Deliverable D5.3

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AM-motion

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

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Abbreviations

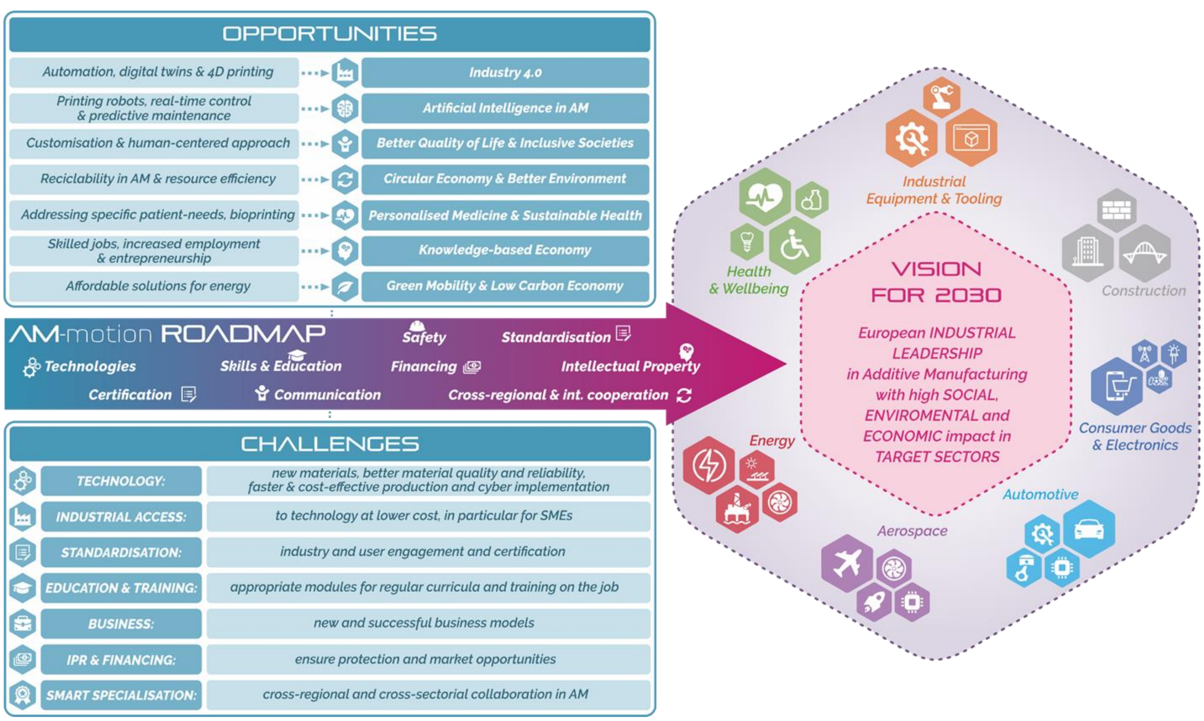
3DP	3D Printing
AM	Additive Manufacturing
CAD	Computer-aided design
CAGR	Compound Annual Growth Rate
EC	European Commission
FDA	Food and Drug Administration
FoF	Factories of the future
IP	Intellectual Property
KETs	Key enabling technologies
MRI	Magnetic resonance imaging
OEM	Original equipment manufacturer
RTO	Research Technology Organization
VC	Value chain

Executive Summary

In 2017, the Additive Manufacturing (AM) industry, consisting of all AM products and services worldwide, grew 21% to $7.336 billion[1] and it is poised to grow up to $21.50 billion by 2025[2]. AM may play a pivotal role in changing the manufacturing paradigm and contributing to address the societal challenges of our time, such as global warming, energy transition, population ageing and decreasing resources.

AM-MOTION vision for 2030 foresees that Europe will improve its leading role in Additive Manufacturing, greatly impacting on the competitiveness of European industrial sectors. Additive Manufacturing will improve the quality of life of European citizens in terms of retention of high quality jobs in Europe, availability of customised, cleaner, safer and affordable products and increased access to cleaner energy, mobility and effective and personalised medicine.

Figure below summarises AM-MOTION Vision for AM in 2030, including the envisaged **opportunities and challenges** as well as the **areas of intervention which are covered by the roadmap** (i.e. technologies, standardisation, certification, skills and education, financing, intellectual properties, safety, communication, cross-regional and international cooperation).



AM-MOTION Vision

Based on the identified challenges and opportunities, **the current draft AM-MOTION roadmap** proposes future actions for the AM development and successful market uptake in target sectors:

[1] Wohlers, T. &. (2018). *Wohlers Report.* Colorado: Wohlers Associates Inc.

[2] Frost & Sullivan's Global 360° Research Team (May 2016), *Global Additive Manufacturing Market, Forecast to 2025,* Frost & Sullivan, Mountain View, California

- Health;
- Aerospace;
- Automotive;
- Consumer goods and Electronics;
- Industrial equipment and Tooling;
- Construction;
- Energy.

The roadmap includes also cross-cutting actions (technical and non-technical), covering several sectors.

AM-MOTION roadmap may be seen as an evolution of FOFAM[3] Roadmap, which has been further developed and expanded in AM-MOTION project involving around 130 external experts through physical meetings and remote surveys.

The full draft Roadmap will be publicly available at the end of July 2018. In August-September 2018 the whole community will be asked to participate online to a public consultation.

The revision of the roadmap will lead to the release of the **Final AM-MOTION Roadmap**, to be presented at “**AMEF2018 Additive Manufacturing European Forum**” (Brussels, 23-24 October 2018).

[3] https://cordis.europa.eu/project/rcn/193434_en.html

1. Introduction

The present document constitutes Deliverable D5.3 in the framework of the AM-Motion project "A strategic approach to increasing Europe's value proposition for Additive Manufacturing technologies and capabilities" (Project Acronym: AM-motion; Contract No.: 723560). This report is the result of activities performed within the framework of Work Package 5 "Roadmap Development", and more specifically on Task 5.3 "Roadmap Development" led by RINA-C. Task 5.3 (M13-M24) is focused on the development and release of the **AM-MOTION European Research and Innovation Roadmap** for successful market implementation of **Additive Manufacturing (AM)**.

AM technologies refer to a group of technologies that build physical objects from Computer Aided Design (CAD) data. The main difference between traditional and AM-technologies is that parts produced via AM are created by the consecutive addition of liquids, sheet or powdered materials in layers, instead of removing material to generate a desired shape which is common to traditional technologies such as milling or drilling. Additive Manufacturing has many common names, involving rapid manufacturing, direct manufacturing, 3D-printing, rapid tooling and rapid prototyping. In line with previous studies[4], we consider AM as the umbrella term for additive technologies; the terms direct manufacturing, rapid tooling and rapid prototyping refer to the application of AM.

