>20,0%</td><td>0,1%</td><td>0,0%</td><td>0,0%</td><td>19,9%</td><td>20,0%</td><td>20,0%</td><td>19,9%</td></tr>
<tr><td>Furniture</td><td>5,1%</td><td>14,3%</td><td>4,1%</td><td>0,0%</td><td>1,0%</td><td>9,2%</td><td>6,1%</td><td>20,4%</td><td>5,1%</td><td>0,0%</td></tr>
<tr><td>ICT industry (including electronics, computer and communication related products)</td><td>11,6%</td><td>11,6%</td><td>7,1%</td><td>0,0%</td><td>1,6%</td><td>3,9%</td><td>6,1%</td><td>19,7%</td><td>18,7%</td><td>1,0%</td></tr>
<tr><td>Measurement</td><td>4,5%</td><td>1,1%</td><td>3,4%</td><td>2,2%</td><td>43,8%</td><td>3,4%</td><td>2,2%</td><td>6,7%</td><td>4,5%</td><td>2,2%</td></tr>
<tr><td>Medical & Healthcare</td><td>2,7%</td><td>3,4%</td><td>19,6%</td><td>0,3%</td><td>0,9%</td><td>1,9%</td><td>19,8%</td><td>18,7%</td><td>13,7%</td><td>11,4%</td></tr>
<tr><td>Production technology (machinery / equipment / automation)</td><td>2,9%</td><td>4,1%</td><td>21,2%</td><td>0,0%</td><td>2,8%</td><td>0,8%</td><td>19,2%</td><td>17,6%</td><td>14,2%</td><td>8,2%</td></tr>
<tr><td>Ships and Boats</td><td>0,6%</td><td>0,8%</td><td>0,5%</td><td>0,0%</td><td>0,5%</td><td>19,0%</td><td>18,5%</td><td>19,3%</td><td>18,8%</td><td>0,3%</td></tr>
<tr><td>Sporting Goods</td><td>0,5%</td><td>19,1%</td><td>18,1%</td><td>0,0%</td><td>0,0%</td><td>0,5%</td><td>12,6%</td><td>20,0%</td><td>16,3%</td><td>0,0%</td></tr>
<tr><td>Textile & Fashion</td><td>13,6%</td><td>16,1%</td><td>1,6%</td><td>0,0%</td><td>1,9%</td><td>4,7%</td><td>2,8%</td><td>19,0%</td><td>28,5%</td><td>0,0%</td></tr>
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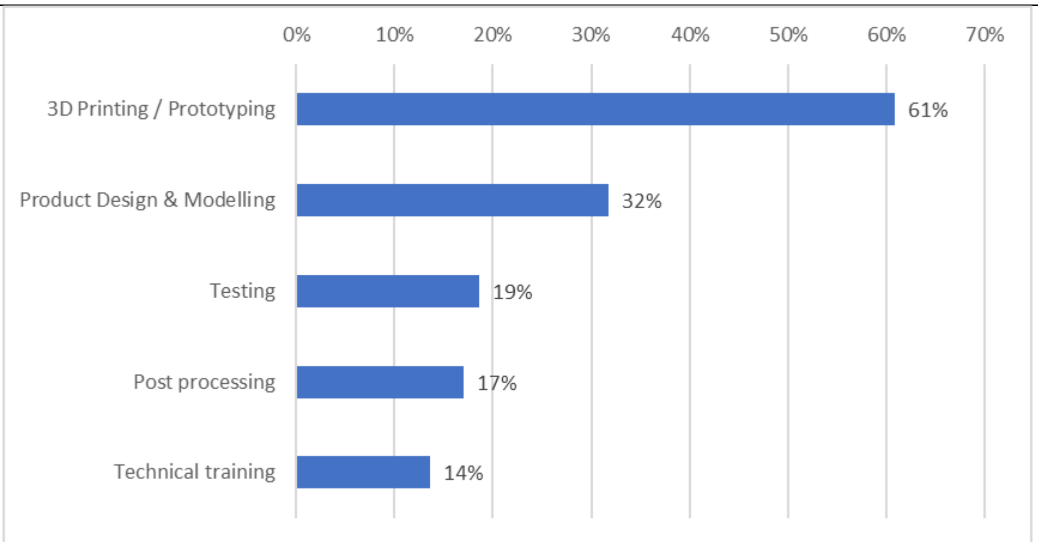
<tr><td>Services - The FCs average (% of FCs providing a given service)</td><td colspan="2">



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Source: IDEA Consult, based on 3DP Pan EU data

Detailed analysis of the equipment and service offer of Facility Centres is provided in the chapter 3. These actors have a crucial role in the uptake and deployment of technology and knowledge, by, among others, offering access to SMEs to innovation services and support and transferring knowledge to SMEs and enabling them to 'test before they invest'.

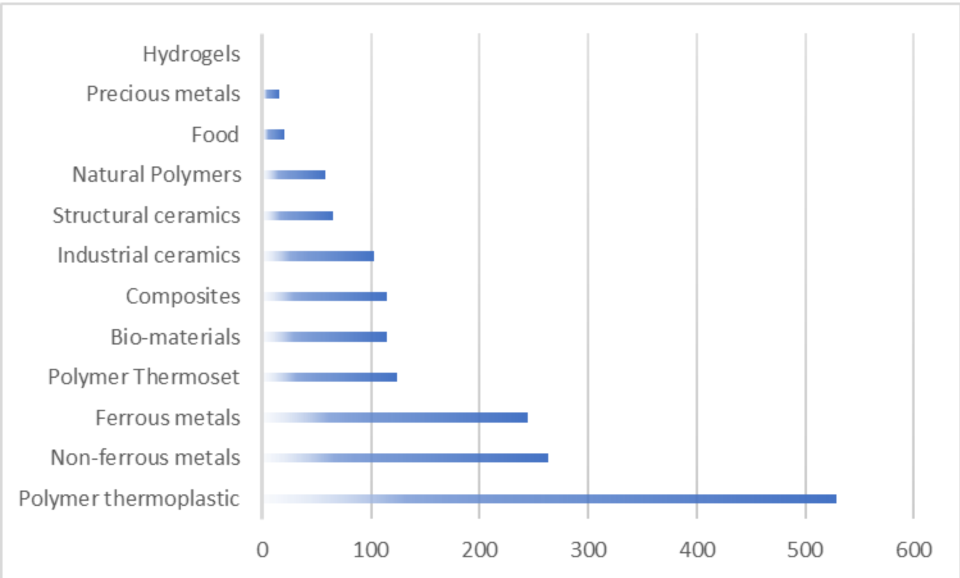
1.2.2.4 Material suppliers

Material suppliers supply adequate materials for the targeted 3D printed products and processes. Several printer manufacturers offer integrated solutions of certified materials for specific printers in order to guarantee the right quality. The number of material suppliers worldwide increased from 71 in 2017 to 153 in 2020, which corresponds to an increase of 115% in three years.[17]

The material sales for AM systems worldwide have increased significantly in the last decade. In 2010, sales accounted for around €246 million. In 2019 sales accounted for €1.7 billion.[18] This corresponds to an increase of 590% in ten years.

In 2019, 31.9% of the worldwide materials market consisted of the sale of photopolymers. 28.1% consisted of the sale of polymer powders and 20.6% of the sale of filaments. 17.4% of the market was focused on metal powders, in which the top five leading vendors are BASF (Germany), Sandvik (Sweden), Rio Tinto (Canada), Alcoa (USA) and Allegheny Technologies (USA).[19] The remaining 2% of materials include ceramics, materials for binder jetting, solidscape machines and sheet lamination. When looking at the European Market (and Facility Centres's equipment in particular), the prominent role of polymers and metal is confirmed. As further detailed in subsequent chapters, the EU does have a relative strong positioning on the 3D Printing metal segment.

Figure 5: Use of materials in the EU (3DP Pan EU FCs) equipment (in number of equipment)



Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

1.2.2.5 Machinery and equipment manufacturers

Machinery and equipment manufacturers provide the tools that allow the realisation of 3D printed parts. The characteristics of the product, such as size, quality or complexity, are determined by the technology of the printer being used. AM machines can be categorised into two main segments of printers, namely industrial systems and desktop systems. The number of manufacturers of industrial systems worldwide rose from 33 in 2012 to 213 in

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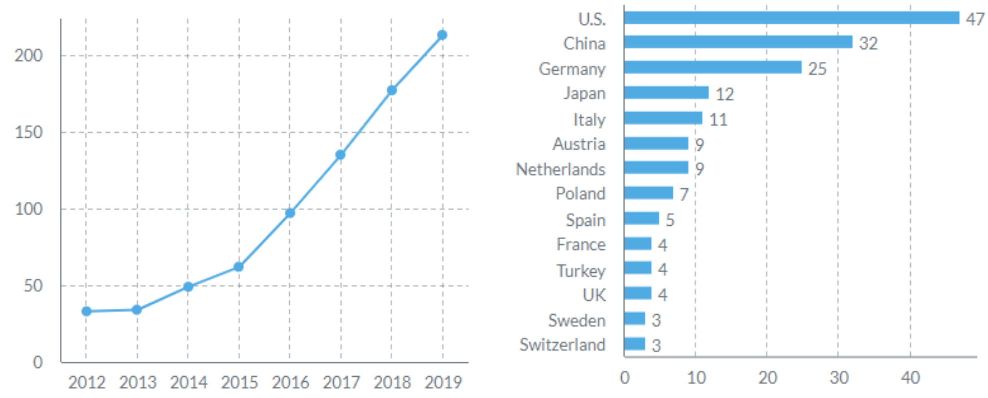
[17] Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry, pp. 160-165

[18] Average USD exchange rate for 2019: 0,893 EUR. Calculation: 275 million USD * 0,893 = 245,6 million EUR; 1,9 billion USD * 0,893 = 1,6967 EUR

[19] Technavio, (2020), Metal Powders Market by Type and Geographic - Forecast and Analysis 2020-2024, consulted online: https://www.technavio.com/report/metal-powders-market-industry-analysis

2019.[20] This is an increase of 545% in seven years. European countries with the highest number of industrial system manufacturers are Germany, Italy and Austria.[21]

Figure 6: Total number of industrial system manufacturers and total number of industrial system manufacturers per country, 2019

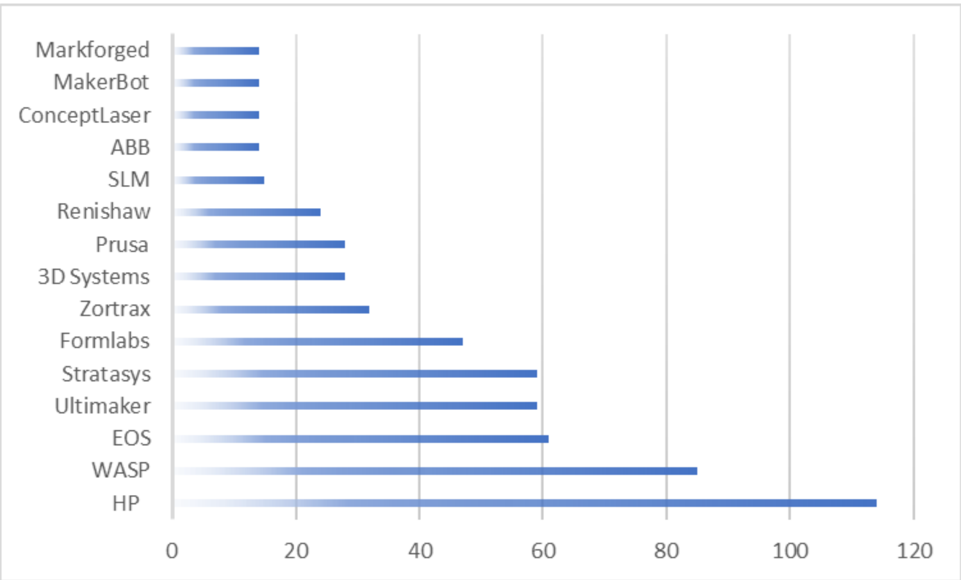


Source: IDEA Consult, adapted from Wohlers Report 2020 (Wohlers Associates, 2020)

Desktop 3D systems can be considered to be AM systems that are sold for less than €5.000. In 2019, the average worldwide selling price of desktop 3D printing systems was €1.068 in comparison with an average selling price of €87.608 for industrial systems. Although there is a large difference in average selling price, the overlapping capabilities of the two segments is increasing each year.

The figure below provides more information about the most commonly used equipment in Europe (figures at the level of speicfic models are presenetd in the chapter 3).

Figure 7: Brand of equipment registered on the 3DP Pan EU Data Base



Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

Depending on the AM technology, a set of post-processing solutions is necessary to reach the finished product. In comparison to 3D printing solutions, post-processing is still an underdeveloped segment in the additive manufacturing value chain. Automation is one of the requirements to increase efficiency of post-processing.

[20] Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry, pp. 82, 105-109

[21] Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry, pp. 94 – 104.

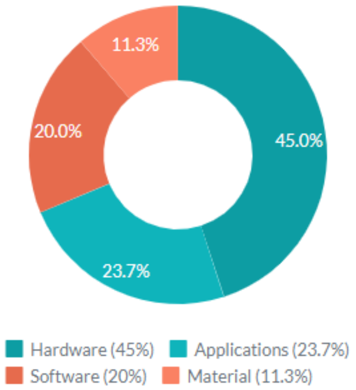
Recently, more companies have started to introduce more solutions to increase automation and optimisation of the post-processing workflow such as Additive Manufacturing Technologies (United Kingdom), DyeMansion (Germany) and Rösler (Germany).[22]

1.2.2.6 Start-ups

Start-up companies can be considered to be another set of stakeholders even if they also include some of the stakeholders mentioned before. In the field of AM, they represent a part of the ecosystem that plays an important role in steering the development because of the industry's high momentum and flexibility. From the 1400 AM start-ups scouted by AM Ventures (a venture capital firm that focuses on early-stage AM start-ups), 221 were founded worldwide in 2019 alone, suggesting a high level of activity and increased momentum in AM-related start-ups. European regions where the most start-ups are located are the DACH region (Germany, Austria and Switzerland with hotspots in Munich, Vienna and Zurich) and the BeNeLux countries (Belgium, Netherlands and Luxembourg). The common success factors of regions with many start-ups are the following:[23]

- world-class technical universities that provide highly educated talent;
- availability of large corporations with high-tech capabilities potentially serving as development partner and pilot customer;
- experienced and well-connected angel and other investors who provide funds and relevant networks;
- outstanding technical and commercial infrastructure with worldwide access.

Figure 8: Focus of AM start-ups share, 2019



Source: IDEA consult, adapted from Wohlers report 2020 (Wohlers Associates, 2020)

When looking at the focus of AM start-ups, most of them are hardware oriented. The main innovation aspects that these start-ups address are material dispensing and energy application systems. The group of software and application start-ups is steadily growing, as the AM hardware is becoming more mature and more applications can be explored. The material start-ups represent the smallest group. These companies are and will often stay niche-oriented due to strong competition from dominating system manufacturers.

[22] AMFG. (2020). *The Additive Manufacturing Landscape 2020.*
[23] Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry, p. 287.

2 / Demand of (demonstration) services - Current and future areas

This chapter aims at assessing the (existing and potential) demand in terms of demonstration services (and demonstration equipment) that are needed for SMEs to uptake 3DP technologies. It further highlights demand trends that are shaping the industry and dictate where it will be leading towards in the future. In order to do so, an analysis of the effective demand of services and remaining barriers is developed below.

The 2020 Covid-19 pandemic has lasting effects on industries as global supply chains are disrupted, pushing for local production and supply reliability on the one hand and decreased overall demand. These effects have repercussions in the long term, which is why developments in individual market segments should be accompanied by an assessment of the pandemic's impacts. Even if an accurate assessment is not always possible as long-lasting effect remain unclear in early 2021, such considerations allow for an improved understanding of how external shocks may shape individual market segments in AM.

2.1. Overall Assessment of Strategic Market Evolutions

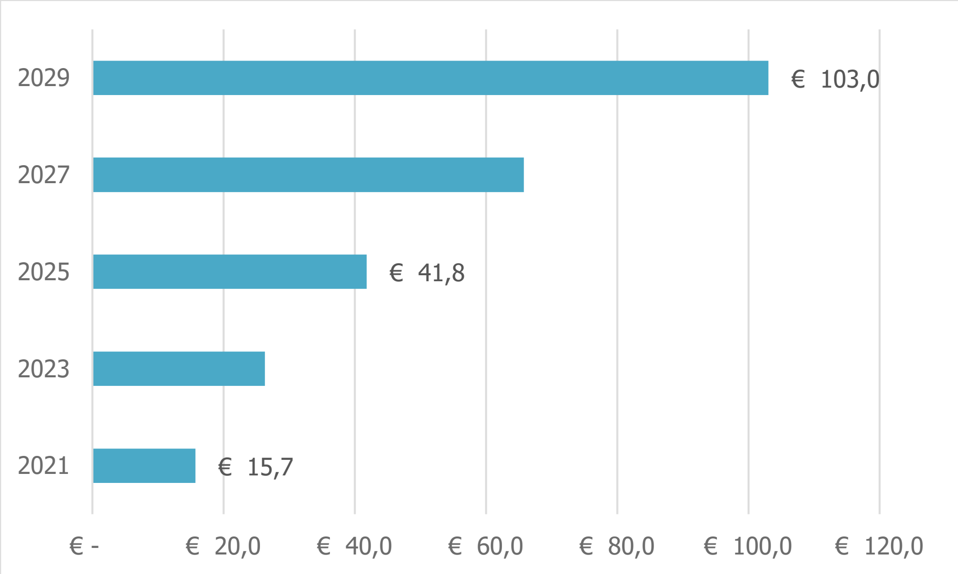
2.1.1 Global trends

3D Printing is a fast-evolving technology subset that has started to gain momentum in the early 2000s and in 2020 is affecting all sectors in different ways. In this section we aim to provide an insight into how 3D printing will evolve in the future and what technologies will emerge in the coming 5 to 10 years based on current demand. When considering AM company valuations in Q1 2020, the industry is anticipated to grow, specifically due to demand increase for 3D printing systems, consumables and part-building services. The information provided in this chapter is designed to provide anecdotal evidence in order to showcase what the possibilities are.

In 2021 the **total market value of AM products** and services is expected to approach €16 billion. This overall assessment does not account for the impact of the Covid-19 pandemic, which has diverse effects on AM. However, the global manufacturing economy is said to be €11.4 trillion. At €10.6 billion in 2019, AM accounts for less than 0.1% of that total manufacturing economy. If AM grows in the coming years to 5% of this global market, it **could easily become a €570 billion industry**. The projection for 2029 foresees an increase to over €100 billion, or ten times more than what it was in 2019.[24]

[24] Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry, p. 294

Figure 9 Market forecast of AM products and services worldwide, in billion euros



Source: IDEA Consult, based on Wohlers Associates Inc., 2020

Across AM segments, the **cost of AM parts has been decreasing** in recent years while quality has been improving along with it. One of the main remaining challenges is the reproducibility of parts. Following a 2021 survey of European industry stakeholders, there is confidence in the demand and related sales of products and parts, machines, materials and services. Industry stakeholders foresee the strongest growth however in metals and plastics. In the short term, the industry expects decreased interest from the aerospace and automotive industries while significant growth is expected in the medical industry.[25]

Following the disruption of the 2020 Covid pandemic on global supply chains, the number of companies using AM technologies for **full-scale series production of hundreds of thousands** of parts grew from 7% in 2019 to 14% in 2020. Furthermore, 84% of surveyed leading manufacturing companies across the world believe that companies investing in AM in 2020 will have a competitive advantage in the following five years.[26] The success of large companies which patented 3D printing technologies has been such that it has attracted start-ups' curiosity and large investments.[27] R&D proofs-of-concept keep being realised and are becoming more viable, therefore, growing future investments are to be expected.

The growing and key importance of 3D Printing in Europe can also be further demonstrated by the current importance AM has on Smart Specialisation Strategies of several regions. First, 29 EU regions joined the Vanguard Initiative 3DP Pilot, which connects innovation ecosystems of regions that do have 3D Printing as one of their key priorities. For illustrative purposes, and (to some extent) beyond the Vanguard Initiative, regional Smart Specialisation Strategies in the Portugal centre region, Valencia in Spain and Nouvelle-Aquitaine in France have identified additive manufacturing and advanced materials to be a key point in bringing their regions forward. [28]

2.1.2 AM and future applications areas for final products

In a 2020 Survey of 283 service providers, manufacturers and producers of third-party materials and desktop 3D printers, representing over 150.000 current **users of AM**, 16,4% of respondents indicated to be active in the

[25] Cecimo, (2021), Cecimo presse release: the first European survey on key market trends in the additive manufacturing sector, consulted online: https://www.cecimo.eu/news/press-release-the-first-european-survey-on-key-market-trends-in-the-additive-manufacturing-sector/

[26] Essentium, (2020), Essentium Research Shows Additive Manufacturing is Ready for Prime Time, consulted online: https://www.essentium.com/news/essentium-research-shows-additive-manufacturing-is-ready-for-prime-time/

[27] Forbes. (2019). Why Are Investors Pouring Millions Into 3-D Printing? Retrieved from https://www.forbes.com/sites/sarahgoehrke/2019/01/25/why-are-investors-pouring-millions-into-3-d-printing/?sh=5afd38287f94

[28] CENTIMFE. (2018). Technological Roadmap on Additive Manufacturing and Advanced Materials in the SUDOE Region. CENTIMFE. P. 39.

automotive sector, 15,4% in the consumer products and electronics sector and 14,7% in aerospace followed by Medical/dental, academic institutions, power/energy, government/military and architectural/construction.[29]

Specific products and sectors that will experience a significant uptake in the coming 10 years include polymer end-use products in aerospace, ceramic materials in the dental sector, etc.[30] In the following section, specific application areas in the **automotive industry** (brake callipers, structural components, trim), the **aerospace** sector (structural components, engine components), the **healthcare** sector (metal implants, dental devices, drill and cutting guides and surgical planning models), the **food industry** (bioprinting), the **construction** industry and for online market places are elaborated by using existing examples of successful cases, i.e., components or items that have been developed, tested and used. This provides an insight into future application areas for final products in important industrial sectors for Europe.

The **automotive industry** has made use of 3D printing applications since the technology emerged in the 1980ies, mainly for prototyping and concept design, which is still largely the case in 2020. Some manufacturers like Bugatti, Ford and BMW have started using AM techniques for production cars. Daimler Trucks produces spare parts for its large trucks by A, improving maintenance and repair times. Bugatti uses AM for brake callipers, spoilers and even final trim components. Notable application areas to gain importance in the near future are AM for maintenance and repair of truck fleets and utility vehicle fleets.

Figure 10 Bugatti exhaust cover produced by AM

Source: Bugatti, 2020[31]

The **aerospace sector** was an early adaptor of AM technologies. Since the 1990ies, Boeing has manufactured over 60.000 flying production parts through AM. Other major players on the marker using AM include Airbus, Honeywell Aerospace, Lockheed Martin and Northrop Grumman. For spacecraft AM plays an even bigger role as NASA, the European Space Agency and SpaceX use AM to manufacture igniters, thrusters, injectors and combustion chambers for rocket engines. 3DP printing normalisation in the aerospace industry has been anticipated to take place in 2020 and although not the case yet, the interest of the sector is the strongest following the healthcare and medical devices sector in Europe. These trends converge in fact with the search data we analysed of the 3DP PAN EU Platform in section 2.2.

In the Machine and Tool industry, AM technologies were explored for a few years already. Companies typically execute R&D and prototyping for small series production in-house, making them an important type of actor to engage with in industrial ecosystems. Relevant companies in Europe include DMG MORI AG (Germany), Trumpf

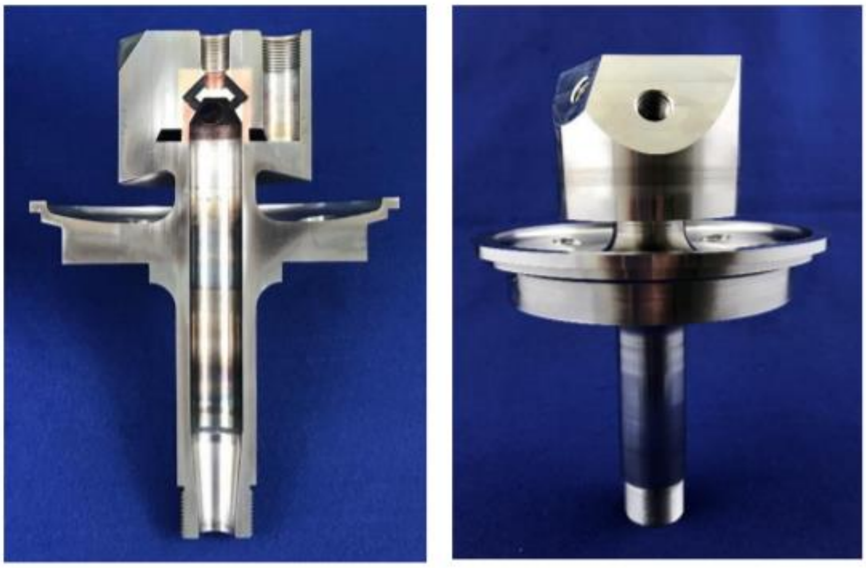
[29] Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry, p. 22..

[30] Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry, pp. 123 – 133.

[31] Bravo, T., (2020), Technological Innovations – Bugatti Prints Trim Covers Made of Titanium, consulted online: https://newsroom.bugatti/en/press-releases/technological-innovations-3d-printing

(Germany), Hofmann tooling (Germany), Sandvik (Sweden), Atlas Copco (Sweden), TE-Connectivity (Switzerland), LTH Casting (Slovenia) and MARSI Group (Slovenia).[32]

Figure 11 Nasa augmented spark igniter produced by hybrid manufacturing



Source: NASA, 2018, Additive Manufacturing of Liquid Rocket Engine Combustion Devices: A Summary of Process Developments and Hot-Fire Testing Results

The **construction sector** has also made major breakthroughs in AM. German based PERI is the first company to have printed a fully certified building under national building regulation in December of 2020. Even though many companies have created walls and partial buildings by applying AM techniques in the past decade, creating an entire building that would stand up to the same quality standards as conventional construction methods is a newer breakthrough and will lead to further uptake of AM in the construction sector. Worldwide, the revenue of the construction additive manufacturing market is expected to grow from €0.06 billion in 2017 to close to €34 billion by 2027 – a 570-fold increase.[33][34] Therefore, manufacturers of AM systems for construction purposes and modular buildings of 2020 will face significant increase in demand in the coming years, in particular in fields of Modular light-weight building segments, for further assembling on-site.

[32] EASME. (2021). Advanced Technologies for Industry – Product Watch. 3D printing fort he machine tool industry. P. 12.
[33] Statista, (2018), Revenue of construction additive manufacturing market worldwide in 2016 to 2017, with forecasts from 2018 to 2027, consulted online: https://www.statista.com/statistics/894665/global-construction-additive-manufacturing-market-revenue/
[34] Average USD exchange rate for 2018: 0,848 EUR. Calculation: 0.07 billion USD * 0,848 = 0.06 billion EUR / 40 billion USD * 0,877 = 35.08 billion EUR

Figure 12 3D printed wall printed with BOD2 printer

Source: PERI, 2020: https://www.peri.com/en/business-segments/3d-construction-printing.html

AM is also used to produce **patterns for investment casting of metal parts and moulds** in the jewellery industry but also in the automotive sector where AM sand moulds are used for casting prototype engine, transmission and brake parts. AM moulds allow for the easy addition of conformal cooling channels that remove heat faster from the components, resulting in faster moulding times and more qualitative parts.

Figure 13 Renishaw InfiniAM Spectral software for laser powder-bed fusion (LPBF) technologies

Source: Make Parts Fast, 2019, https://www.makepartsfast.com/look-into-the-additive-manufacturing-melt-pool/

The possibility of designing cooling channels more flexibly is also a reason the **ICT industry** is interested in AM. This industry is particularly relevant for AM because it affects many different fields such as smart software, robotics, AI, Big Data, embedded electronics, etc. Electronic and electrical equipment consists of functional components that in order to operate are made of metals such as aluminium, copper, steel and gold, plastics and ceramics. Manufacturers of **semiconductors and CPU cooling components** are looking into the possibility of 3D printing copper, which allows for intricate and complex designs, accommodating micro cooling channels resulting in flow mixing capabilities twice as high and twice the heat transfer of traditional components.[35]

Only recently has AM made its way into the **medical & healthcare sector**. It is however becoming standard practice to manufacture among other parts, metal implants, dental devices, drill and cutting guides and surgical planning models. Hospitals in the U.S.A. are investing into 3DP equipment to manufacture parts in house. 160 hospitals disposed of printing systems in 2019 and medical reimbursement plans for 3D printed parts have been adopted, which is something Europe is still lacking. By 2025, healthcare providers expect to make cost savings of up to 5% through the adoption of AM technologies.

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[35] Donaldson, B., (2020), The Case for Tackling the Toughest Material First, Additive Manufacturing Magazine, consulted online: https://www.additivemanufacturing.media/articles/the-case-for-tackling-the-toughest-material-first

AM is also used to manufacture tools such as **jigs, fixtures, templates, gauges and drill and cutting guides** for the medial & healthcare sector. AM is ideal for this application as low quantities are required and items can be manufactured in house, or close to the production site. Their relative cost if used for manufacturing large batches of components is also marginal. Linking onto the growing IoT market, electronics manufacturers are anticipated to adopt **3D printed electronics for stretchable and flexible electronics** in medical and sporting applications on a large scale.

Figure 14 Think3D custom dental implant drill guide made by AM

Source: Think3D, 2019, https://www.think3d.in/3d-printed-surgical-guides/

Specific segments within the AM industry that will generate significant innovations in the coming 10 years include **custom products for consumer**. In 2018, 71% of European companies considered themselves to be intermediate users or experts in 3D printing applied to consumer goods specifically. The survey was conducted with over 600 European companies, but also includes responses from American and Asian companies.[36]

Final part manufacturing is the fastest growing sub-sector of AM with the likes of GE Aviation, Liebherr and Airbus manufacturing over 30.000 components for their equipment and aircraft.[37] Many application areas still emerge and will continue to be developed as the benefits of AM for different applications are embraced by engineers, manufacturers and customers. Examples include food 3D printing for edible components (especially interesting in the context of space exploration and vitamin delivery for the elderly), and bioprinting for recreating living tissue and even fully functional organs. This last example is being investigated as the use of patients' own cells for creating new tissue increases the likelihood of that tissue being accepted by the body.[38] By 2025, healthcare providers expect to make cost savings of up to 5% through the adoption of AM technologies.[39] Cosmetic models are also very popular, although these are only used to demonstrate design intent amongst engineers or for presentations with management and customers to further develop their models, not for end-user production. Functional prototypes are also used by engineers to test form, fit and function of components. These functional models are considered an essential step in order to validate designs before they move into production.

Another relevant market evolution is that of **online marketplaces**. These are service providers who connect creators of 3D content, users of AM machines and customers who ultimately order individual parts from a library of 3D designs that they have shared themselves or other users have made available to a wider public. Prominent examples of such marketplaces include Shapeways, i.materialise and Thingiverse.

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[36] Sculpteo, (2018), The State of 3D Printing, consulted online: https://info.sculpteo.com/hubfs/downloads/Sculpteo%20State%20of%203D%20Printing%20-%202018.pdf

[37] Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry, p. 31.

[38] ALL3DP, (2020), Most Promising 3D Organs for Transplant, consulted online: https://all3dp.com/2/most-promising-3d-printed-organs-for-transplant/

[39] IDC, (2020), IDC FutureScape Worldwide Imaging, Printing, Document Solutions and 3D Printing 2021 Predictions, consulted online: https://www.idc.com/getdoc.jsp?containerId=US47035120&pageType=PRINTFRIENDLY

2.1.3 Innovative technologies and processes of 3D Printing and related demonstration needs

While the proof for where innovations are leading towards in the near future is mainly anecdotal, this section aims to provide more information on fields where Additive Manufacturing is expected to experience crucial innovations. This section focuses in particular on interlinkages between Additive Manufacturing and other technology fields (AI, IoT, etc.).

In the future, there is a broad range of services and products that will be developed and some of them are unknown at the moment as the pace of innovation in this technology is very high. One aspect that will be the focus across most sectors will be the **ability to provide serial manufacturing capabilities**, moving away from prototyping and small-scale production. Quality also plays an important role as 3D manufactured items need to withstand strong forces over long periods of time, depending on the application area. Related to this, another key opportunity for further growth in AM is automated and integrated **post-processing**. Automation is one of the requirements to increase efficiency of post-processing. As indicated in section 1.2, more companies have recently started to introduce more solutions to increase automation and optimisation of the post-processing workflow in Europe such as Additive Manufacturing Technologies (United Kingdom), DyeMansion (Germany) and Rösler (Germany).[40]

The majority of AM systems providers focus on **hardware innovations**. Hardware start-ups specifically focus on material dispensing and energy application systems while established system manufacturers focus on increasing production speeds. By 2022, 75% of new 3D printers and AM systems sold on the market worldwide will be supporting innovative materials with properties like gel and rubber.[41]

Important innovations in 3D printing will be on the **software and imaging** side of the production process. Companies like Materialise (USA), Oqton (USA) and Voxeldance (China) will be leading the way by increasing speed and quality. Oqton sets itself apart by providing software that integrates design and production. In future design processes, AI will play a larger role as demonstrated by the open generative-engineering platform ELISE. This software was used to manufacture a titanium bracket for the Ariane 6 satellite resulting in a 56% weight reduction.[42]

Generative design software is anticipated to be used for 50% of AM prints by 2023. This technology marries AI with big data and has been producing reliable and light products on several occasions, allowing designers to focus on the function of the part rather than on the manufacturability, which is taken care of by intelligent software processes.[43] This technology will particularly be relevant for applications where individual components are subject to big loads, stress and continuous strain. The aerospace, car manufacturing and construction/infrastructure sectors are particularly interested in components displaying such properties as they typically are part of large machinery or structures that is expected to function reliably and efficiently for long periods of time.