The overall aim of AM-MOTION roadmap is to create a common vision for successful European leadership in additive manufacturing, highly impacting of societal challenges of our time, and to suggest common goals and specific actions to solve the existing gaps between the current status and the target vision.

The roadmap methodology used to build the roadmap is presented in **Chapter 2**. The roadmap is an evolution of the recent FOFAM AM Roadmap, extensively revised and further developed in terms of sectors, products and identified gaps and actions and related content with the help of **external experts** (in technical and non-technical aspects). **Chapter 3** presents the **vision of the roadmap**, including opportunities and challenges foreseen for the successful market uptake of AM.

Chapter 4 describes the **target sectors** addressed by the roadmap. After a general description of each sector, **target product groups** (and examples of specific products) and the **regional capabilities** are presented by sector, including also maps of regional and national AM projects. Details of European, national and regional projects are reported in annex A and B, respectively. Information on key enablers (i.e. AM actors) are reported in annex C.

Chapter 5 reports the **identified actions for future research and innovation activities**, dividing them between technical and non-technical actions. In turn, technical actions are segmented in cross-cutting (i.e. relevant for more/all sectors) and sectorial ones. **Details of each action** in terms of identified gap with the description of the current context, description of proposed activities, initial and target TRL etc. are reported in annex D.

Chapter 6 describes the **impact** of the identified actions, considering the results of semi-quantitative estimation with selected key impact indicators performed by the experts in workshops and surveys. The **conclusion** (**Chapter 7**) summarises the key results of this Draft Roadmap and the **next plans for the release of the final Roadmap (October 2018**), which will be a revision of the present document and will include also model for business collaboration (as resulting from WP4 activity).

[4] Prof. Dr.-Ing. Jürgen Gausemeier . Thinking ahead the Future of Additive Manufacturing –Exploring the Research Landscape. Heinz Nixdorf Institute, University of Paderborn – Paderborn 2013.

2. Roadmapping methodology

The roadmapping activity performed to develop this **AM-MOTION European Research and Innovation Roadmap** is a method to produce strategic plans and ideas for future successful development of AM- based products relevant in particular for the identified sectors:

- Health;
- Aerospace;
- Automotive;
- Consumer goods and Electronics;
- Industrial equipment and Tooling;
- Construction;
- Energy.

Details of the applied methodology are explained in the sections below.

2.1. Background: the FOFAM experience

AM-MOTION roadmapping approach is built on the experience the strategic research agendas developed by the European Technology Platform on AM "AM-Platform" and the methodology developed under the previous **FOFAM CSA** (2015-2017, grant agreement n° 636882). FOFAM AM roadmap focused on five sectors (i.e. those addressed by the present roadmap except energy and construction), identifying technical and non-technical actions to be performed at short, medium or long term in order to achieve the final target, i.e. the commercialisation of AM machines, products and related services.

The sectors and market addressed in FOFAM roadmap were selected together with external experts (workshop September 2015), according to the FoFAM project need to be relevant to the technological advancements across Europe and their potential to positively influence societal and economic challenges. These sectors were also the focus of a number of relevant documents i.e. the "European Additive Manufacturing Strategic Research Agenda"[5], which highlights priority areas for future development in AM.

For each of selected sectors, a **value chain (VC) approach** was followed to find the gaps preventing complete market deployment and to propose the corresponding needed actions. The VC is defined as the set of activities from research to market, along a process to generate and add value. The steps of the value chain considered in the roadmap for gap analysis are shown in Figure 2.1

[5] www.rm-platform.com/linkdoc/AM SRA - February 2014.pdf

Figure 2.1: *Steps of AM value chain in FOFAM and AM-MOTION roadmaps*

The actions proposed are classified in cross-cutting actions relevant to all sectorial value chains, responding both to technological and non-technological gaps and actions specific to a particular value chain. The timeline for the proposed actions was also indicated considering short-term (2017-2020), medium term (2020–2025) and long-term actions (beyond 2025).Moreover, technical gaps include the current Technology Readiness Level (TRL). TRLs are based on a scale from 1 to 9 with 9 being the most mature technology[6], as shown in Table 2-1.

Table 2-1 *Description of Technology Readiness Levels (TRL)*

TRL	Description
1	Basic principles observed
2	Technology concept formulated
3	Experimental proof of concept
4	Technology validated in lab
5	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies (KETs))
6	Technology demonstrated in relevant environment (industrially relevant environment in the case of KETs)
7	System prototype demonstration in operational environment
8	System complete and qualified
9	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

The FOFAM plans for future actions for each sector were developed as shown in Figure 2.2 , which present the example of the heath sector.

[6] http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf

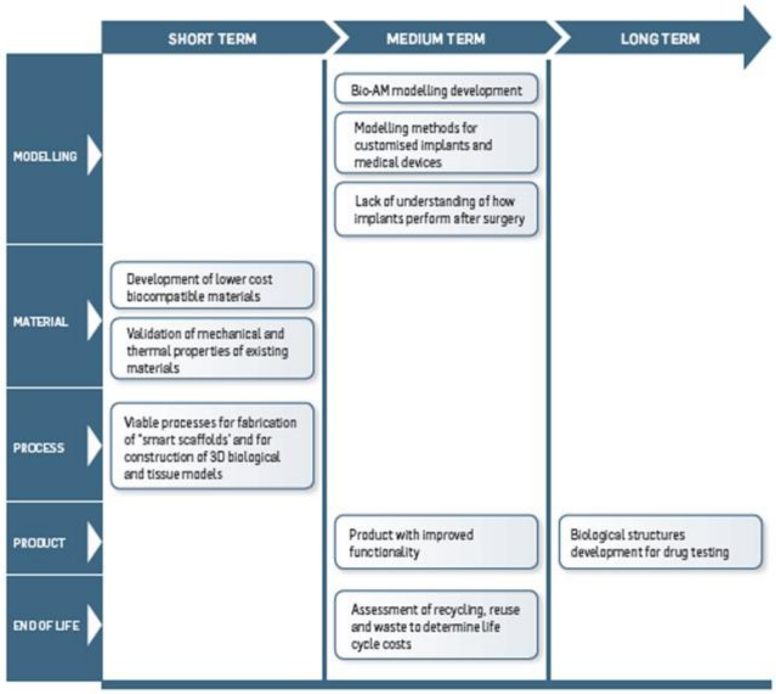


Figure 2.2: *Example of FOFAM plans for future action – the health sector*

2.2. AM-MOTION roadmapping approach and development steps

AM-MOTION Roadmap starts from the main funding of the FOFAM Roadmap, further developed and expanded by means of combination of desk research (integrating the results of key initiatives in AM[7]) and working group sessions. In particular, AM-MOTION roadmap has adopted the same **Value Chain approach** of FOFAM, and it focuses on **7 sectors**, considering sectorial and cross-cutting actions to solve current gaps, both technical and non-technical ones. In addition to FOFAM, AM-Roadmap starts from a **VISION for European AM in 2030, identifying key challenges and opportunities for successful market uptake of AM products.** In this framework, for each sectors, **target product groups** have been identified and linked with specific future actions aimed at solving current gaps. The roadmap includes a semi-quantitative **impact assessment** of the identified actions, considering economic, social and environmental key impact indicators (KPIs). The roadmap integrate AM-MOTION findings in terms of **regional capabilities in AM** (maps of regional and national projects by sector) and suggestions on **possible business collaboration models**.