A common property across materials and segments that stakeholders appreciate in 3DP manufactured components are the **lattice structures the designed components** allow for. These lattice structures result in higher shock absorbance for flexible components (highly relevant for e.g. sporting equipment), weight reductions (highly relevant for e.g. aerospace and automotive), and increased stress-resistance and reliability (highly relevant for e.g. production technology and equipment). As these are qualities that can give individual companies a competitive edge and improve their products overall, it is very likely that the indicated segments and related sectors will experience an important uptake in innovations in the near future.

Multi-material printing of components is a very promising innovative activity within AM. This implies using several materials while printing a component. This allows additional functionality to be designed into components through various material density, flexibility and strength. Industrial examples exist, such as the use of nitinol alloy for the opening system of satellite panels.[44] **3D printed electronics for stretchable and flexible electronics** could also be manufactured through multi-material printing, highlighting once more the versatility of AM and potential for cross-sectoral collaboration.

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[40] AMFG. (2020). *The Additive Manufacturing Landscape 2020.*
[41] International Data Corporation, (2018), IDC FutureScape: Worldwide 3D Printing 2019 Predictions, p. 5.
[42] Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry, p. 286.
[43] International Data Corporation, (2018), IDC FutureScape: Worldwide 3D Printing 2019 Predictions, p. 5.
[44] Sirris, (2020), cited in the 3DP Pilot Plenary Meeting 26.11.2020 - Takeaways Report.

When looking at specific materials, demand in the **metal AM** industry specifically is increasing sharply. In May 2019 Honeywell Aerospace had access to 100 metal AM machines but needed 420 to keep up with demand. In the coming 5 to 10 years, system manufacturers will experience an increase in demand for printing systems that allow for quick production times, high precision and ease of replacing individual components for different applications. As shown in Figure 15, suppliers in the metal AM market worldwide expect an increase in their annual growth larger than the buyers annual growth. There is an overestimation by the suppliers regarding the sales revenue which causes the differing figures. PBF machine supplier in particular have inflated their market size expectations.[45]

Figure 15: Metal Additive Manufacturing market 2019 – supplier vs. Buyer forecast 2024 in billion euros

Source: AMPOWER Report (2019)

The following materials are also expected to gain importance in the AM industry: **Precious metals** for ICT industry; **Ceramics** for components with high stress resistance and low density; **Composite** materials for all applications and sectors. Materials are expected to provide improved properties compared to materials used in conventional production methods in terms of temperature, corrosion and wear resistance, and for metallic alloys specifically high conductivity and heat dissipations and mechanical resistance. Bio-medical materials with biocompatible and bio-active materials are also a main of attention in the near future for the AM market in Europe.[46]

Hydrogels also provide an interesting example of a material that is currently rarely used or sought after but which holds huge potential for the future. Hydrogels and shape memory poylmers are the basis for 4D printing and are deemed to be "smart materials". 4D printing is expected to allow printing of components that change their shape over time. Potential application sectors include:

- Self-repair systems for different sectors
- Self-assembly furniture
- Medical industry
- Aerospace labs
- Reshaping transports in case of an accident
- Reducing environmental impact through diminishing volume of packaging

It is expected that such components will not be relevant on the AM market before 2030.[47]

[45] AMPOWER Report. (2019). Metal Additive Manufacturing suppliers predict a market size growth of 27.9 %. Consulted online: https://additive-manufacturing-report.com/additive-manufacturing-market/

[46] CENTIMFE. (2018). Technological Roadmap on Additive Manufacturing and Advanced Materials in the SUDOE Region. CENTIMFE. P. 32.

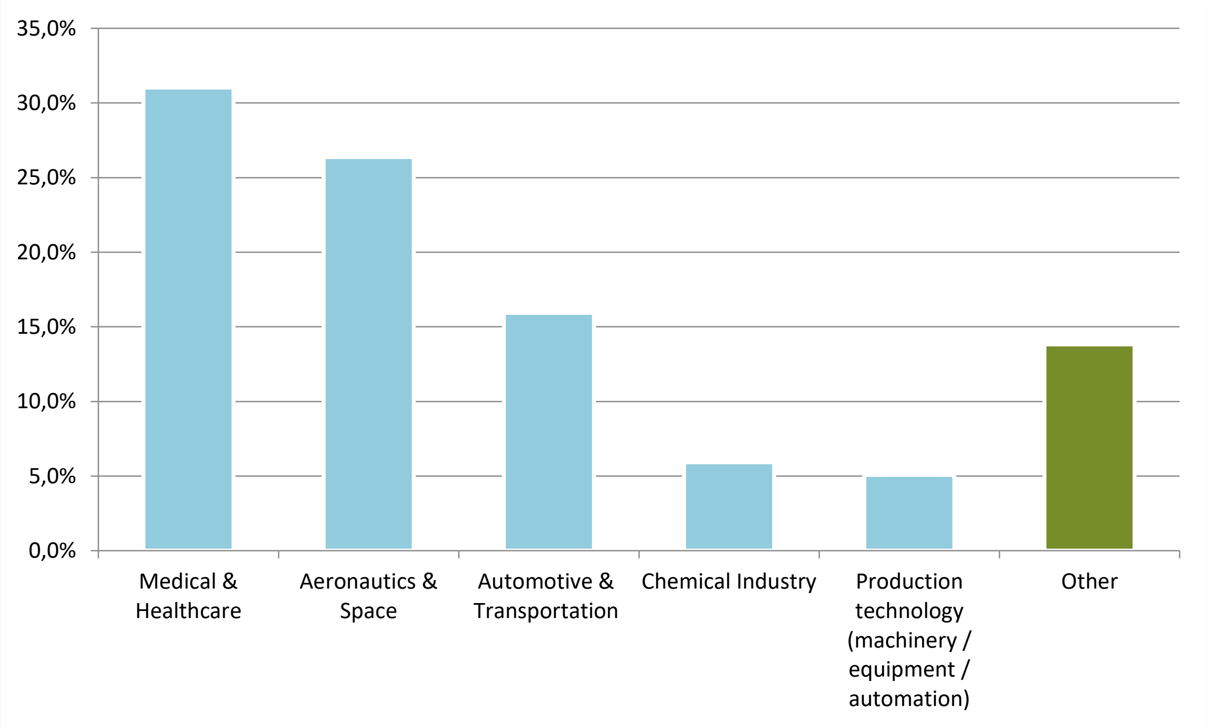
[47] Lortek. (2020). Long-term technological and industrial plan. P. 29.

2.2. Analysis of 3DP PAN EU Demonstration Requests

The 3DP PAN EU Platform, set up through the DG GROW funded project '3DP PAN EU', aims to provide matching opportunities between the demand and supply of demonstration service. Through this platform, any interested organisation is able to contact suppliers of 3D Printing related demonstration services. Up to October 2020 the platform counts **381 Facility Centres in 27 countries** providing services from simulation to post-processing and giving access to a broad range of printers, AM Systems and other supporting manufacturing equipment. Facility centres are typically R&D&I organisations, such as universities, Research and Technology Organisations (RTOs) that support in the development and demonstration on the technological solution.

Since being online, over **3500 individual searches** have been made on the platform between March and October 2020. Of those searches, only 700 were sector-specific. The most sought-after application sector on the platform is **Medical & Healthcare (31% of all sector-specific searches), followed by Aeronautics & Space and Automotive & Transportation.** The sectors with the **least searches on the platform are Textile & Fashion, followed by Energy and Consumer Goods & Products**, which reflects quite well anticipations foreseen (in terms of expected industrialisation per application area) and described in 2.1.

Figure 16: Top 5 sector searches on the 3DP Pan EU Platform, per sector (% of total searches)



Source: IDEA Consult, based on 3DP PAN EU Platform data

The following table highlights the top 5 sector-related searches made on the Platform and the service distribution within the search for that specific sector.

Table 3: Top 5 sector searches and related services on the 3DP Pan EU Platform

Sector-specific services searched for	% of searches
1. Medical & Healthcare	**31,0%**
3D Printing / Prototyping	83,9%
Technical studies - state of the art	7,5%
Product Design & Modelling	4,3%

2. Aeronautics & Space	**26,4%**
3D Printing / Prototyping	47,2%
Product Design & Modelling	11,1%
Market studies - technology cost comparison	8,3%
3. Automotive & Transportation (excluding ships and boats)	**15,1%**
3D Printing / Prototyping	50,0%
Product Design & Modelling, Thermal	31,3%
Market studies - technology cost comparison	18,8%
4. Chemical Industry	**5,9%**
3D Printing / Prototyping	62,5%
Acoustic noise testing	15,6%
Technical studies - feasability	12,5%
5. Production technology (machinery / equipment / automation)	**5,1%**
Mechanical testing, surface finishing	43,8%
3D Printing / Prototyping	31,3%
Mechanical testing	12,5%

Source: IDEA Consult, based on 3DP PAN EU Platform data

The most sought-after services on the 3DP PAN EU Platform are **3D Printing / Prototyping and support services, mainly state of the art technical studies.** Of all Medical & Healthcare related searches, 83.9% were related to 3D Printing / Prototyping.[48]

Worldwide, prototyping was the most common use of 3D printing, with 68% of 1.600 companies surveyed indicating it as the primary use. This is followed by proof of concept and production.[49] Beyond 3DP Printing / Prototyping, services of 'product design and modelling' were most popular. This tends to indicate that organisations in need of 3D printing services want physical prototypes to be manufactured off site (i.e. by competent Facility Centre), in order to be tested at a later stage/in-house/elsewhere, with the exception of the production technology sector, where mechanical testing and more specifically surface finishing are services that individual companies require primarily.

When specific materials were looked for, which was only the case for around 10% of all searches, **Ferrous metals were most popular, followed by Natural Polymers and Hydrogels.**. The main materials searched for within the Medical & Healthcare sector was polymer thermoplastic, while in Aeronautics & Space as well as in the Automotive & Transport (excluding ships and boats) sectors, the main materials were somewhat more diverse with Hydrogels, natural polymers and ferrous metals being the most looked for materials. Again, these observations are in line with expected growing importance (in terms of industrial applications) of these materials (see 2.1). 93% of all searches made on the platform are detailed searches for industry partners made through the platform's in-depth matchmaking tool. The rest of the searches were made for general facility centres and 112 searches were made in the summer of 2020 for facility centres capable of delivering Covid-19 related services. Likely these requests relate

[48] Analysis made by IDEA Consult based on a data extraction of the 3DP PAN EU Platform website for searches made between 05/03/2020 and 20/10/2020.
[49] Statista, (2020), Leasing uses of 3D printing from 2015 to 2020, consulted online: https://www.statista.com/statistics/560271/worldwide-survey-3d-printing-uses/

to the demand of printed respirator valves as was the case in Italy, when the startup Isinnova was able to supply 100 of them to the local hospital within a few days.[50]

In terms of location, it is not possible to analyse the search data of the platform according to location. The data protection Directive 95/46/EC states that IP addresses are considered to be personal data and that information inferred from it cannot be shared.

There is a strong demand in member states for knowledge sharing in the form of seminars and workshops as well as company visits between different regions in collaboration with enterprises and research organisations – whether they are public or private.[51]

2.3. Barriers

This section briefly analyses what are the main (non-technological) barriers currently hampering the uptake of 3D Printing solutions within companies. In the chapter, more specific and upcoming possible barriers in the further uptake and deployment are presented, relying upon insights from all previous sections. The barriers mentioned are echoed to one extent or the other by all reports analysed in the context of this study.

A barrier to 3DP uptake is the **design process**. In order to fully exploit the benefits AM offers, designers need to approach their process from the functionality point of view more so then from the manufacturability point of view. The lack of repeatability Training in this regard is crucial to have designers adapt their approach. The lack of a **skilled labour force** and, more to the point, access to adequate training or engineers having been trained in relevant AM technologies is another barrier for companies. This also influences investment decisions into appropriate training. Specifically skills in modelling, design, materials science, metallurgy, structural integrity, quality control and inspection of AM parts will be relevant in the coming years.[52] To overcome this barrier, a strong communication between industry, academia and recruitment offices is necessary as AM does promise increased job growth in the coming years, only however if people are trained appropriately. For more on this see section 1.2.While **high-cost of equipment and materials and long production times** have been an issue since 3DP emerged, these entry barriers have become less important, as the complexity and versatility in manufacturing trump the cost and time concerns in specific cases. For SMEs, the high acquisition cost of AM systems remains a barrier, however the European market especially has facility centres that allow SMEs to simulate, prototype and manufacture products without the need for them to own any of the expensive AM systems themselves, which allows them to test functionalities before investing. Furthermore, costs barriers tend to vary according to the technologies applied and AM systems used. The investment barrier for Metal FDM system for instance tends to have low costs.[53]

Another barrier is that of **current regulation-related aspects** in the AM industry. In order guarantee a positive uptake of AM in Europe, overregulation should be avoided by involving industries in the decision-making process of national and international policy.[54] Overregulation in legislation puts a particular burden on SMEs and their competitiveness on the global market. These do not have the market reach and financial resources to maintain operations while complying with legislation that covers their activity but is not tailored to their needs. Therefore legislation and policies should be designed in consultation with industry stakeholders in order to ensure environmental and economic sustainability of AM.[55]

The **lack of harmonized standards, legislation and regulations** also hampers a proper uptake and deployment (at large scale/large series) of additive manufacturing. Specifically, lacking legislation and standards in

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[50] Whitwam, R., (2020), Italian 3D Printing Startup Creates Replacement Respirator Valves for Covid-19 Patients, Extremetech, consulted online: https://www.extremetech.com/extreme/307773-italian-3d-printing-startup-creates-replacement-respirator-valves-for-covid-19-patients

[51] CENTIMFE. (2018). Technological Roadmap on Additive Manufacturing and Advanced Materials in the SUDOE Region. CENTIMFE. P. 43

[52] European Commission. (2021). Global and Societal Milestones Report – Executive Summary. P. 10.

[53] AMPOWER Report. (2019). Metal Additive Manufacturing suppliers predict a market size growth of 27.9 %. Retrieved from https://additive-manufacturing-report.com/additive-manufacturing-market/

[54] CECIMO. (2020). Additive Manufacturing European Conference – Key Takeaways. Consulted online: https://www.cecimo.eu/wp-content/uploads/2020/12/AMEC-Takeaways-FINAL.pdf

[55] CECIMO, (2019), The European Machine Tool Sector and the Circular Economy, p. 35

AM may raise concerns about the safety of manufactured parts in risk environment sectors such as aviation, automotive, aerospace and infrastructure.[56]

Another general but important barrier to the uptake of 3D Printing-related solutions is a **conservative company culture** in SMEs. Established and proven-to-work practices in an organisation can lead to hampering innovation. When an organisation has embraced innovation as an established practice already, it is able to integrate new technologies with high efficiency and effectiveness. The solution for more rigid organisations is the compilation of datasets that allow for a side-by-side comparison of conventional and modern manufacturing methods.[57] This would allow to bridge a knowledge gap that deters companies form investing into the technology that best suit their needs.

Lack of **awareness** related to the fast-moving/evolving opportunities offered by AM remain also a barrier. Many companies are indeed not aware of the potential added value (but also associated well-estimated costs) of using AM in their own manufacturing processes. For example, in France, manufacturing companies are often not convinced of the quality of finishing of components and therefore resort to traditional manufacturing technologies. There is a clear need of private manufacturing companies for demonstrations of AM technologies and the availability of scientific and technological centres that can provide relevant services and support SMEs in their AM transition.[58]

3 / Supply of (demonstration) services – Equipment, expertise, and services

This chapter aims at further analysing the supply-side in terms of the demonstration services provision both of equipment manufacturers and facility centres.