The core AM-Motion roadmapping and networking activity was performed by the whole consortium and through the interaction between 5 Expert groups formed by selected experts in different technological and non-technological areas and chaired by project partners, involving overall 100 experts:

- Industrial EWG: representing the key AM industrial players from different sectors and VC segments.

[7] E.g. The 3D printing Pilot of the Vanguard Initiative (http://www.s3vanguardinitiative.eu/cooperations/high-performance-production-through-3d-printing); EC Report- EASME Tender "Identifying current and future application areas, existing industrial value chains and missing competences in the EU, in the area of additive manufacturing (3D-printing)". 2016.; Lloyd Register Foundation. Roadmap for additive manufacturing. 2017.

- Materials & process EWG: Main players from industry and RTDs working on material development/production for AM and process development, including machine builders, software developers, post-processing experts.
- Non-technological aspects EWG: experts working on non-technological aspects such as standardisation, IPRs or education.
- Regional Development EWG: representing the regions with interest and/or capabilities on AM.
- Financial EWG: Financial experts and investors.

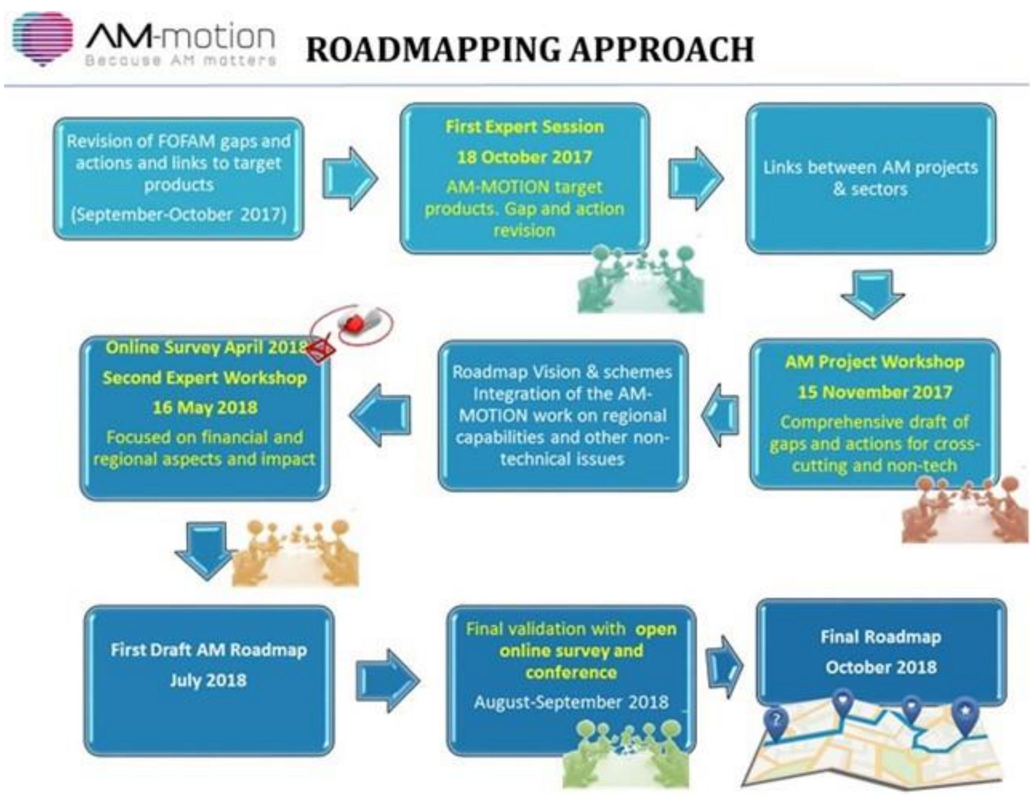


Figure 2.3: *AM-MOTION Roadmapping steps*

The Figure 2.3 summarises the main AM-MOTION roadmapping steps, from the revision of FOFAM gaps to the release of and actions to the release of the present draft AM Roadmap up to the final release in October 2018. Detailed results of expert sessions are reported in deliverables D5.1 and D5.2.

3. AM-MOTION Vision

Global warming, energy transition, population ageing and decreasing resources present us with immense challenges. In order to deal with these, we need fresh approaches, technological advances and clear implementation strategies. In this framework, Additive Manufacturing may play a pivotal role in changing the manufacturing paradigm and contributing to address the societal challenges of our time. For example, lightweight production and functional complexity enabled by AM technologies can help to reduce the consumption of resources for the process and the product itself, streamline manufacturing processes and make more sustainable products.

AM-MOTION vision for 2030 foresees that Europe will improve its leading role in Additive Manufacturing, greatly impacting on the competitiveness of European industrial sectors. Additive Manufacturing will improve the quality of life of European citizens in terms of retention of high quality jobs in Europe, availability of customised, cleaner, safer and affordable products and increased access to cleaner energy, mobility and effective and personalised medicine.

Figure 3.1 summarises AM-MOTION Vision for AM in 2030, including the envisaged **opportunities and challenges** as well as the **areas of intervention which are covered by the roadmap** (i.e. technologies, standardisation, certification, skills and education, financing, intellectual properties, safety, communication, cross-regional and international cooperation).

The following lists describes some of the upcoming **opportunities** offered by market uptake of AM technologies:

- Additive Manufacturing is one of the **pillars of the Fourth Industrial Revolution** (also known as **Industry 4.0**), which is a transformation that makes it possible to gather and analyse data across machines thus enabling faster, more flexible, and more efficient processes to produce higher-quality goods at reduced costs with greater agility.[8]. In particular, AM can highly contribute to Industry 4.0 approaches by increasing process automation and the intrinsic digital core of AM manufacturing technologies make them relatively easy to use effectively digital twin approaches[9]. The application of digital twin in AM-enabled value chains can allow companies to have a complete digital footprint of their products from design and development through the end of the product life cycle. The digital twin may help to solve physical issues faster by detecting them sooner, predict outcomes to a much higher degree of accuracy, design and build better products, and, ultimately, better serve their customers. Finally, AM approaches includes recent breakthroughs as 4D Printing, which is a mean to enable **smart and Internet of Things[10] functionalities in AM products.** In fact, 4D Printing is a combination of 3D printing and the fourth dimension, which is time and/or the change of functionalities. This technique allows a printed object to be programmed to carry out shape change

[8] https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

9 The digital twin is a near-real-time digital image of a physical object or process that helps optimize business performance. From https://www2.deloitte.com/insights/us/en/focus/industry-4-0/digital-twin-technology-smart-factory.html

[10] The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity, which enables these things to connect and exchange data, creating opportunities for more direct integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions. More info on: Internet of Things: Science Fiction or Business Fact?" Harvard Business Review. November 2014.

while adapting to its surroundings. This allows for mastered self-assembly, multi-functionality, and self-repair and sensoring capabilities.