3.1. AM Equipment in Europe

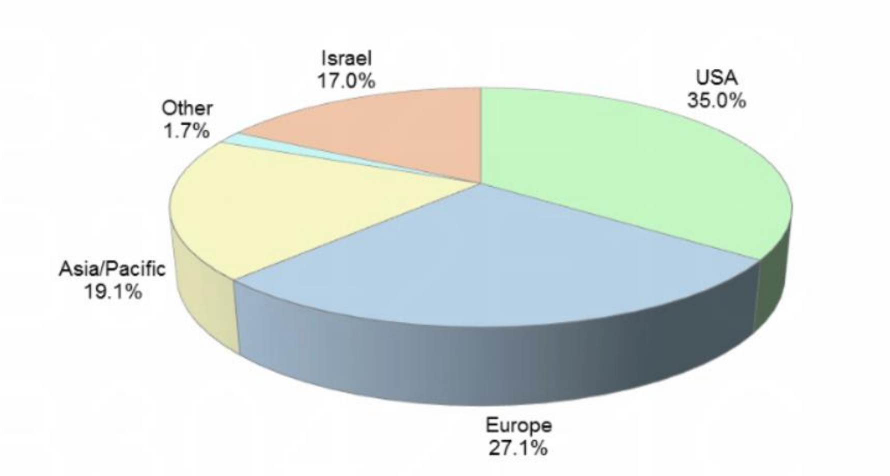
In this section, we provide an overview of the current (and expected) availability of AM Equipment in Europe. This section is therefore not restricted to the demonstration activities (i.e. including equipment used purely for commercial/industrial deployment). A focus on demonstration-related equipment is proposed in the section 3.2.

Worldwide, 213 AM system manufacturers sold industral AM systems as of March 2020. In 2019, Europe counted 94 AM system manufacturers, suggesting a strong position of the European AM industry. The European manufacturers with the most sales of industrial AM systems on the market in 2019 were Envisiontec (Germany), Prodways (France – facility centres on the 3DP PAN EU Platform have access to 6 of these AM systems), DWS (Italy - facility centres on the 3DP PAN EU Platform have access to 9 of these AM systems), Sinterit (Poland - facility centres on the 3DP PAN EU Platform have access to 12 of these printers), who also offer desktop printers and W2P (Austria). Between 2009 and 2019, the unit sales volume of industrial systems has increased from 4.500 to over 22.000 worldwide, representing an increase of 388%.[59]

When looking at the total number of industrial AM systems sold in 2019 in the figure below, the USA held a third of the market (in abolute number of units sold), while Europe followed as close second with 27,1%. Europe counts a total of 95 industrial AM systems manufacturers - 26 more than the year before, proving once again the industry's strong momentum. 27 Of these manufacturers produce AM systems for metal parts specifically, where Europe holds a strong technical expertise. The large share of Israel is mainly due to the fact that Stratasys (formerly American) became an Israel-based company in 2012.

[56] EASME. (2021). Advanced Technologies for Industry – Product Watch. 3D printing for the machine tool industry. P. 12
[57] Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry, p. 192.
[58] CENTIMFE. (2018). Technological Roadmap on Additive Manufacturing and Advanced Materials in the SUDOE Region. CENTIMFE. P. 25.
[59] Average selling price of an AM system in 2019 : 98.105 USD. Average USD exchange rate for 2019: 0,893 EUR. Calculation: 98.105 USD * 0,893 * 5994 units = 525.120.943 EUR

Figure 17 Worldwide Industrial AM Systems Units Sold, 2019

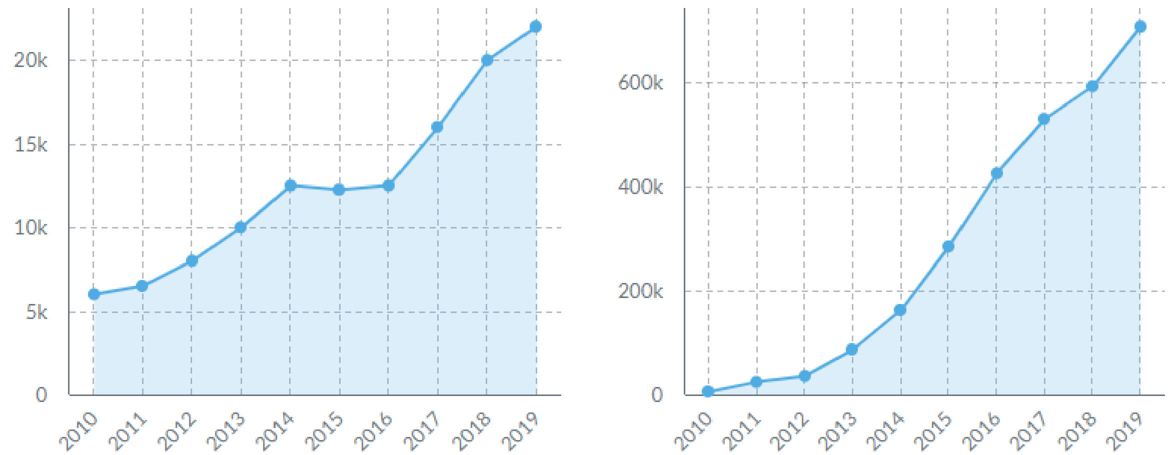


Source: Wohlers Associates, 2020

A cumulative total of 163.061 industrial AM systems had been sold up to 2019 worldwide. These are systems that sell for over €5.000 as cheaper systems are referred to as desktop printers or low-cost systems. While not all of them would still be in use today, a conservative estimate would suggest that over 30.000 industrial AM systems are currently in use in Europe.[60] In 2019 alone, 22.115 units were sold, 5.994 of which by European companies. This adds up to a European turnover of over €500 million for industrial AM systems alone that year. Only the U.S.A sold more industrial AM systems with 35% of the market share and Europe is expected to hold its number two position in additive manufacturing in the foreseeable future.

At an average selling price of close to €100 thousand, many private hobbyists, entrepreneurs and SMEs resort to cheaper desktop printers. Such smaller AM systems however also have an important impact on the manufacturing industry as they enable individuals and organisations to circumvent traditional channels used for designing and creating manufactured components. An estimated 705.694 desktop printers were sold in 2019, up from 1.816 in 2009. This represents an important market as the sale of smaller desktop systems is expected to grow quicker than the sale of industrial AM systems as also suggested by Figure 18.

Figure 18: Worldwide sales of industrial AM systems (left) and desktop systems (right)



Source: Wohlers Associates report 2020

2020 having been a disruptive year in many ways, not least on the AM industry, it remains to be seen how the sales of industrial AM systems and desktop printers will evolve.

[60] Based on IDEA assessment of Wohlers Associates 2020 data of the 2019 market share of European AM systems sold and 10% of all AM systems sold having been put out of use over time.

In total, 1.42 million 3D printers were sold in 2018 worldwide and by 2027 it is expected that the sales will increase to 8.04 million. The increase will largely be driven by industry rather than private demand. With the cost of acquisition and materials decreasing it is unlikely that overall spending will grow as sharply as the sales of AM systems and printers, however this indicates a strong growth of the industry overall.[61]

3.2. 3DP PAN EU Platform Facility Centres

The 3DP PAN EU Platform, set up through the DG GROW funded project '3DP PAN EU', aims to provide matching opportunities between the demand and supply of demonstration service. Through this platform, any interested organisation is able to contact suppliers of 3D Printing related demonstration services. Up to October 2020 the platform counts **381 Facility Centres in 27 countries** providing services from simulation to post-processing and giving access to a broad range of printers, AM Systems and other supporting manufacturing equipment. Facility centres are typically R&D&I organisations, such as universities, Research and Technology Organisations (RTOs) that support in the development and demonstration on the technological solution. Since being online, a total of 132 facility centres have registered equipment, totalling over 1300 machines.

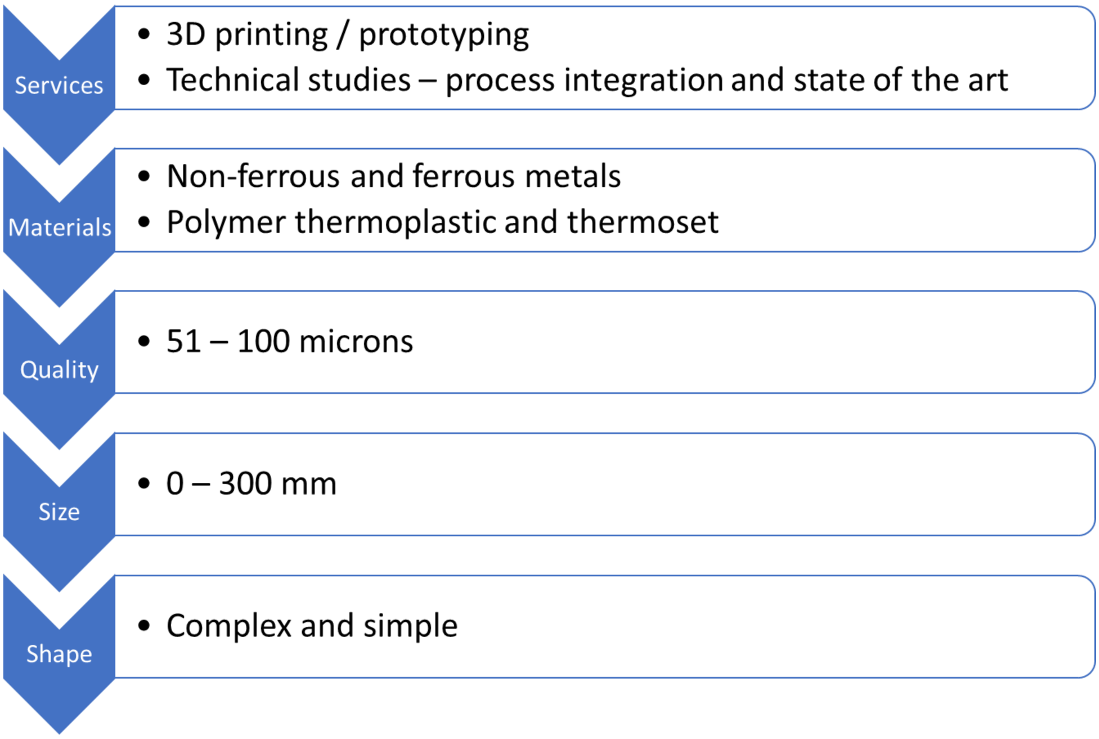
Facility centres in Europe answer to demonstration needs in several sectors simultaneously and are strong in numbers and networks in sectors such as aeronautics & space, automotive & transportation, medical & healthcare and production technology.

Before analysing in details the characteristics of the equipment and services of the Facility Centres, the box below provides the profile of a 'typical' /median facility centre registered on the 3DP PAN EU Platform.

Box 1: The 'Average' Facility Centre

[61] Statista, (2018), Global unit shipments of 3D printers from 2018 to 2027, consulted online: https://www.statista.com/statistics/370297/worldwide-shipments-3d-printers/

Figure 19: Average facility centre profile registered on 3DP PAN EU Platform



Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

This profile is composed based on the most common traits of all facility centres on the platform. 3D printing / prototyping is the main service that the European facility centres provide (such equipment are used for demonstration/innovation purposes rather than series production). These facility centres typically/usually offer the possibilities for technical studies and other services discussed in the next section.

Of the 381 facility centres registered on the platform, 132 have registered equipment, totalling over 1300 machines. These machines are either individual 3D printers or complete AM systems able to manufacture finished or semi-finished products. Not all facility centres own or have 3d printing equipment at their disposal but rather provide related services such as technical studies. The facility centres that do have access to equipment have on average access to between 6 and 7 printers and/or AM systems.

11.6% of registered facility centres having provided this information are able to provide a sterile work environment, necessary especially for medical applications, but also for specific components for aerospace and any end-use that requires highly specialised parts. It not surprising that only a small share of facility centres are able to manufacture parts in sterile conditions as the industry is largely still chasing series production and sterile 3D printing remains reserved to few applications.[62]

1 in 4 registered facility centres have equipment with multi-material capabilities. This means that these facility centres are able to develop and manufacture final or semi-finished components made out of several materials. Multi-material properties can have several meanings. In the context of the 3D printing equipment, this signifies that it is capable of either layering different materials or extruding composite materials.

3.2.1 Equipment

Over 1300 pieces of equipment have been registered by facility centres on the 3DP PAN EU Platform. The top 15 **brands** represented make up 60% of all represented brands, of which there are over 160. Facility centres indicated

[62] Neches, Russell & Flynn, Kaitlin & Zaman, Luis & Tung, Emily & Pudlo, Nicholas. (2016). On the intrinsic sterility of 3D printing. 10.7287/PEERJ.PREPRINTS.542V2.

the specific brand of their equipment for 1000 out of over 1300 registered pieces of equipment. It is important to note that the higher number of equipment suggests a common use of smaller printers, as large AM systems require significant floorspace and are expensive. Hence, they tend to be smaller in numbers. The numbers representing equipment both include small 3D printers and large AM systems. The top 3 brands of AM equipment registered on the platform are **HP**, **WASP** and **EOS**.

Table 4 Top 15 brands of AM equipment registered on the 3DP PAN EU platform

Equipment brand	Number of equipment
HP (US/EU)	114
WASP (EU)	85
EOS (EU)	61
Ultimaker (EU/US)	59
Stratasys (US/IL)	59
Formlabs	47
Zortrax	32
3D Systems	28
Prusa	28
Renishaw	24
SLM	15
ABB	14
ConceptLaser	14
MakerBot	14
Markforged	14
Total of platform equipment	*>1300*

Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

The following table shows the top 3 specific **models** within the top 5 brands. As such, the **HP Multi Jet Fusion** is the most common HP printer. HP is developing its multi jet fusion technology in order to manufacture printers able to work with several materials and embedded electronics. While this printer produces small to medium sized components, the **Delta WASP 3MT INDUSTRIAL 4.0** printer, of which over 20 are registered on the platform, produces large parts over 2.5m. The **EOS M29**0 is the most common EOS-branded metal 3D printer. The **Ultimaker 2+** and **Ultimaker 2+ Extended** models are the most common Ultimaker printers. These can be considered desktop printers and are used for extruding plastic materials. The **Fortus 450MC** is a large printer of Stratasys, used with engineering grade as well as high-performance thermoplastics.

Table 5 Top 3 models of top 5 brands of AM equipment registered on the 3DP PAN EU platform

Equipment brand and top 3 models	Number of equipment
HP	
HP Multi Jet Fusion	>22
HP MJF 4210 Build Unit	18
4200	10
TOTAL HP Equipment	*114*
WASP	
Delta WASP 3MT INDUSTRIAL 4.0	>20
Delta WASP 2040 INDUSTRIAL 4.0	>20
Delta WASP 4070 INDUSTRIAL 4.0	21
TOTAL WASP Equipment	*85*
EOS	
M290	24

P396	9
M400 (-4)	7
TOTAL EOS Equipment	*61*
Ultimaker	
2+ (Extended)	17
S3	9
3 (Extended)	6
TOTAL Ultimaker Equipment	*59*
Stratasys	
Fortus 450MC	10
Objet 30 Pro	5
Fortus 900MC	4
TOTAL Stratasys Equipment	*59*

Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

When looking at the geographical distribution of the AM equipment, 475 machines are located in the north and west of Europe, 579 machines in south-European countries and fewer (105 machines) in eastern Europe and the Baltics.[63] As it stands, the Platform has a large coverage of facility centres in Italy, Spain, Belgium, France and Germany while Eastern European facility centres are less prominent. The population and representativity of member states on the platform is interestingly in line with the observation that the strongest European 3DP players are located in these five countries.

When considering how many pieces of AM equipment process different materials, close to half of facility centre equipment registered on the platform processes plastics (polymer thermoplastic and polymer thermoset) and/or metals (ferrous and non-ferrous), which is in line with Europe's identified current strengths in AM as well as the current market trends. Bio-materials can be printed by 18.2% of all Facility Centres and industrial ceramics by 16.5% of them, which is crucial as these materials represent emerging trends in the AM industry in personalised medicine (e.g. 3D printed drugs and specialised equipment) and in the ICT industry (3D printed semi-conductors and cooling plates). The highest share for equipment capable of processing structural ceramics can be found in Germany (13,8%) while the highest share for industrial ceramics lies in Italy. The difference of these two materials mainly relates to their application uses. While structural ceramics are especially relevant biomedical devices and medical applications, industrial ceramics are relevant for more industry-oriented applications such as semi-conductors, car brakes, turbines, etc. Therefore, equipment capable of treating these **materials** will increase in demand in the foreseeable future. European AM stakeholders are furthermore expected to invest heavily in metallic materials and noble metals such as titanium for advanced applications.[64] The printing of food and hydrogels remains a niche material in the medium term, is already anticipated to grow however in the long term.

Country-specific insights show that material capabilities across the top six countries are largely the same with some notable exception. As indicated, plastics (polymer thermoplastic and polymer thermoset) are processed by close to half of the equipment, with the Netherlands showing the highest share in equipment processing polymer thermoplastic. Belgium and France, have a relatively higher share of equipment capable of printing metals (ferrous and non-ferrous) than the other three countries, although Germany is also considered to be a strong AM player for metal parts.

The table below characterises further the capabilities of the equipment in terms of '**multi-material'** capabilities (ability to use several materials while printing a component) and the ability to work in **sterile environment**. Almost half the printers in Italy have multi-material capabilities while France lacks such equipment. A total of 176 printers across 28 facility centres in Europe operate in a sterile work environment, which is relatively high considering the organisational effort facility centres have to go through to provide such an environment. Over one

[63] The following geographical distribution is used: North/West: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, the Netherlands, Sweden, United Kingdom; South: Italy, Spain, Greece, Cyprus, Malta, Croatia, Portugal and East/Baltic: Lithuania, Estonia, Latvia, Czech Republic, Poland, Bulgaria, Hungary, Romania, Slovakia, Slovenia.
[64] CENTIMFE. (2018). Technological Roadmap on Additive Manufacturing and Advanced Materials in the SUDOE Region. CENTIMFE. P. 20.

in three printers in Spain and Belgium operates under sterile conditions, while the share of printers in sterile conditions does not exceed 10% in Italy, France or Germany. Percentages in the table indicate the share in total equipment of the country.

Table 6 Number of equipment registered on 3DP PAN EU platform working with different materials, multi-material or sterile capabilities and % of the total number of equipment in a country

	Italy	Spain	Belgium	France	Germany	The Netherlands	EU Total
Polymer thermoplastic	157 (43,3%)	89 (57,4%)	37 (40,2%)	34 (42,5%)	16 (20%)	57 (50%)	529 (45,6%)
Non-ferrous metals	56 (15,4%)	40 (25,8%)	39 (42,4%)	32 (40%)	9 (11,3%)	16 (14%)	263 (22,7%)
Ferrous metals	46 (12,7%)	27 (17,4%)	32 (34,8%)	38 (47,5%)	28 (35%)	14 (12,3%)	244 (22,1%)
Polymer Thermoset	19 (5,2%)	18 (11,6%)	26 (28,3%)	24 (30%)	5 (6,3%)	19 (16,7%)	124 (10,7%)
Bio-materials	60 (16,5%)	8 (5,2%)	3 (3,3%)	5 (6,3%)	10 (12,5%)	1 (0,9%)	115 (9,9%)
Composites	55 (15,2%)	18 (11,6%)	13 (14,1%)	0	2 (2,5%)	3 (2,6%)	115 (9,9%)
Industrial ceramics	48 (13,2%)	18 (11,6%)	7 (7,6%)	4 (5%)	4 (5%)	14 (12,3%)	103 (8,9%)
Structural ceramics	29 (8%)	5 (3,2%)	8 (8,7%)	1 (1,3%)	11 (13,8%)	0	65 (5,6%)
Natural Polymers	25 (6,9%)	11 (7,1%)	9 (9,8%)	0	4 (5%)	2 (1,8%)	58 (5%)
Food	20 (5,5%)	0	0	0	0	0	20 (1,7%)
Precious metals	3 (0,8%)	3 (1,9%)	3 (3,3%)	0	0	2 (1,8%)	16 (1,4%)
Hydrogels	2 (0,6%)	0	0	0	0	0	2 (0,2%)
Other material	*18 (5%)*	*17 (11%)*	*4 (4,3%)*	*15 (18,8%)*	*1 (1,3%)*	*14 (12,3%)*	*117 (10,1%)*
Equipment with multi-material capabilities	164 (45,2%)	35 (22,6%)	34 (37%)	1 (1,3%)	24 (30%)	17 (14,9%)	352 (30,4%)
Equipment in sterile environment	37 (10,2%)	61 (39,4%)	36 (39,1%)	1 (1,3%)	8 (10%)	18 (15,8%)	176 (15,2%)
Total equipment	**363**	**155**	**92**	**80**	**80**	**114**	**1159**

Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

The following table provides an overview of what **technologies** the facility centres having registered their equipment on the platform apply within additive manufacturing. Material extrusion (mainly plastics based) and powder bed fusion (for metal AM) are the technologies within additive manufacturing that the highest share of equipment performs (45,5%). The percentages in the table indicate the share in total equipment for that country.

The Netherlands has the highest share of equipment in material extrusion (66,7%) and is relatively weaker in the other AM technologies. Belgium is relatively stronger in material jetting than the other top six countries, while it has relatively less equipment for powder bed fusion. When relating this to the material capabilities this means that Belgian facility centres develop and manufacture a lot of parts in polymer thermosets such as resins. Italy, together with Spain and Germany, is relatively strong in powder be fusion, for which metals are used. Powder Bed Fusion and VAT photopolymerization are relatively less used in the East/Baltic area than in North/West and South Areas, which can also be linked to a higher focus on consumer products and large parts such as for furniture. When comparting North/West and the South, Powder Bed Fusion-based machines are relatively more present in the Southern areas.

Table 7 Equipment registered on the 3DP PAN EU platform per AM technology used (and % of the total number of equipment)

AM technologies	Italy	Spain	Belgium	France	Germany	The Netherlands	EU total
Material extrusion	46 (37,7%)	32 (28,8%)	14 (25,9%)	26 (41,3%)	12 (29,3%)	60 (66,7%)	292 (45,5%)
Powder Bed Fusion	54 (44,3%)	51 (45,9%)	11 (20,4%)	18 (28,6%)	15 (36,6%)	9 (10%)	189 (29,4%)
VAT photopolymerization	10 (8,2%)	14 (12,6%)	10 (18,5%)	8 (12,7%)	6 (14,6%)	7 (7,8%)	64 (10%)
Material jetting	4 (3,3%)	5 (4,5%)	11 (20,4%)	2 (3,2%)	5 (12,2%)	4 (4,4%)	36 (5,6%)
Direct Energy Deposition	6 (4,9%)	7 (6,3%)	4 (7,4%)	2 (3,2%)	0	0	29 (4,5%)
Binder jetting	2 (1,6%)	2 (1,8%)	3 (5,6%)	7 (11,1%)	3 (7,3%)	8 (8,9%)	27 (4,2%)
Total	**122**	**111**	**54**	**63**	**41**	**90**	**642**

Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

From 2018 to 2023 R&D organisations in France and Portugal are planning to invest into Electron Beam Melting, France, Portugal and Spain plan to invest into Selective Laser Melting, Spain and Portugal plan to invest into Polyjet and France alone plans to invest into Selective Laser Sintering. While these technologies are also used by facility centres registered on the 3DP PAN EU platform, at the time of writing they are still largely underrepresented in European facility centres. In these same countries, investments in research have recently been focused on the same technologies – namely Stereolithography, Selective Laser Sintering and Selective Laser Melting.[65]

[65] CENTIMFE. (2018). Technological Roadmap on Additive Manufacturing and Advanced Materials in the SUDOE Region. CENTIMFE. Pp. 20, 35.

The majority of facility centres registered on the platform work with plastics (polymer thermoplastic and polymer thermoset) and metals (ferrous and non-ferrous), which is in line with Europe's identified current strengths in AM as well as the current market trends. Bio-materials can be printed by 18.2% of all Facility Centres and industrial ceramics by 16.5% of them, which is crucial as these materials represent emerging trends in the AM industry in personalised medicine (e.g. 3D printed drugs and specialised equipment) and in the ICT industry (3D printed semi-conductors and cooling plates). Therefore, equipment capable of treating these **materials** will increase in demand in the foreseeable future. The printing of food and hydrogels remains a niche material in the medium term, is already anticipated to grow however in the long term.

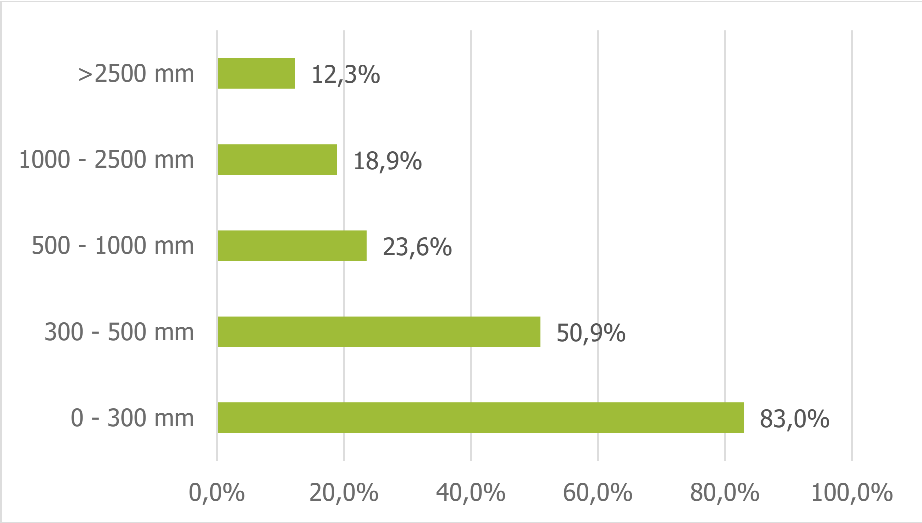
Table 8: Materials used by facility centres registered on the 3DP PAN EU platform

Material	Number of FCs working with materials	% of FCs working with material
Polymer thermoplastic	65	53,7%
Ferrous metals	63	52,1%
Non-ferrous metals	51	42,1%
Polymer Thermoset	32	26,4%
Composites	27	22,3%
Natural Polymers	25	20,7%
Bio-materials	22	18,2%
Industrial ceramics	20	16,5%
Structural ceramics	14	11,6%
Precious metals	10	8,3%
Hydrogels	2	1,7%
Food	1	0,8%
Other	*29*	*24,0%*

Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

Of the facility centres having indicated what **size parts** they are able to produce, 83% indicated to be able to manufacture small parts between 0 and 300mm. As larger parts require larger printers, larger facilities and oftentimes bigger investments, only 12 facility centres with a total of 97 printers and AM systems in Europe are able to manufacture large parts above 2.5m. Four of these facility centres are located in the Netherlands and focus on the construction sector specifically, where modular parts for buildings are 3D printed in a factory before being transported and assembled on site. Other sectors for which large parts can be produced include furniture, automotive, aerospace, ships and boats and production technology.

Figure 20: Component size capabilities of facility centres in EU



Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

The following table provides an overview of the amount of equipment capabilities of printing components in different sizes in the selected five countries. Much in line with the figure presented above, most equipment is capable of manufacturing small part between 0 – 300 mm. Contrary to what the data on facility centres shows us however, the amount of equipment capable of printing large parts >2500 mm is relatively high with close to 100. 56 of these printers are located in Poland and operated by WOLF 3D, who specialise in 3D printing of large furniture pieces. The second country with the most equipment capable of printing large part (>2500 mm) is The Netherlands with 16.

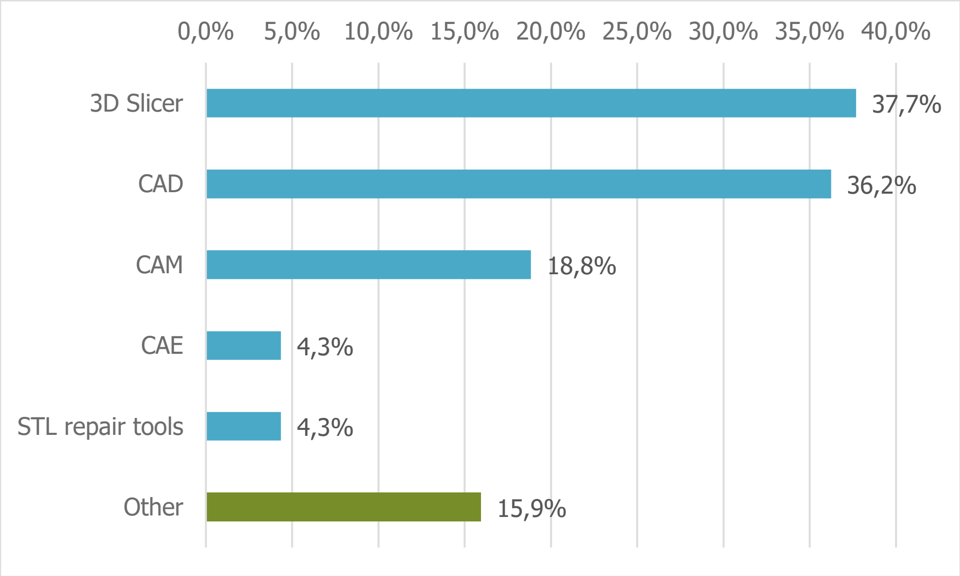
Table 9 Number of equipment of facility centres registered on the 3DP PAN EU Platform per size and top 5 countries

Component size	Italy	Spain	Belgium	France	Germany	The Netherlands	EU Total	EU facility centres
0 - 300 mm	87	96	37	53	34	64	463	88
300 - 500 mm	34	19	33	9	13	3	146	54
500 - 1000 mm	19	3				0	33	25
1000 - 2500 mm	7	6	5		1	1	29	20
>2500 mm	10	5	5			16	97	13

Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

The **software** that is most used on the equipment is 3D Slicer, used by 37,7% of the 69 registered facility centres having provided information on the software their equipment runs on. This is followed by CAD (36,2%), print and CAM (18.8%) software. 3D Slicer and CAD software are primarily used for Polymer Thermoset and Thermoplastics, while CAM software for working with ferrous and non-ferrous metals. CEA is a more generic type of software for 3D modelling while STL repair software is used to troubleshoot and repair virtual 3D models. These results show that plastics remain a main driver for 3D printing followed by resins and metals. It would be important to follow how the use of this software evolves in the coming years as additive manufacturing continues to gain ground.

Figure 21 Main software used by facility centres registered on the 3DP PAN EU platform



Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

The main **application sectors** for which the registered equipment is used are production technology, consumer goods & products, automotive & transportation, aeronautics & space and medical and healthcare. For these five sectors there are over 100 3D printers and AM systems capable of manufacturing components. Some country specificities include The Netherlands which holds the highest share in equipment active in production technology. Belgium is relatively more active in consumer goods & products, medical & healthcare as well as in the chemical industry. Of the countries selected, only Italy serves the food industry which is still a rather new aera for AM. Spain demonstrates a strong concentration in automotive & transportation as well as aeronautics and space, which are of course related sectors. AM for the ICT industry is not particularly strong for any of the selected countries. In Lithuania and Slovenia however, 15% and 33% of equipment is used to manufacture parts for the ICT industry, which tends to indicate a high focus on this market segment. The percentages in the table indicate the share in total equipment for that country.

Table 10 Number of equipment of facility centres registered on the 3DP PAN EU platform per application sector and country (and % of the total equipment in a country)

Application sector	Italy	Spain	Belgium	France	Germany	The Netherlands	EU Total
Production technology (machinery / equipment / automation)	199 (54,8%)	40 (25,8%)	4 (4,3%)	19 (23,8%)	21 (26,3%)	69 (60,5%)	409 (35,3%)
Consumer Goods & Products	84 (23,1%)	35 (22,6%)	68 (73,9%)	2 (2,5%)	5 (6,3%)	2 (1,8%)	257 (22,2%)
Automotive & Transportation	56 (15,4%)	47 (30,3%)	16 (17,4%)	13 (16,3%)	17 (21,3%)	19 (16,7%)	256 (22,1%)
Aeronautics & Space	67 (18,5%)	61 (39,4%)	12 (13%)	21 (26,3%)	2 (2,5%)	20 (17,5%)	228 (19,7%)
Medical & Healthcare	94 (25,9%)	14 (9%)	47 (51,1%)	18 (22,5%)	14 (17,5%)	16 (14%)	227 (19,6%)
Construction & Building sector	6 (1,7%)	12 (7,7%)	0	0	0	3 (2,6%)	58 (5%)
Energy	19 (5,2%)	14 (9%)	3 (3,3%)	16 (20%)	0	0	52 (4,5%)
Chemical Industry	0	7 (4,5%)	24 (26,1%)	0	6 (7,5%)	5 (4,4%)	50 (4,3%)
ICT industry (including electronics, computer and communication related products)	8 (2,2%)	13 (8,4%)	1 (1,1%)	3 (3,8%)	3 (3,8%)	2 (1,8%)	43 (3,7%)
Food	21 (5,8%)	0	0	0	0	1 (0,9%)	22 (1,9%)
Other	*9 (2,5%)*	*21 (13,5%)*	*9 (9,8%)*	*7 (8,8%)*	*13 (16,3%)*	*5 (4,4%)*	*76 (6,6%)*

Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

The following table illustrates what **materials facility centres are able to work with per sector**. As an example on how to read the table, It indicates that of all the equipment registered on the platform that manufacturers parts for the Aeronautics and Space sector, 1,8% are capable of producing parts made out of bio-materials. The table is based on the information that facility centres provided specific to their equipment. It is important to note that not all listed equipment has been linked to specific materials, leading to the percentages per sector adding up to between 89,3 and 100%.