- Bringing **Artificial Intelligence** to the world of AM can lead to faster and more precise processes, by giving smart advice on the choices to make, both in terms of design, of materials and of technologies, especially in presence of control and monitoring systems (including in line and real-time ones) and predictive maintenance approaches. When coupled with robotic arms for printing large/complex shapes, artificial intelligence algorithms enable machine to see, create, and even learn from their mistakes during the printing process, thus being able to produce complex, large and precise patterns without sacrificing speed, as recently showcased by the company Ai Build[11].
- High degree of product customisation and human-centred approach offered by AM will contribute to improve the **quality of life**, with affordable and high quality products built based on customer needs, and also potentially address specific needs of the growing elderly population or of the people with physical impairments, thus building more inclusive societies. Co-creation approaches, involving researchers, industrial end-users and final customers in the design process, will contribute to EC strategies towards more **inclusive and Responsible Research and Innovation** (RRI).
- AM may play a lead role in the **Circular Economy** for example by producing high added-value products from recycled or bio-based powders and enabling full re-use of AM by-products in new products. The exploitation of the full potential of AM will also lead to resource and energy saving in the whole value chain and in particular in manufacturing and transportation, thus contributing to the **environment**.
- AM presents transformative potential manufacturing methods in the health sector being able to provide patient-specific solutions (e.g. from smart wheelchairs to orthopaedic implants), thus enabling **Personalised Medicine** approaches, which in the medium term can be affordable for most of the population. The advent of Bioprinting[12], with its ability to create complex geometries and microarchitectures that mimic tissue complexity, can offer innovative solutions in the field of tissue engineering (i.e. printing biological tissues and potentially even organs) for patient-specific regenerative medicine and drug testing.
- AM full market deployment will offer new employment and investment opportunities in several sectors enabling industries (including SMEs) to compete in highly aggressive and complex commercial environments. Furthermore, the new knowledge gained such multi-disciplinary and multi-sectorial domain will contribute to the improvement of workforce skills and education in **European Knowledge-based economy**, i.e. increasingly based on knowledge and information sharing.
- Finally, AM technologies can contribute to the availability at low cost of highly efficient green energy solutions (e.g. renewable energy components and energy storage solutions), thus contributing to the EC **2050 Low Carbon Economy Roadmap[13], as well as to EC plans for sustainable transportation[14]**.

[11] https://www.digitaltrends.com/cool-tech/ai-build-wants-to-change-the-way-we-build-the-future/
[12] Bioprinting can be defined as "the use of 3D printing technology with materials that incorporate viable living cells, e.g. to produce tissue for reconstructive surgery" (https://en.oxforddictionaries.com/definition/bioprinting)
[13] https://ec.europa.eu/clima/policies/strategies/2050_en
[14] https://ec.europa.eu/transport/themes/sustainable_en

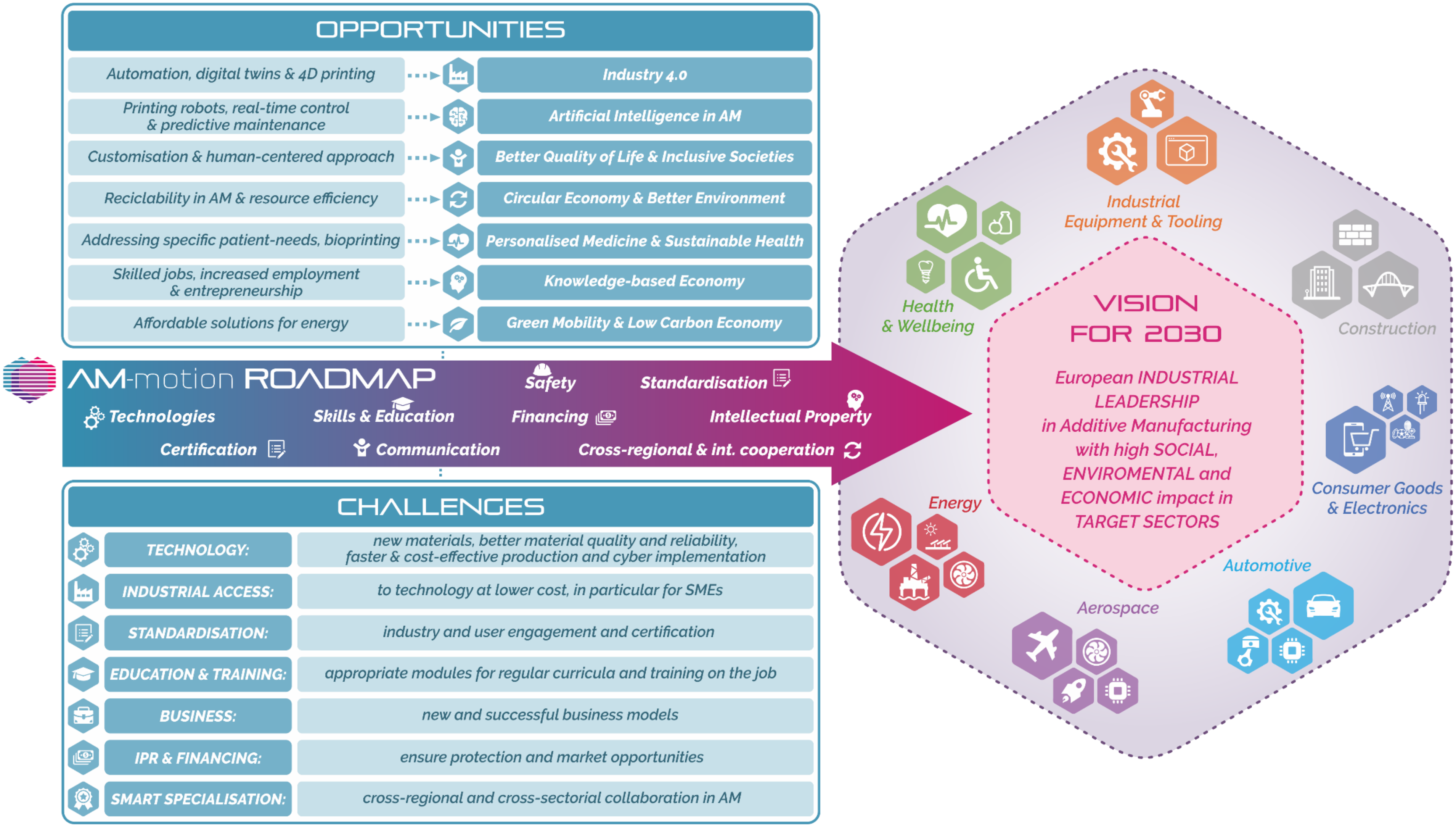


Figure 3.1: *AM-MOTION Vision*

However, Europe must address several **technical and non-technical challenges**, which may hinder AM full development and market success:

- **Technology**: the availability new breakthrough materials and of advanced materials with better quality, reliability and affordability, together with faster and cost-effective manufacturing processes, integrating effectively industry 4.0 approaches, with focus on automated monitoring and control mechanisms as well as advanced design, modelling and simulations.
- **Industrial access** to technology at low prices. Industries (especially SMEs) in periods of limited resources find difficult to keep pace with the emerging innovation in AM, which may require the use of expensive machines and/or can be used effectively by highly-skilled workforce with multi-disciplinary curricula. There is risk for European SMEs to stay behind without being able to compete in such highly technological arena.
- **Standardisation** requires effort from individual specialists on the short term while the gains will be on the long term for a wide community. From one side, there is need to increase industry engagement on standards development; from another side, standards harmonization will have a significant influence on the long-term perspective. Harmonizing standards can be very time consuming, but standards are needed for the uptake of technologies. Moreover, in order to provide manufacturers with the greatest opportunity to exploit AM and provide confidence to manufactures and end-users that parts are safe, reliable and robust, an early publication of AM **Certification** Guidelines is paramount.
- **Education and training:** industries are currently facing some obstacles to find out the missing necessary people (technicians, engineers, designers and operators) specialized in technical and non-technical aspects of AM. The demands on—and expectations for—AM talent are high, especially because the technical and engineering skills required vary widely and because AM professionals are expected to be at the same time creative, and able to constantly adapt to new developments. There is need for proper communication campaigns, industry involvement in education and training aspects, delivering proper learning contents at all levels, specific educational programmes, workplace training, on-line education and reskilling actions for current work force.
- **New business models:** Bringing prototypes to production by securing the reproducibility of application remains a critical point for the industry. AM is still perceived too much as a technology solution instead of a business solution. There is need for availability of effective business models, able to address all the emerging opportunities (including co-creation platforms, provision of AM as a service etc.).
- **IPR and Financing**: -IPR Regimes should be reflected upon as to ensure protection without hampering market entry. Protection should be further ensured (IPR enforcement) and new IP-based reward systems should be thought of as to foster the development and commercialisation of AM-based products. In particular, it is important to give clearer guidance on defining for example whether a CAD file could benefit from copyright protection or other IP protection and build-up of a set of use cases in which IP can be used as an inclusion tool instead of exclusion tool.

- **Smart Specialisation**: as reported in previous studies[15], the European AM landscape however remains fragmented. The concentration of AM capabilities in specific Western European regions leaves a picture of leading regions specializing in particular segments of the AM value chain, covering both supply and demand sides. Eastern (and to some extent Southern) Europe is however at a discovery stage: only a limited number of 3D-printer manufacturers and specialized service providers could be identified in Eastern European regions. In these regions, most efforts are being made in key RTOs where public investments contributes to the absorption and development of AM knowledge and technologies. In order to enlarge industrial research and business opportunities, cross-regional and cross-sectorial cooperation is required. In this framework, collaborations among S3 Smart Specialisation Thematic Platforms - SSTPs (up to now European Commission set up SSTPs for interregional cooperation on Industrial Modernisation, Agri-Food and Energy) would be important to enhance AM penetration in traditional sectors and to foster cross-contamination between western and eastern regions.

AM-MOTION Roadmap aims to catch the foreseen opportunities and address the described challenges by suggesting recommendations focusing on industrial sectors of high economic, social and environmental impact, described in the subsequent chapter.

[15] EC report- “Identifying current and future application areas, existing industrial value chains and missing competences in the EU, in the area of additive manufacturing (3D-printing)”. EASME Tender 2016. l by IDEA Consult, AIT, VTT, CECIMO

4. Target sectors and products

According to Wohlers Report 2018[16]: "In 2017, the AM industry, consisting of all AM products and services worldwide, grew 21% to $7.336 billion. The growth in 2017 compares to 17.4% growth in 2016 when the industry reached $6.063 billion and 25.9% growth in 2015… The total industry estimate of $7.336 billion excludes internal investments from the likes of Airbus, Adidas, Ford, Toyota, Stryker, and hundreds of other companies, both large and small. A surprising number of the $1-5 billion companies – many of which are unfamiliar to most of us – are investing in AM R&D (research and development)." This demonstrate that this is not a market segment that is declining, as shown in Figure 4.1, Additive manufacturing is poised to grow at a rate of 15.0% (CAGR, 2015–2025)[17]

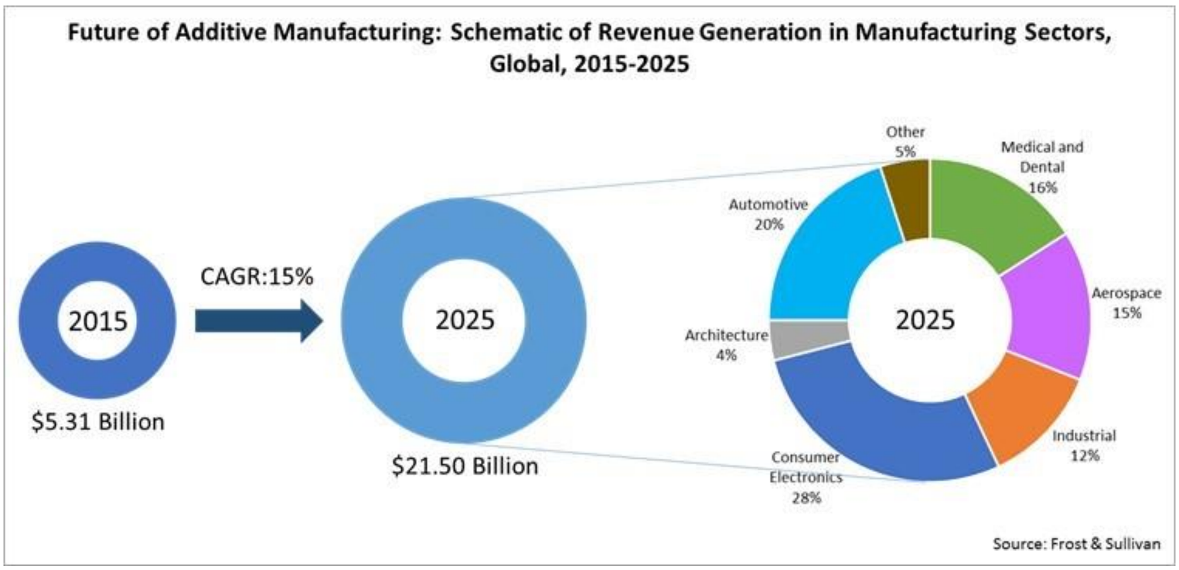


Figure 4.1: *3D Printing Market Potential (Source: Frost & Sullivan)*

Advancements in additive manufacturing technology have expanded its applications across various industries; however, the challenge for companies is understanding how progress can impact existing business functions. Furthermore, as the adoption of the technology grows, the value and potential of AM for promising applications can vary from one sector to another.