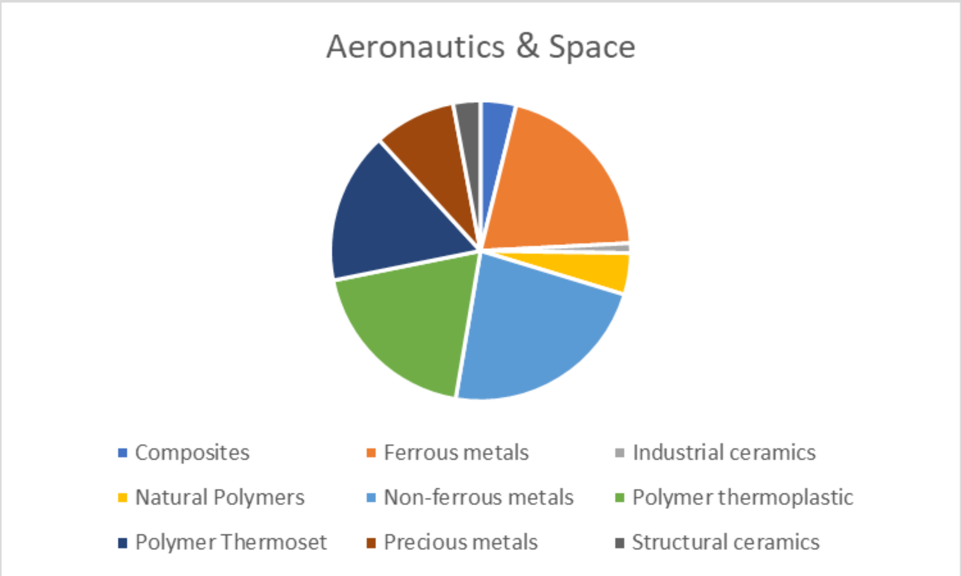
Table 11: Materials use per sector by facility centres registered on the 3DP PAN EU Platform (in % of the total FCs)

	Bio-materials	Composites	Ferrous metals	Hydrogels	Industrial ceramics	Natural Polymers	Non-ferrous metals	Polymer thermoplastic	Polymer Thermoset	Precious metals	Structural ceramics	Other
Aeronautics & Space	1,8%	3,4%	18,4%	0,1%	1,0%	4,0%	20,7%	17,3%	14,8%	8,0%	2,7%	5,6%
Automotive & Transportation (excluding ships and boats)	4,9%	11,0%	17,5%	0,2%	1,9%	2,0%	17,3%	17,7%	14,0%	0,9%	0,7%	7,2%
Chemical Industry	5,7%	5,3%	20,1%	1,3%	9,1%	2,2%	21,1%	17,0%	8,2%	0,0%	7,2%	0,0%
Construction & Building sector	3,6%	7,3%	5,1%	0,0%	9,3%	9,7%	13,6%	17,2%	16,5%	0,1%	3,4%	13,3%
Consumer Goods & Products (excluding sporting goods, textile and furniture)	3,6%	17,9%	14,8%	0,3%	0,9%	3,8%	15,0%	22,2%	11,9%	0,5%	0,0%	5,2%
Energy	2,8%	3,8%	22,6%	0,0%	6,8%	3,1%	23,1%	11,1%	8,0%	0,7%	3,1%	7,1%
Environment	21,4%	14,3%	0,0%	3,6%	0,0%	17,9%	10,7%	10,7%	3,6%	0,0%	0,0%	14,3%
Food	0,1%	0,0%	20,0%	0,1%	0,0%	0,0%	19,9%	20,0%	20,0%	19,9%	0,0%	0,0%
Furniture	5,1%	14,3%	4,1%	0,0%	1,0%	9,2%	6,1%	20,4%	5,1%	0,0%	1,0%	18,4%
ICT industry (including electronics, computer and communication related products)	11,6%	11,6%	7,1%	0,0%	1,6%	3,9%	6,1%	19,7%	18,7%	1,0%	0,8%	14,0%
Measurement	4,5%	1,1%	3,4%	2,2%	43,8%	3,4%	2,2%	6,7%	4,5%	2,2%	5,6%	16,9%
Medical & Healthcare	2,7%	3,4%	19,6%	0,3%	0,9%	1,9%	19,8%	18,7%	13,7%	11,4%	1,2%	2,4%
Production technology (machinery / equipment / automation)	2,9%	4,1%	21,2%	0,0%	2,8%	0,8%	19,2%	17,6%	14,2%	8,2%	3,1%	3,3%
Ships and Boats	0,6%	0,8%	0,5%	0,0%	0,5%	19,0%	18,5%	19,3%	18,8%	0,3%	0,0%	19,7%
Sporting Goods	0,5%	19,1%	18,1%	0,0%	0,0%	0,5%	12,6%	20,0%	16,3%	0,0%	1,9%	0,5%
Textile & Fashion	13,6%	16,1%	1,6%	0,0%	1,9%	4,7%	2,8%	19,0%	28,5%	0,0%	0,6%	11,1%

Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

In the **Aeronautics & Space** sector, European facility centres are strong in the use of metals and polymer thermoplastics. Precious metals are also used in manufacturing components, composite materials however are not as exploited as the market would suggest. In fact the development of 3D manufactured composite materials is on the rise and will be a determining factor in determining what companies will be industry leaders in 3D printed components for the sector. The same tendencies as for material use can be observed in Automotive & Transportation and Ships & Boats sectors, with the sole difference that precious metals take a smaller share than for the Aeronautics & Space sector.

Figure 22: Materials use by facility centres registered on the 3DP PAN EU Platform active in aeronautics & space



Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

The use of composite materials in 3D printing is most developed for **Consumer Goods & Products (excluding sporting goods, textile and furniture), sporting Goods and Textile & Fashion**, which converges well with global trends observed in these industries towards lightweight and strong consumer products. Demand for composite materials is increasing and companies able to deliver will likely experience strong growth in the coming years and new players will emerge as the market pulls for such expertise. When confronting with the platform's search data, where composite materials are the most sought after, the relevance for such materials becomes all the more evident.

The challenge that remains for **composite materials** is the recycling phase which is not structurally addressed during the design and material research in Europe, but also worldwide. Recycling of composite materials constitutes a market opportunity but should also be approached from a circular perspective, in the sense that composite materials should be avoided altogether for large series production as they create new waste streams that burden national waste treatment capacities.

Figure 23: Materials use by facility centres registered on the 3DP PAN EU Platform active in sporting goods

Source: IDEA Consult, based on 3DP PAN EU Platform data, 2021

3.2.2 Services

The 3DP PAN EU Platform counting 381 Facility Centres in October 2020 gives access to a range of technical services introduced in section 2.1 to all relevant sectors who potentially benefit from AM technologies. The following two tables show the percentage of facility centres providing services per sector and per service type. Facility centres on the platform are capable to perform services for all 17 sectors listed on it. 260 facility centres have indicated to answer specific sector needs. Over 40% of them indicated to cater to the automotive & transportation, medical & healthcare, while over 30% treat production technology and aeronautics and space sectors. Other sectors, while on the rise globally and in Europe, are less focused on by facility centres, such as construction & building (10,4%), the ICT industry (9.6%).

Country-specific insights show that relatively more facility centres in Spain are active in automotive & transportation and aeronautics and space, which is aligned with the sector-specific equipment use in the country detailed in the previous section. France is also relatively more active in these sectors than in others. Activities in German facility centres are more spread out across different industries. In general however the provided services logically follow the trend of the equipment distribution in the top six countries. The percentages in the table indicate the share in total facility centres for that region.

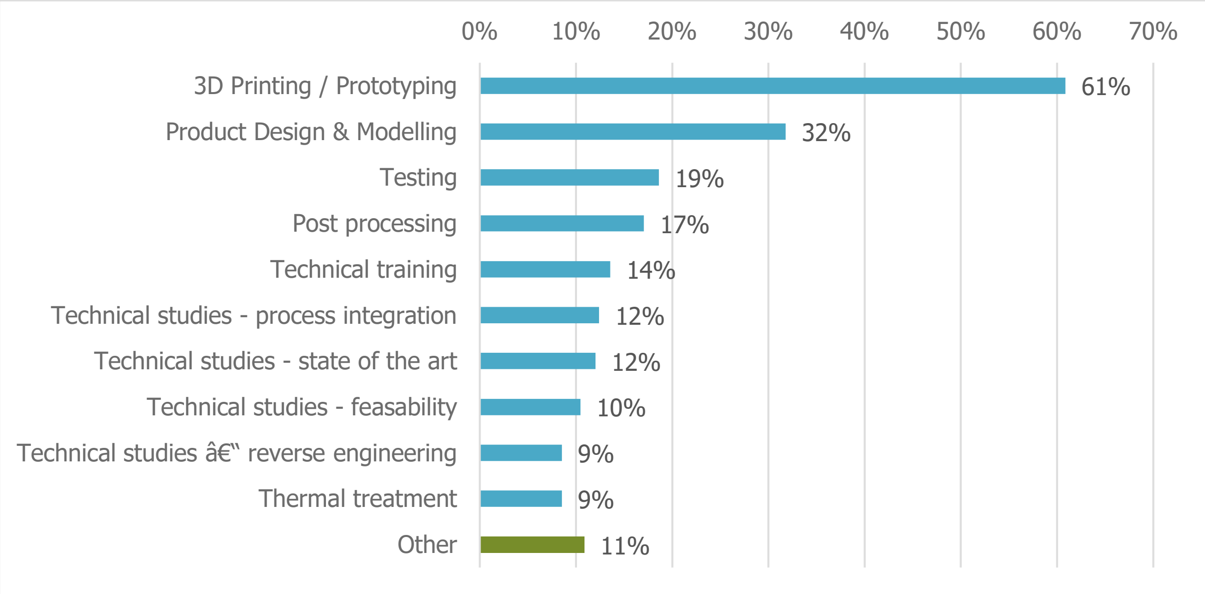
Table 12: Number of facility centres offering services per sector per country (and % in total number of FCs in a country)

Sector	Italy	Spain	Belgium	France	Germany	The Netherlands	EU Total
Automotive & Transportation	42 (53,%)	15 (62,5%)	5 (29,4%)	9 (30%)	5 (15,2%)	6 (46,2%)	106 (40,8%)
Medical & Healthcare	35 (44,9%)	12 (50%)	5 (29,4%)	11 (36,7%)	6 (18,2%)	5 (38,5%)	90 (34,6%)
Production technology (machinery / equipment / automation)	30 (38,5%)	14 (58,3%)	4 (23,5%)	9 (30%)	5 (15,2%)	5 (38,5%)	88 (33,8%)
Aeronautics & Space	27 (34,6%)	12 (50%)	5 (29,4%)	11 (36,7%)	5 (15,2%)	4 (30,8%)	78 (30%)
Consumer Goods & Products	33 (42,3%)	10 (41,7%)	3 (17,6%)	2 (6,7%)	3 (9,1%)	3 (23,1%)	76 (29,2%)
Energy	13 (16,7%)	7 (29,2%)	2 (11,8%)	6 (20%)	3 (9,1%)	0	31 (11,9%)
Construction & Building sector	9 (11,5%)	7 (29,2%)	1 (5,9%)	1 (3,3%)	0	2 (15,4%)	27 (10,4%)
ICT industry (including electronics, computer and communication related products)	6 (7,7%)	5 (20,8%)	2 (11,8%)	1 (3,3%)	1 (3%)	0	25 (9,6%)
Chemical Industry	5 (6,4%)	8 (33,3%)	3 (17,6%)	1 (3,3%)	1 (3%)	1 (7,7%)	20 (7,7%)
Measurement	1 (1,3%)	1 (4,2%)	0	2 (6,7%)	0	0	9 (3,5%)
Environment	2 (2,6%)	1 (4,2%)	0	0	0	0	5 (1,9%)
Food	2 (2,6%)	2 (8,3%)	0	0	0	1 (7,7%)	5 (1,9%)
Other	8 (10,3%)	3 (12,5%)	2 (11,8%)	2 (6,7%)	3 (9,1%)	0	23 (8,8%)
Total	**78**	**24**	**17**	**30**	**33**	**13**	**260**

Source: IDEA Consult, based on 3DP PAN EU Platform Data, 2021

As for the services specifically, 61% of the registered facility centres provide 3D printing / prototyping, while 31.8% also provide product design & modelling and 18.2.% provide post processing services. As indicated in section 1.3, technical training is crucial in facilitating the uptake of 3D printing for the European additive manufacturing industry and is provided by 13.6% of Facility Centres in total. Technical studies on various aspects of component design, testing and practical aspects are also prevalent in the facility centres' offer of services. The table below lists the top 10 services offered by facility centres. Macroregional differences will be disclosed later in details, to highlight possible differences in the services offer at regional level.

Figure 24 Top 10 services offered by facility centres registered on the 3DP PAN EU Platform



Source: IDEA Consult, based on 3DP PAN EU Platform Data, 2021.

3.3. A look at lower-TRLs projects

This chapter presents a very brief overview of activities funded at lower TRLs (i.e. TRL 3-6, before demonstration activities). This can indicate coverage (or gaps) of key emerging trends.

Worldwide, AM System manufacturers are the largest recipients of funding in the AM landscape, followed by materials providers, 3D printing services companies and software companies. Most of these investment activities are based in the US. However, Europe's investments have been growing, while investments in China have been growing even quicker.[66] These trends suggest an accelerated uptake.

The EU has financed AM projects with over €320 million between 2007 and 2019. A comprehensive list of funded projects is presented in the Annex. This highlights the most recent and relevant EU-funded AM-related projects. While the table is not exhaustive, it provides some indications as to what types of efforts have been and are being funded. For illustrative purposes, three of the largest projects in terms of coverage and funding are "Digital Intelligent Modular Factories, Intelligent data-driven pipeline for the manufacture of certified metals parts through DED processes" and "novel all-in-one machines, robots, and systems for affordable, worldwide and lifetime distributed 3d hybrid manufacturing and repair operations.". This suggests a relevant coverage of some of the expected trends identified on the demand side (see chapter 4).

[66] AMFG, (2020), The Additive Manufacturing Landscape 2020, p. 7.

4 / Preliminary Conclusions on AM uptake and deployment in Europe

4.1. Review of the overall AM industry in Europe

The analysis of the 3DP worldwide as well as EU 3DP landscape results in a structured SWOT analysis of the competitive positioning of the EU in additive manufacturing. Here, we present all information on both internal (strengths/weaknesses of European 3DP stakeholders) and external factors (opportunities/threats that can influence the value creation of 3DP for European industries) in a structured manner based on the literature review and 3DP PAN EU Platform analysis presented in previous sections. While the present section focuses generally on the current EU relative positioning of the 3D Printing landscape as a whole, the next section focuses on a specific analysis of 1) expected emerging trends related to the use and provision of 'demonstration services' and 2) possible current and expected gaps associated to these trends (see section 4.2).

Figure 25 European AM Industry SWOT

Strengths

- AM equipment manufacturing
- Sector/technology/material-specific expertise
- Reactivity of AM market
- Cross-regional collaboration
- Innovation ecosystems

Opportunities

- Material savings and cost reductions
- Series manufacturing
- Data driven technology
- Shorter value chains – logistics efficiency

Weaknesses

- Standardisation
- Skills and education / trainings
- Software design
- Specific gaps (equipment/expertise) identified in key demonstration areas (section 4.2)

Threats

- Access to raw materials
- International competition on AM market
- Brexit
- Economic downturn
- Rapid changes in technology

4.1.1 Strengths

Sector/technology-specific expertise is the main strength of the European AM landscape. The EU holds a strong position in the field of metal and hybrid additive manufacturing systems, due to its long history of investments in the field. This competitive advantage should be maintained with continued R&D&I investments, the search for appropriate business models and new market opportunities. Especially in metal AM, Europe holds a strong position both in terms of expertise and equipment manufacturing as elaborated upon in section 2.1.

In 2019 there were 27 manufacturers producing AM systems for metal parts in Europe compared to 21 a year earlier, suggesting strong growth as well as industry excellence. Germany especially is a strong player in the metal AM industry with globally recognised companies such as Arburg, BigRep, Coherent, DMG Mori, Envisiontec, EOS, German RepRap, Nanoscribe, Rapidshape, SLM Solutions, Trumpf and Voxeljet.[67] Some other notable examples of companies contributing to Europe's strong standing in the AM industry include:

- France: 3DCeram, expert in technical ceramics and BeAM, expert in laser metal deposition;
- The Netherlands: Additive Industries, expert in automation;
- Sweden: Digital Metal, expert in complex small parts;
- Norway: Norsk Titanium, expert in aerospace grade titanium;
- Italy: DWS, expert in jewellery and dental applications;
- Austria: Hage3D, expert in automation and Lithoz, expert in engineering and bioresorbable ceramics;

Industrial equipment and tooling represents another important area for European companies. Industrial AM system manufacturers mentioned earlier have built up their expertise in recent years in repairing tools and produce individual parts for industrial equipment using AM techniques.[68] As mentioned in section 1.2, Germany, Italy and Austria are the **strongest European countries in the manufacturing of AM systems**. This correlates with the high presence of facility centres in these countries on the 3DP PAN EU Platform and the high number of equipment these facility centres dispose of relative to facility centres registered from other countries.

The health sector has demonstrated interest in AM in order to provide more **customised solutions for patients in need of prosthetics or personalised medicine**, but also to provide time and cost-effective solutions to practitioners in healthcare and medicine. While this is a worldwide trend, European stakeholders have in the past decade secured a leading position in the field. One example of that is additive manufacturing being used to manufacture more life-like organs for training purposes in a collaboration between British, Norwegian and Finish universities and research centres. Beyond standardised organs for training purposes, 3D scanning and manufacturing makes it possible to manufacture models of a patient's organ before the surgeon operates on it, increasing success rates.[69] Other examples in which European research institutes and private companies have manufactured prototypes and components to be used on patients include hearing aids, dental components, implants, prostheses and surgical drill guides.

In the aerospace industry the European strength lies mainly in **optimisation of processes for the development of high performances parts and hybrid manufacturing for large components**. Closely linked to the aerospace industry in the context of AM is the automotive industry which has many of the same requirements, especially when considering high-end or high-performance cars. The main characteristics sought are lightweight and high stress resistance of components. Here, the Vanguard Initiative lists two cross regional demo cases, namely "3D-Printed automotive components" led by Aragon, Spain and "3D-printed hybrid components" led by Emilia Romagna, Italy. Both of these demo cases involve many European regions and produce relevant use cases that prove industry excellence.[70]

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[67] RINA Consulting et al. (2018). A STRATEGIC APPROACH TO INCREASING EUROPE'S VALUE PROPOSITION FOR ADDITIVE MANUFACTURING TECHNOLOGIES AND CAPABILITIES: Final AM Roadmap. European Commission. P. 320 – 327.
[68] See online: https://www.s3vanguardinitiative.eu/cooperations/high-performance-production-through-3d-printing
[69] Magrone, I. (2020). UWE research uses 3D printing to create organ simulators. Consulted online: https://3dprintingindustry.com/news/uwe-research-uses-3d-printing-to-create-organ-simulators-174590/
[70] RINA Consulting et al. (2018). A STRATEGIC APPROACH TO INCREASING EUROPE'S VALUE PROPOSITION FOR ADDITIVE MANUFACTURING TECHNOLOGIES AND CAPABILITIES: Final AM Roadmap. European Commission. Pp. 23 – 28.

Another strength the European AM market has demonstrated in 2020 is its **reactivity to market demand**. Hospitals were in need of protective equipment such as masks and medical equipment such as ventilators within a very short timeframe. In a matter of weeks 3D printing manufacturers and facility centres were able to quickly deliver the requested items to hospitals.[71] This reactivity is proof that AM technologies allow for shorter timespans from proof of concept to finished products – a relevant quality that the manufacturing industry seeks.

Overall, Europe is a strong **collaborative hub for AM** as demonstrated, among others, through the active implementation taking place in the Vanguard Initiative 3DP Pilot, the many projects funded by the EU, industry associations and national governments and facilitated by universities, facility centres and private companies. The 2018 AM-Motion Roadmap lists over 100 cross-regional AM-related projects and 240 regional AM-related projects in Europe including labs and facility centres that have been established as a direct result of national and regional funding.[72]

Europe is a worldwide leader in **innovation in AM**. European companies lead by example in supply chain management, data innovation and integration of AM technologies into conventional manufacturing practices. If Europe manages to leverage the expertise and support their key players through adequate regulation, standardisation, funding and partnership opportunities, it can maintain and strengthen its position and induce innovation. This will be crucial in the coming years as AM implementation rises and manufacturers worldwide seek services and equipment to support them.[73]

In addition to these general industrial strengths, the table in the section 4.1 provides more information about more specific demonstration-related strengths.

4.1.2 Weaknesses

Europe is still lagging behind in terms of **standardisation activities** in the field of 3D printing. Key problems are the difficulty to secure funding and a lack of coordinated European effort that brings together efforts done at local or regional level. Standardisation is challenging in additive manufacturing specifically because of the multitude of technologies, materials, processes and software. One example is the standardisation process for metal materials in the aerospace industry under additive manufacturing where the qualification process for new materials can cost several million euros and take up to fifteen years to be finalised, putting a strain on European competitiveness.[74] Standardisation is very relevant, as in 2020, close to 50 standardisation projects were ongoing. These focused on different challenges within the AM industry and involved 25 participating organisations and eight observing nations through national membership organisation, highlighting a global demand for standardisation in additive manufacturing.[75]

Standardisation is not necessarily a Europe-specific weakness or point of interest but one that most regions struggle with. A collaboration between ASTM F42 and ICO/TC 261 is especially relevant as it aims to standardise test methods and protocols for AM worldwide. While the resulting standards are not mandatory, they do provide a level playing field and understanding for AM stakeholders on the benefits of AM as test results become comparable.[76]

There is a **lack of labour force** with the right technical skills due to the lack of adapted education in universities, but also trainings in companies. More appropriate training modules, curricula and training opportunities are needed across Europe to fill this skill-gap. Due to the nature of AM, this is particularly important as the technologies evolve quickly and especially SMEs need a labour force that has been trained in current technologies and practices in order to adapt quickly to industry demands. Developing educational and training modules in higher education and on the

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[71] Examples of companies manufacturing equipment for hospitals in their region include Materialise in Belgium, Eurocat and Leitat in Spain and Issinova in Italy.
[72] RINA Consulting et al. (2018). A STRATEGIC APPROACH TO INCREASING EUROPE'S VALUE PROPOSITION FOR ADDITIVE MANUFACTURING TECHNOLOGIES AND CAPABILITIES: Final AM Roadmap. European Commission. Pp. 89 – 141.
[73] Cecimo, (2020), Key Takeaways, Cecimo Additive Manufacturing Conference. Consulted online: https://www.cecimo.eu/wp-content/uploads/2020/12/AMEC-Takeaways-FINAL.pdf
[74] Cecimo, (2017), European Additive Manufacturing Strategy, consulted online: https://www.cecimo.eu/wp-content/uploads/2019/03/AM_European_Strategy_2017_LQ.pdf
[75] Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry, p. 247
[76] Sher, D. (2017). ASTM F42, a Vision for Standardizing the Additive Manufacturing World. 3D Printing Media Network. Consulted online: https://www.3dprintingmedia.network/astm-f42-vision-standardizing-additive-manufacturing-world/

job is also identified by AM-Motion as a non-technical cross cutting action that needs to be undertaken.[77] Safety guidelines on the factory floor differ in additive manufacturing from conventional technologies as well as powder metals and static electricity pose new safety challenges. European examples of training projects and programs that have proven to be successful in the past or are still running are listed in the following table. These can be referred to as best practice examples to be replicated on differing scales throughout Europe.

Table 13 List of European training programs/projects on AM

- LearnAMforlife: Portfolio of AM learning courses for industrial professionals eager to learn how additive manufacturing can be applied in their organization. (present)
- 3DWIT: Based in Ireland, 3DWIT offers Additive Manufacturing training programs (present)
- TÜV SÜD: Series of training modules on different topics within the Additive Manufacturing process. (present)
- SAM: Project Sector Skills Strategy in Additive Manufacturing (2019 – present)
- LIAM: Laser Innovation for Additive Manufacturing (2016 – present)
- CLAIMM: Creating knowledge and skills in Additive Manufacturing (2018 – 2020)
- METALS: Machine Tool Alliance for Skills (2015 – 2018)
- 3DPRISM: 3D Printing Skills for Manufacturing (2014 – 2018)
- Interaqct: International Network for the Training of Early stage Researchers on Advanced Quality control by Computed Tomography (2013 – 2017)

The most successful companies in **software design for additive manufacturing** are located in China and the USA. The developed software used by European stakeholders as well includes 3D design, simulation and machine control software. This is an activity in which European stakeholders are not particularly strong, even if software for the operation of AM equipment itself is created by European manufacturers of AM systems.

Sectors such as the **textile and fashion, sporting goods and food industry are demonstrating appetite for AM** capabilities, yet based on the 3DP PAN EU platform and the state of the market analysis these latter are still not very developed in Europe, as only 6% or less of facility centres provide services to these sectors (See section 3.2.2).

In addition to these general industrial strengths, the table in the section 4.1 provides more information about more specific demonstration-related weaknesses for which corrective actions are needed.

4.1.3 Opportunities

The AM industry provides great opportunities for contributions to the **European job market** as in order for it to flourish it requires engineers, mathematicians, programmers, statisticians, mechanics, industrial designers and a range of other professions. If the AM industry convenes with schools, universities, job agencies and other organisations focused on skills development, a new labour force could be created for the AM industry solving two problems at the same time: the lack of qualified labour in the AM industry and unemployment rise in several countries in Europe.

As market forces result in cost reductions in feedstocks, machines, processing costs and even industrial AM systems, **series manufacturing** becomes a realistic option. A current example is metal binder jetting as it has already surpassed the threshold to become more cost effective than its technologically conventional counterpart.[78] The hardware market for 3D printing is becoming more mature. Mature hardware offers the possibility to explore more potential application areas.

[77] RINA Consulting et al. (2018). A STRATEGIC APPROACH TO INCREASING EUROPE'S VALUE PROPOSITION FOR ADDITIVE MANUFACTURING TECHNOLOGIES AND CAPABILITIES: Final AM Roadmap. European Commission. P. 15

[78] Wohlers Associates, (2020), Wohlers Report 2020: 3D Printing and Additive Manufacturing - Global State of the Industry, p. 113, p. 295

Additive manufacturing is a data-driven technology that allows to optimise the efficiency of the product development process and production process. The availability of the amount of data also offers opportunities to make use of this data on the level of decision making in companies but also on EU-level. The **digitalisation of supply chains** bears the potential to bring AM closer to businesses who could benefit from it. To achieve this, the machines, factories and processes need to be streamlined, which gives the added advantage of being able to monitor the production. Making the supply chain digital also allows to collect many data points which can be analysed and ultimately lead to more qualitative parts at higher speeds. Digitalisation of the supply chain implies connecting information on inventory, equipment, and logistics. The digital supply chain further helps mitigate exogenous risks such as pandemics as the system can adapt and necessary components are ready to be manufactured on sight in a time-efficient way. Digital, AM centred supply chains can lead to cost-saving of up to 70%. The benefit of decentralised production and a digital supply chain has been promoted for a long time, however the pandemic stands as a case study for its practical implications.[79]

High logistic costs and also the increased pressure on widespread value chains due to the COVID-19 pandemic, push companies to **shorten their value chains**, produce more locally and closer to the end-user market. Additive manufacturing offers multiple benefits to manufacturers such as a quicker reaction to changing market conditions, the modification of production rates to match demand, inventory reduction and part consolidation. The uptake of additive manufacturing in production companies, can offer opportunities for European companies to shorten their value chain while remaining competitive.

Another opportunity for further growth in AM is **post-processing**. Even if this is a structural and worldwide concern, European stakeholders have the capability to make post-processing an asset. Automation is one of the requirements to increase efficiency of post-processing. As indicated in section 1.2, more companies have recently started to introduce more solutions to increase automation and optimisation of the post-processing workflow in Europe such as Additive Manufacturing Technologies (United Kingdom), DyeMansion (Germany) and Rösler (Germany).[80] 18.9% of facility centres registered in the 3DP PAN EU platform offer post-processing as a service, a percentage which is likely to increase (see section 3.2.2).

AM offers a lot of potential to sustainability solutions, but economic incentives are needed to push the actors of the additive manufacturing landscape towards the adoption of **environmentally sustainable practices** in the relevant value chain segments. The potential of AM and opportunities for European stakeholders to be pursued can for circularity can be broadly summarised as follows:[81]

- **Lighter components** with higher functionality and durability leading to material savings of up to 95%;
- **On-demand manufacturing** leading to reduced transportation and warehousing of components;
- Cost-effective **repairability and remanufacturing** of equipment and components leads to longer operating lives;

A concern to bridge is that of energy requirements of AM technologies, which are higher than those of conventional techniques. Therefore it is important that companies embrace other opportunities for sustainable practices such as energy and heat savings, material saving and recycling, remanufacturing and reduced transportation of components and equipment.[82]

There are still a lot of opportunities to explore for European stakeholders to continue improving and developing AM manufactured components. Some of the **components for which industry stakeholders need sustained policy support**, and examples mentioned throughout the report, are:

- **Automotive industry**: brake callipers, trim pieces, structural components;
- **Healthcare industry and sporting goods**: metal implants, dental devices, drill and cutting guides, surgical planning model, bioprinting of living tissue, 3D printed electronics for stretchable and flexible electronics;

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[79] Diaz, M., (2020), Resilient supply chains with AM, CECIMO Additive Manufacturing Conference. Consulted online: https://www.cecimo.eu/wp-content/uploads/2020/12/AMEC_TRIDITIVE.pdf

[80] AMFG. (2020). *The Additive Manufacturing Landscape 2020.*

[81] CECIMO, (2019), The European Machine Tool Sector and the Circular Economy

[82] Maw, I., (2020), Engineering Magazine, consulted online: https://www.engineering.com/AdvancedManufacturing/ArticleID/19437/How-Additive-Manufacturing-Drives-Sustainable-Manufacturing.aspx

- **Aerospace industry**: interior cabin components for aircraft, functional parts for spacecraft e.g. spark igniters;
- **ICT industry**: semiconductors and CPU cooling components.

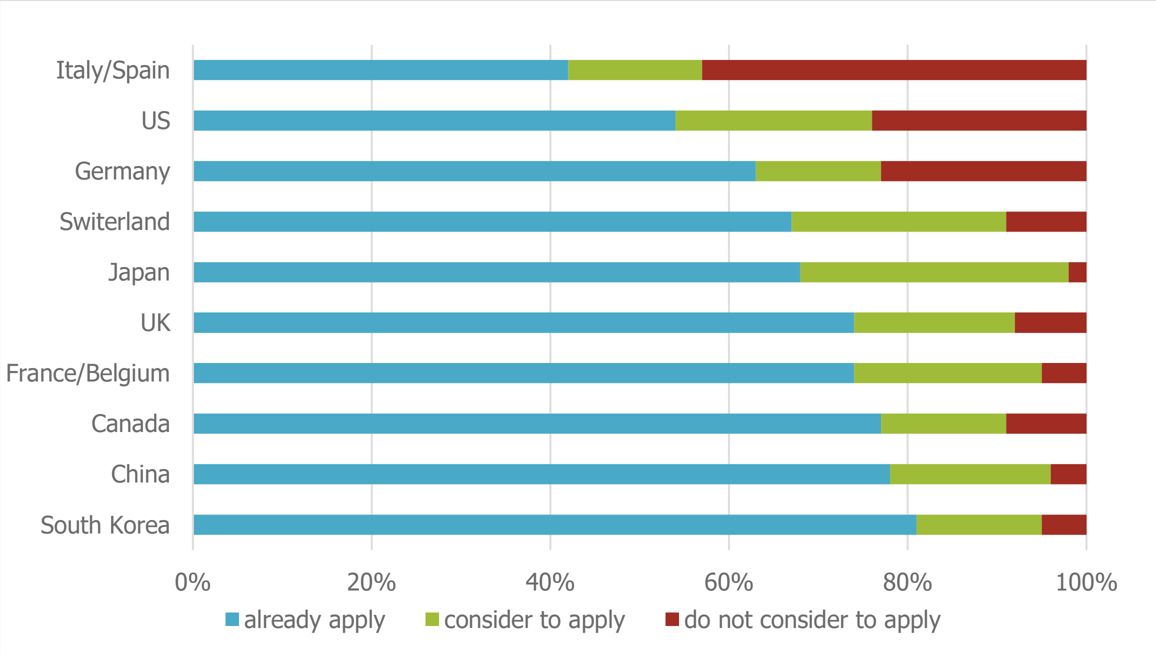
The indicated industries would also benefit from synergies between different sectors and mutual learning between them. In addition to these general industrial strengths, the table in the section 4.1 provides more information about more specific demonstration-related opportunities.

4.1.4 Threats

Europe's industry is heavily **dependent on raw materials** that are sourced in countries outside the EU. Especially in terms of metals, Europe depends on countries that mine and partially process these materials such as titanium or magnesium. Recycling critical materials will be an important challenge in order to maintain Europe's competitive advantage and reduce its dependency on non-EU countries in terms of primary raw materials.

Competition along the AM value chain is rising. For example in the field of metal manufacturing systems, more and more Chinese companies are entering the market. Also in terms of desktop systems, Asian companies are putting high pressure on the price of these systems. At the beginning of 2019, the largest share of companies already applying or considering to apply AM technologies were located in Japan (98%), South Korea (95%) and China (95%). Some of the strongest European countries in AM still did not consider to apply AM technologies. Such was the case in Spain and Italy with 43% of their companies indicating not planning to apply AM technologies in the foreseeable future and 23% in Germany. The competition in Asia especially is fierce and the uptake of AM more pronounced than in Europe.