Adoption of AM has been highest in industries where its higher production costs are outweighed by the additional value AM can generate: improved product functionality, higher production efficiency, greater customization, shorter time to market (that is, improved service levels), and reduced obsolescence, particularly in asset-heavy industries. Engineering-intensive businesses such as aerospace, automotive, and medical can accelerate prototyping, allowing them to explore completely new design features or create fully individualized products at no extra cost. High-value/lower-volume businesses see faster, more flexible manufacturing processes, with fewer parts involved, less material wasted, reduced assembly time for complex components, and even materials with completely new properties created. Finally, spare-parts-intensive businesses in fields such as maintenance, repair, and overhaul get freedom

[16] Wohlers, T. &. (2018). *Wohlers Report.* Colorado: Wohlers Associates Inc.

[17] Frost & Sullivan's Global 360° Research Team (May 2016), *Global Additive Manufacturing Market, Forecast to 2025,* Frost & Sullivan, Mountain View, California

from obsolete parts, faster time to market, more local and on-demand production opportunities, and independence from traditional suppliers[18].

The AM-Motion roadmap focus in particular on the following top-level sectors:

Figure 4.2: *AM-Motion key sectors*

A brief overview on the market potential, along with key innovative AM products for each sector identified is reported below.

4.1. Health

Health is one of the most valuable aspects of anyone's life, which makes this sector one of the world's largest and fastest-growing industries, consuming over 10% of gross domestic product (GDP) of most developed nations. Healthcare applications accounted for 12.2% of the related revenue for their AM market[19] with a share that will likely reach $450m by 2020[20]. Equally, the medical sector has seen 25% compound growth in the AM market every year since 2009[21].

AM offers high added value to a number of applications and has already established itself as strong sector using the technology. The dental market currently holds the largest share in AM with hip and knee implants becoming the second largest area of the healthcare sector. In dental AM is widely adopted for the production of crowns, bridges, drill guides and dental aligners The AM hip implant cup was one of the first applications used in large production quantities mainly owning to this promotion of bone ingrowth. Other early acceptance of applications include visualisation models, hearing aids, hip implants, teeth braces and drilling guides.

[18] Jörg Bromberger and Richard Kelly , *Additive manufacturing: A long-term game changer for manufacturers*, September 2017
[19] Wohlers, T. &. (2016). *Wohlers Report.* Colorado: Wohlers Associates Inc.
[20] Global metal additive manufacturing market 2016-2020 Technavio Inifiniti Research Limited 2015
[21] http://www.medicalplasticsnews.com/why-is-2016-the-year-for-additive-manufacturing-in-the-medic/

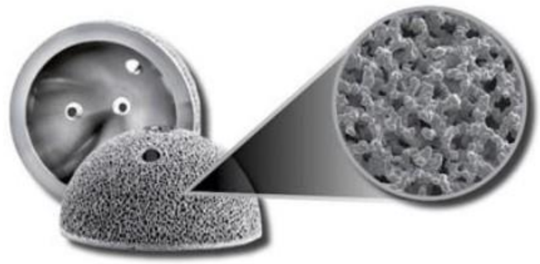


Figure 4.3: *3D printed acetabular cups with integrated Trabecular Structures for improved osseointegration (Source www.arcam.com)*

Moreover, AM is being used for the creation of assistive, surgical and prosthetic devices and customised implants, with a typical focus on non-standard, complex or accuracy sensitive cases, where models for pre-analysis and for practicing the actual surgery are also developed;. Here AM is able to bring significant improvements due to the nature of the process that allows for complex parts to be produced accurately and to the patient's specific needs and profile. Thus, reducing the removal of healthy bone, eliminating the need for bone grafting whilst promoting effective planning of implantation/surgery and shortening the time of anaesthesia and increasing implant life particularly in an era of an ageing population[22].

Current research interests also focus in bio-printing of skins and organs, including the production of bone and cartilage scaffolds. Although still in its infancy, 3D bio-printing offers additional advantages over the traditional regenerative method, particularly in bone and scaffold regeneration, such as highly precise cell placement and high digital control of speed, resolution, cell concentration and drop volume[23].

Other growing areas of focus in this sector are also well-being (including pharma) and food, where the key drivers are the possibility for personalisation, rapid experimentation, on demand supply and of having novel functions and forms, offered by these technologies.

On the other hand, products for use in the health sector are often critical and need to meet very high standards regarding reliability, safety, bio-compatibility and require certification (e.g. CE mark according EEC/93/42 for Europe or US food and drug administration (FDA-approval for USA)), which slows down the utilisation of new technologies and especially materials.

There are a number of key drivers for the healthcare sector to adopt AM and hence increase the potential impact. These include:

- Personalisation
- Mass customisation
- Efficient bio-compatibility
- Promotion of healthy bone ingrowth after surgery
- Integration of medicine and healthcare through digital innovation
- Increased efficiency of supply chain
- Reduced lead time
- Quicker response times

[22] Wohlers, T. &. (2016). *Wohlers Report.* Colorado: Wohlers Associates Inc.
[23] Vincent Bonneau & Hao Yi, IDATE; Laurent Probst, Bertrand Pedersen & Olivia-Kelly Lonkeu, PwC (January 2017), *The disruptive nature of 3D printing*, EC - Digital Transformation Monitor

4.1.1. *Target Products*

In the Health sector there are a number of **key innovative AM products.** As shown in 4.4, eight main product groups were identified. The detailed list of products for each group is reported in Table 4.1.

Figure 4.4: *Health key product groups*

Table 4.1: *HEALTH - Detailed list of key innovative products*

	PRODUCT GROUP	PRODUCTS
	Medical Implants	• Dental implants (stems, Crowns, Bridges) • 4D Biocompatible Implants • Biodegradable Implants • Other endo-prostheses: Orthopaedic and cardiovascular implants
	Living Tissues & Organs	• Bioprinted constructs for tissue engineering • Bioprinted organs for transplantation (*) • Bioprinted cartilages • 3D printed scaffolds for tissue engineering
	Assistive & Prosthetic Devices	• Orthoses • Flexible supports (instead of rigid cast) • Prosthetic limb • Advanced / Individualized hearing aids • Esoskeletons • Bespoke assistive devices for elderly and disability (crutches, wheelchairs etc.)
	Surgical Guides, Tools & Models	• Customised surgical guides and tools (e.g. guides for drilling and for seaming) • Case-specific surgical models (focus on soft tissues) • Models for communication with patients and surgical planning
	Other Customized Products	• Special soles and other shoe parts for sports and orthopaedics • Flexible supports for orthopaedics (instead of rigid cast).

	PRODUCT GROUP	PRODUCTS
	Other Dental Products	• Crowns • Bridges • braces • dental aligners • dentures • Osteotomies • tweezers
	Food	• 3D Cooked food • Consumable "food inks" • In-house 3D Printers • Personalised Diet
	Pharmaceutical Products	• Drugs • Drug Delivery Systems with Smart Biocompatible Materials

(*) High challenging and long term target; under scientific discussion.

4.1.2. *Regional Capabilities*

According to the AM-motion mapping exercise of 18 European regions, the health industry appears as one of the sector where most of the regions apply AM to one extent or another. Key players from the regions Asturias, Valencia, Basque Country, Catalonia, Flanders, Normandy, Noord-Brabant, East Wales, Thüringen and Norte are involved with AM in the health sector.

Moreover, within the Vanguard 3DP pilot[24], a Health demo case project has been proposed by Emilia Romagna region (Italy). Current interested regions are: Saxony, Wallonia, Nordrhein-Westfalen, East Netherlands and Flanders, Emilia Romagna. The case aims at developing cross regional demonstration activities in the fields of 3D printed external orthosis and internal implants/prostheses. In the long term, the main objective seeks to demonstrate the feasibility, the value, the sustainability and the efficacy, as well as safety, of the 3DP technology once applied to medical problems.

Here below (Figure 4.5) is reported a map showing the national and regional activity (based on number of projects) in the Health sector. Germany, France, UK and Spain are the countries with higher number of projects related to the health sector. In Germany half of the listed projects focus on dental products, while in France different projects are related to bioprinting for bone tissue. In addition, a couple of projects from Spain focus on bioprinted scaffolds and osseointegration, with attention to 3D printed food. Projects from UK deal more on optimization of materials and processes.

[24] https://s3vanguardinitiative.eu/cooperations/high-performance-production-through-3d-printing; https://www.s3vanguardinitiative.eu/sites/default/files/docs/general/vanguard_initiative_flyer_3dp_0_002_0.pdf

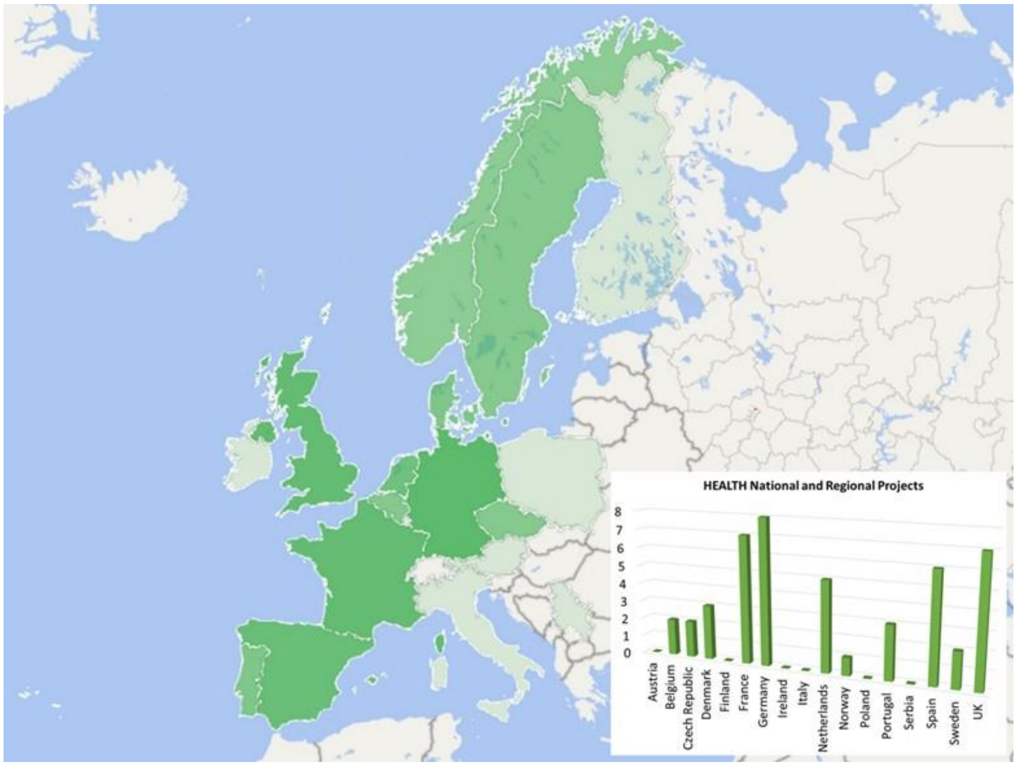


Figure 4.5: *HEALTH - Map of National and Regional Projects*

The complete list of national and regional projects divided by country can be found in ANNEX B.

4.2. Aerospace

The Aerospace sector has been one of the early adopters of 3D printing. According to the Wohlers report this industrial sector has grown by 4.3% in 2015 and is the second largest sector for AM[25]. Currently represents about 16% of the global AM market[26] with a share that is predicted to reach $1bn by 2021[27]. The aerospace industry includes design, manufacturing and operation of aircrafts and spacecrafts. Many examples of niche components being made and supplied using various forms of AM[28] are available, this is mainly owing to the advantages AM provides in terms of reducing the weight of the components without sacrificing their performance, and reducing the buy-to-fly ratio. By utilizing topological optimisation and other digital modelling tools new materials and digital manufacturing, parts can be designed to be much lighter but still present equal or even better performance(an example is shown in Figure 4.6),. In addition, part consolidation i.e. printing parts in a single piece instead of several fitted together, reduces assembly costs. Parts are used in rather small quantities, and they have often complex geometries as well as advanced materials, which might be challenging to manufacture by conventional means[29].