Figure 26 Experience of AM technologies per country 2019 (%)



Source: IDEA Consult, based on EY Global 3DP Survey, April 2019, n = 900 companies

A threat to large manufacturing companies specifically is the **low barrier to entry that additive manufacturing represents for SMEs.** Decentralised ownership of the means of production gives individuals and SMEs easy access to manufacturing technologies. Custom made products become easy to produce and to run in small batches. This is something large manufacturing companies can only compete with if other support services are offered and the quality of produced goods is demonstrably better.[83]

[83] Anderson, C., 2014, Makers: The New Industrial Revolution, Crown Business

The **Brexit** also poses a challenge on the the European 3D printing market. The United Kingdom is home to some key actors in the field that are involved in pan-European economic collaborations. Since the UK has officially left the EU, difficulties have risen in terms of collaboration agreements. Restrictions imposed on the UK might also result in a loss of skilled labour and capacity.

The **economic downturn due to the global COVID-19** pandemic is a threat to many European markets. If industries lower their investments in R&D and new technologies, a breakthrough of additive manufacturing in new application areas could potentially be delayed. The high cost of entry for industry stakeholders in AM is another deterrent for companies who would benefit from AM to invest in it. This poses a threat for the further uptake of AM in Europe and needs to be countered with cross-regional projects and structural funding.

The AM market is currently dominated by technologies such as LB-PBF.[84] However, as other technologies emerge and enter the market, the share of currently market dominating technologies will decrease. In the future, technologies such as Wire Arc Deposition and Powder Laser Deposition will increase, leaving less space to PBF. Europe needs to account for these **rapid and large changes** in technology occurring in the market to adapt and stay competitive.

In addition to these general industrial strengths, the table in the section 4.1 provides more information about more specific demonstration-related strengths.

4.2. A look at the future supply and demand for demonstration services

While the previous section provides an overall assessment of the strengths, opportunities, threats and weaknesses of the overall AM industry, we zoom in in this section on the matching between the expected/upcoming demand and supply of demonstration services and the possible gaps that might require corrective (policy) actions.

Such analysis is based on the following steps:

1. First, we have identified (relying upon insights from chapters 1-3) some key 'trends' that will characterise the demand for 3D Printing solutions and, in particular, the associated needs in terms of demonstration services. These trends are grouped according to several key categories:
    - Specific future application areas for final products;
    - Production scale and finishing;
    - Material/applications areas;
    - Technical/technological combinations and segments;
    - Non-technological demonstration services;
    - Ecosystem(s).

    Trends in every of these categories have been identified and selected based on evidences presented in the previous sections, including analysis of the 3DP Pan EU data.
2. Second, an assessment of the expected 'ability' of the EU 'supply side' (i.e. demonstration service providers: facility centres) to address/to cover these emerging needs is provided. Such assessment is based on the current and anticipated EU expertise and capabilities based on the insights gathered through, among others, analysis for the 3DP Pan EU data. Overall, for each expected, trend, two distinct qualitative assessment are proposed:
    a. The equipment/expertise/services and innovation support do seem to already gradually adapt to the trends and are filling in the gaps, without important corrective actions needed;

    Or

    b. The equipment/expertise/services and innovation support do not seem to gradually adapt to the trends and corrective actions are needed.

The table below presents the results.

[84] AMPOWER Report. (2019). Metal Additive Manufacturing suppliers predict a market size growth of 27.9 %. Retrieved from https://additive-manufacturing-report.com/additive-manufacturing-market/

Table 14: Upcoming: expected gaps – Preliminary assessment of areas where 'corrective' actions are needed

Identified EU-relevant trends in terms of demand of (demonstration) services		**Readiness (TRL / IRL)**	**EU Demonstration Expertise and Equipment - A preliminary assessment**	
Categories	Key Upcoming Trends	*Higher TRL level reached*[85]	Gaps, but developments on track	Gaps, corrective/supportive policy-actions needed
Specific future application areas for final products	Automotive & Transportation (excluding ships and boats): brake callipers, trim pieces, structural components	*8*	x	
	Medical & Healthcare: metal implants, dental devices, drill and cutting guides and surgical planning model	*6*		x
	Medical & Healthcare: bioprinting of living tissue	*3*		x
	Medical & Healthcare / sporting goods: 3D printed electronics for stretchable and flexible electronics	*7*	x	
	Production technology: equipment for industrial use	*8*	x	
	Aeronautics & Space: interior cabin components for aircraft *(relevant to some EU countries only)*	*8*	x	
	Aeronautics & Space: functional parts for spacecraft e.g. spark igniters *(relevant to some EU countries only)*	*7*		x
	Construction & Building sector: 3D printing of modular building sections	*8*	x	
	ICT industry (including electronics, computer and communication related products): semiconductors and CPU cooling components	*4*	x	x
	Sporting Goods: multi-material printed shoes and protective gernments	*9*	x	
	Food: edibles for space exploration and vitamin delivery to the elderly	*4*	x	
Production scale and finishing	Automatized and integrated post-processing	*6*		x
	Large volume 3D printing for commercial use	*7*	x	
Material/applications areas	Multimaterials for all applications and sectors	*7*		x
	Precious metals for ICT industry	*6*		x
	Ceramics for components with high stress resistance and low density	*8*		?
	Composite materials for all applications and sectors	*7*	x	
	Biomaterials for various applications and sectors	*7*	x	
	Hydrogels (and shape memory polymers) for various applications and sectors (incl. '4D printing' applications)	*4*		x
Technical/technological combination	Recyclability/energy savings properties in AM	*n/a*		x
	Establishing ICT/AI/AM integration	*n/a*	x	x

[85] This provides an assessment of the current technology readiness level of the identified trend (i.e. higher TRL level that is currently reached in the EU).

s and segments	Establishing IOT/AM integration	*n/a*	x	x
	Increased circularity measures in AM	*n/a*		x
Non-technological demonstration services	Skills/training	*n/a*		x
	Standardisation/certification to facilitate AM uptake	*n/a*		x
	Raising awareness of AM possibilities industry-wide	*n/a*		x
	Energy-savings / Circularity-related measures and knowledge in AM (end of life, etc.)	*n/a*		x
Ecosystem(s)	Creating synergies between tech/industrial communities (multisided 'platforms'/integration)	*n/a*		x
	Intersectoral and interregional AM collaborations/synergies for brain-gain and critical mass	*n/a*		x

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Annexes

A.1 / Overview 3D Printing Landscape

Annex 1: Worldwide Additive Manufacturing Landscape 2020

Source: The Additive Manufacturing Landscape 2020 (AMFG, 2020)

A.2 / EU funded projects

Table 15 List of EU-funded AM projects

Name	Years	Description	€M	Coordinator	Country
3D2DPrint	2016–2021	3D printing of novel 2D nanomaterials: adding advanced 2D functionalities to revolutionary tailored 3D manufacturing	2.5	Provost	Ireland
3D-Nanofood	2020–2024	Advancing frontiers in personalized foods for seniors through nanotechnology and 3D printing of enhanced nutrition and superior flavor	0.15	INL	Portugal
4dhybrid	2017–2020	Novel all-in-one machines, robots, and systems for affordable, worldwide and lifetime distributed 3D hybrid manufacturing and repair operations	9.4	Prima Electro	Italy
AMadam	2017–2020	Advanced design rules for optimal dynamic properties of AM products	0.5	Kraljevo	Russia
Adam^2	2020–2023	Analysis, design, and manufacturing using microstructures	3.4	BCAM	Spain
Addaptta Seals	2018–2020	AM-optimized seals	0.6	Adatica	Spain
Addimot	2019–2021	Additively manufactured, limited angle torque motor for smart active inceptors	0.8	CEIT	Spain
Addi-Optimise	2019–2020	Process efficiency and quality assurance in metal AM	0.1	CROOM	Ireland
Addispace	2016–2019	Selection of aerospace components for improving metal AM technologies	1.7	Estia	France
Admire	2017–2019	Knowledge alliance for AM between industry and universities	1	Cranfield U.	UK
Aiforama	2017–2020	Innovative aluminum alloy for aircraft structural parts using AM	0.6	Lortek	Spain
AMable	2017–2021	Support to SMEs and mid-caps for their individual uptake of AM	8.2	Fraunhofer	Germany
AManeco	2019–2022	Assessment of AM limits for eco-design optimization in heat exchangers	1.5	Lortek	Spain
AMatho	2016–2021	AM process and machine for specific design and manufacture of novel tiltrotor drive system housing	1.75	Polimi	Italy
AMitie	2017–2021	AM initiative for transnational innovation in Europe	0.9	Université De Limoges	France
AMos	2017–2020	AM optimization and simulation platform for repairing and re-manufacturing of aerospace components	1.4	University of Sheffield	UK
Ascent AM	2016–2020	Adding simulation to the corporate environment for AM	0.7	TUM	Germany
Bamos	2017–2020	Biomaterials and AM: osteochondral scaffold innovation applied to osteoarthritis	0.8	ULPGC	Spain
Barbara	2017–2020	Biopolymers with advanced functionalities for building automotive parts by AM	2.7	Fundacion Aitiip	Spain
Bionic Aircraft	2016–2019	AM technologies for aircraft design and production	7.9	Fraunhofer IAPT	Germany
Caxman	2015–2019	Computer-aided technologies for AM	7.1	Sintef	Norway
Cfam	2018–2020	Large-scale, continuous-fiber AM for the maritime and infrastructure sectors	1.3	Cead	Netherlands
Combo3D	2019–2021	Composite mold tool based on 3D printing	0.8	TUM	Germany
Digiman4.0	2019–2022	Digital manufacturing technologies for zero-defect Industry 4.0 production	3.9	Danmarks Tekniske U.	Denmark
Dimofac	2019–2023	Digital intelligent modular factories	19.1	CEA	France
Doc-3D-ceram	2018–2022	Development of ceramics for AM	3.5	Institut Ntl. Polytechnique De Toulouse	France
Dream	2016–2019	Driving up reliability and efficiency of AM	3.2	Cinstm	Italy
Enable	2018–2022	European network for alloys behaviour law enhancement	2.3	Universite De Bordeaux	France
Encompass	2016–2019	Digitally integrated design decision support system to cover the entire manufacturing chain for laser PBF	4	MTC	UK
Fast	2016–2019	Functionally graded AM scaffolds by hybrid manufacturing	4.9	UM	Netherlands

Continued on next page

Name	Years	Description	€M	Coordinator	Country
Fasten	2017–2020	Flexible and autonomous manufacturing systems for custom-designed products	3.1	Inesc Tec	Portugal
Flowcaash	2018–2020	Flow control actuators at aircraft-scale manufacturing by metal PBF with high aerodynamic performance for use in harsh environments	0.5	Lortek	Russia
Freewheel	2017–2020	Lifecycle-reconfigurable smart mobility platform to enable autonomous and cost-effective personalized solutions for social inclusion of the disabled and elderly while leveraging AM	7.2	Iris	Italy
Graphene 3D	2017–2020	Multi-functional graphene-based nanocomposites with robust electromagnetic and thermal properties for 3D-printing	1.9	Bulgarian Academy of Sciences	Bulgaria
Hindcon	2016–2019	Hybrid industrial construction through all-in-one 3D printing machines for large-scale advanced manufacturing and building processes	4.7	Vias	Spain
Hiperlam	2016–2020	High-performance laser-based AM	3.7	Orbotech	Israel
Hlfc 4.0	2019–2022	Hybrid laminar fluid control 4.0	1	Adatica Engineering	Spain
Hot Lithography	2019–2021	Hot lithography with high-performance polymers for AM of spare parts and small series production of functional parts	2.6	F. & G. Hachtel	Germany
Hyprocell	2016–2019	Development and validation of integrated multi-process hybrid production cells for rapid individualized laser-based production	6.1	Lortek	Spain
I am rri	2018–2021	Web of innovation and value chains of AM under consideration of RRI	3	Montanuniversitaet Leoben	Austria
Ibus	2015–2019	Integrated business model for customer-driven custom product supply chains	7.4	U. Limerick	Ireland
Inex-adam	2018–2021	Increasing excellence in advanced AM	1	Sveuciliste U. Zagrebu	Croatia
Innoadditive	2019–2020	Innovation challenges for AM	0.05	Hub Innovazione Trentino	Italy
Innopowder	2018–2020	High-quality and cost-effective metal AM powder for manufacturing light-weight parts with improved properties for aircraft and automobiles	2.1	Innomaq 21	Spain
Integradde	2018–2022	Intelligent, data-driven pipeline for the manufacture of certified metal parts through DED processes	17	Aimen	Spain
Maadam	2019–2021	Material design for AM	0.18	Ecole Polytechnique	France
Mama-mea	2018–2020	Mass manufacture of MEAs using high-speed deposition processes	3	T.U. Chemnitz	Germany
Manuela	2018–2022	AM using "metal pilot line" process	15.5	Chalmers	Sweden
Maya	2019–2021	Manufacturing of a lining panel using hybrid technologies, AM, injection molding, and thermoforming	0.75	LEITAT	Spain
Mems 4.0	2017–2022	Additive micromanufacturing for plastic microflectro-mechanical systems	2.5	EPFL	Switzerland
Mmtech	2016–2019	AM process for aerospace with focus on materials (TiAl alloy)	2.5	AMRC	UK
Moamm	2020–2023	Multi-scale optimization for AM of fatigue-resistant shock-absorbing metamaterials	3.5	Universite De Liege	Belgium
Modulase	2016–2019	Development and pilot-line validation of a modular re-configurable	2.4	TWI	UK
Monaco	2019–2022	Manufacturing of a large-scale AM component	1	TUHH	Germany
Nanotun3d	2015–2019	Development of a complete workflow for producing and using a novel nano-modified Ti-based alloy for AM in special applications	2.9	Aidimme	Spain
Nathena	2018–2022	New AM heat exchanger for aerospace	1.5	Sogeclair Aerospace	France
Openhybrid	2016–2019	Developing a novel hybrid AM approach to offer unrivalled flexibility, part quality, and productivity	6.6	MTC	UK
Padicton	2019–2022	Part distortion, prediction, and design for minimized distortion in polymer AM aerospace parts	0.75	TWI	UK
Palms	2017–2020	Plasma smoothing technology for AM	2.5	Wallwork Cambridge	UK
Pam2	2017–2020	High-precision AM processes and computational design procedures	3.9	KU Leuven	Belgium
Paraddise	2016–2020	Productive, affordable, and reliable solution for large-scale manufacturing of metallic parts by combining laser-based AM and subtractive processes with high efficiency	3.7	Tecnalia	Spain

Continued on next page

Name	Years	Description	€M	Coordinator	Country
Pre-eco	2019–2024	New paradigm to re-engineering printed composites	1.47	Politecnico Di Torino	Italy
Print2fly	2019–2021	Printing aircraft at room temperature	0.2	Universiteit Twente	Netherlands
R2P2	2020–2022	Networking for R&D of human-interactive and sensitive robotics while taking advantage of AM	0.8	TU v Liberci	Czech Republic
Refream	2018–2021	Re-thinking of fashion in research and artist collaboration for urban manufacturing	3.9	Creative Region	Austria
Revolve	2017–2020	Radio technologies for broadband connectivity in a rapidly evolving space ecosystem: innovating agility, throughput, power, size, and cost	1.8	HWU	UK
Rib-AM	2018–2021	Research of innovative and breakthrough AM concepts	0.6	FADA	Spain
Samt Sudoe	2016–2019	Spread of AM and advanced materials technologies for the promotion of key industrial technologies in plastic processing and molding industries	1	AIJU	Spain
Scat	2019–2020	Smart composites for AM technology	0.7	Moi Composites	Italy
Siramm	2019–2022	Eastern European twinning on structural integrity and reliability of advanced materials obtained through AM	0.8	UPT	Romania
Stream	2019–2022	Simulation of turbulence and roughness in AM parts	0.6	Cnrs	France
Supreme	2017–2020	Sustainable and flexible powder metallurgy process optimization by a holistic reduction of raw material resources and energy consumption	9.8	Cea	France
Transfront 3d	2016–2019	3D printing across borders	1.6	Tecnalia	Spain
Xprint	2016–2021	4D printing for adaptive optoelectronic components	1.99	Cnr	Italy
ZFact0r	2016–2020	Zero-defect manufacturing strategies with online production management for European factories	6	CERTH	Greece

Source: H2020 funded projects, AM motion and Ecorda

A.3 / List of countries per macro region

North/West	South	East/Baltic
Austria	Italy	Lithuania
Belgium	Spain	Estonia
Denmark	Greece	Latvia
Finland	Cyprus	Czech Republic
France	Malta	Poland
Germany	Croatia	Bulgaria
Ireland	Portugal	Hungary
Luxembourg		Romania
Netherlands		Slovakia
Sweden		Slovenia
United Kingdom		

IDEA Consult

Jozef II-straat 40 B1

1000 Brussel

Belgium

Contact

T: +32 (0)2 282 17 10

E: info@ideaconsult.be