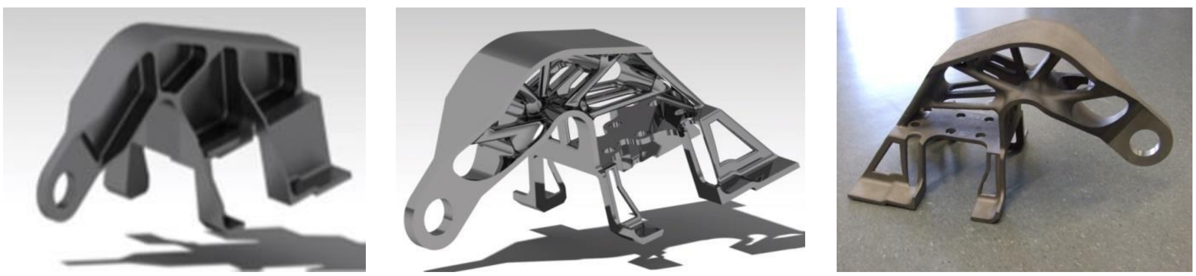


Figure 4.6: *Topology optimization of structural hinge and manufacturing in Titanium (courtesy of PRODINTEC)*

The main focus markets of AM in this sector are engines and aircrafts interior parts, this is also demonstrated by last years significantly growing number of projects in pre-production and flight testing for aircraft engine manufacturing. Other applications, such as UAV's parts are also fast growing markets.

As for the health sector, the aviation industry is strictly regulated. Safety is always the first driver in the aerospace industry; therefore the AM introduction has had to take into account the need to verify the compliance with all existing regulations around the world. The complete strategy is subject to a continuous process of validation, verification and agreement with all applicable Airworthiness Authorities. In more recent times, the industry is making significant moves to qualify AM parts.

There are many other examples of the AM benefits being capitalised on by the Aerospace industry showing that there are a number of key drivers for this sector for the adoption and development of AM and hence potential areas of impact. These include:

- Light weighting
- Energy usage (improved fuel efficiency)

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

[26] DeSilva, R. (2015, November). *Debunking the myths of Additive Manufacturing.* Retrieved July 22, 2016, from Additive Manufacturing Summit: http://www.additivemanufacturingsummit.com/media/1003367/34746.pdf

[27] Smartech. (2014, August). *Additive Manufacturing in Aerospace: Strategic Implications.* Retrieved July 22, 2016, from Smartech Publishing : https://www.smartechpublishing.com/images/uploads/general/AerospaceWP.pdf

[28] Additive Manufacturing Platform. (2014). *Additive Manufacturing Strategic Research Agenda.* Brussels : Additive Manufacturing Platform.

[29] IDEA Consult, VTT Technical Research Centre of Finland Ltd, AIT Austrian Institute of Technology and CECIMO (2016). *Report on 3D-printing: Current and future application areas, existing industrial value chains and missing competences in the EU* https://ec.europa.eu/growth/content/report-3d-printing-current-and-future-application-areas-existing-industrial-value-chains-0_en

- Design freedom 'new' or 'optimised'
- Life cycle cost
- Life time extension
- Reducing the buy-to-fly ratio
- Utilisation of materials
- Performance of materials
- Reduction of time to design and test and validate an aero engine
- Validation in full scale engine tests
- Increased efficiency of supply chain
- Production efficiency
- Simplified assembly process

In the longer term, AM has real potential also for the space industry. In this sense, The European Space Agency (ESA) began to study the potential applicability of AM technology[30]. A roadmap, covering around 30 types of AM parts that would strongly benefit from being manufactured using AM and the entire end-to-end AM process, from initial modelling and design of items to material supply and processing and post-processing stages to qualification and standardisation, has been produced by them. Standardisation is a key element is for space. To give mission managers sufficient confidence in 3D-printed parts, methods need to be in place to ensure that these items perform to a benchmarked, repeatable standard.

One key driver for space structures and equipment is the launching loads. Currently all parts being delivered to the International Space Station, or in a longer term, to the Moon or Mars for example, are launched as finished parts, therefore oversized and under the launching loads. Printing them directly at the destination will save a lot of weight and costs because those parts can be optimized to sustain real operating loads..

On the other hand, the spares sector has potential for AM in terms of parts being delivered literally to any place in the world (usually at short notice). AM could drastically become a game changer, by reducing the needs of stocks by printing the parts closer to the demand and enabling shortening of lead times for part availability. Business models to be adopted will be a major decision to be taken in the industry. Safety, traceability and IP rights will also have to be secured. In 2016 a spare process has been agreed with EASA and several parts have been subsequently approved and available in case of customer demand.

Another relevant and specific niche market is represented by the cabin parts. Surface quality and full harmony with the existing non AM parts are extra requirements which current technologies do not fully cover. Therefore very specific post processes are being developed as well in order to ensure that regulations are met (Fumes Smoke and Toxicity (FST) + Heat Release in case of a fire in the cabin) and full customer satisfaction is granted (no visual difference with existing parts).

[30] http://www.esa.int/Our_Activities/Space_Engineering_Technology/Advanced_Manufacturing ; http://www.esa.int/Our_Activities/Space_Engineering_Technology/Ten_ways_3D_printing_could_change_space

4.2.1. *Target Products*

In the Aerospace sector there are a number of **key innovative AM products.** As shown in Figure 4.7, nine main product groups where identified. The detailed list of products for each group is reported in Table 4.2

Figure 4.7: *Aerospace key product groups*

Table 4.2: *AEROSPACE - Detailed list of key innovative products*

	PRODUCT GROUP	PRODUCTS
	Turbine Parts / Engine	• Turbine Blades, Guide Vanes • Nozzles • Stator Rings • Impellers • Non-structural parts
	Small aircraft wings and fuselage and their components	• Design Of Entire Wings
	Cabin & Cockpit parts	• Interior parts • Airco • Covers • Seats • Door handles • Hinges
	Other complex parts	• Bionic design parts • Integration of parts
	Components of large aircraft wings and fuselage	• Air Foils, Brackets • Landing gear parts
	Spare parts & repair	• Carbon Fibre Printing For Spare And Repair • Repair of engine components

	PRODUCT GROUP	PRODUCTS
	Concept modelling, prototyping and advanced moulds	• Carbon Fibre Mouldings • Components with vibration dampening geometries
	Niche, low volume parts	• Circuits For Flight Test Installation • Customised Cabin Applications (Seats Etc.)
	Embedded Electronics	• Structural health monitoring • Circuits for power supply • Embedded sensors (both in the structure and within engines)

4.2.2. *Regional Capabilities*

Equal to the health sector, the large majority of regions use AM in the aerospace sector. 14 of the regions, among which Catalonia, Emilia-Romagna, Flanders, Auvergne Rhône Alpes, Norte, Thüringen, East Wales, Aragon as well as Basque Country mention this as one of their dominant sectors where AM is already used. Only Tampere, Navarra and Valencia are not including this as a dominant AM sector.

Here below (Figure 4.8) is reported a map showing the national and regional activity (based on number of projects) in the Aerospace sector.

As already anticipated, the Aerospace sector is one of the dominant in the AM industry, and this is also demonstrated by the overall number of listed national and regional projects focusing on the sector (about 19% of the total and second only to Industrial Equipment and Tooling).

The countries with a higher number of related projects are Germany, France and Spain, all focusing mainly on optimisation of processes for the development high performances parts and hybrid manufacturing for large components.

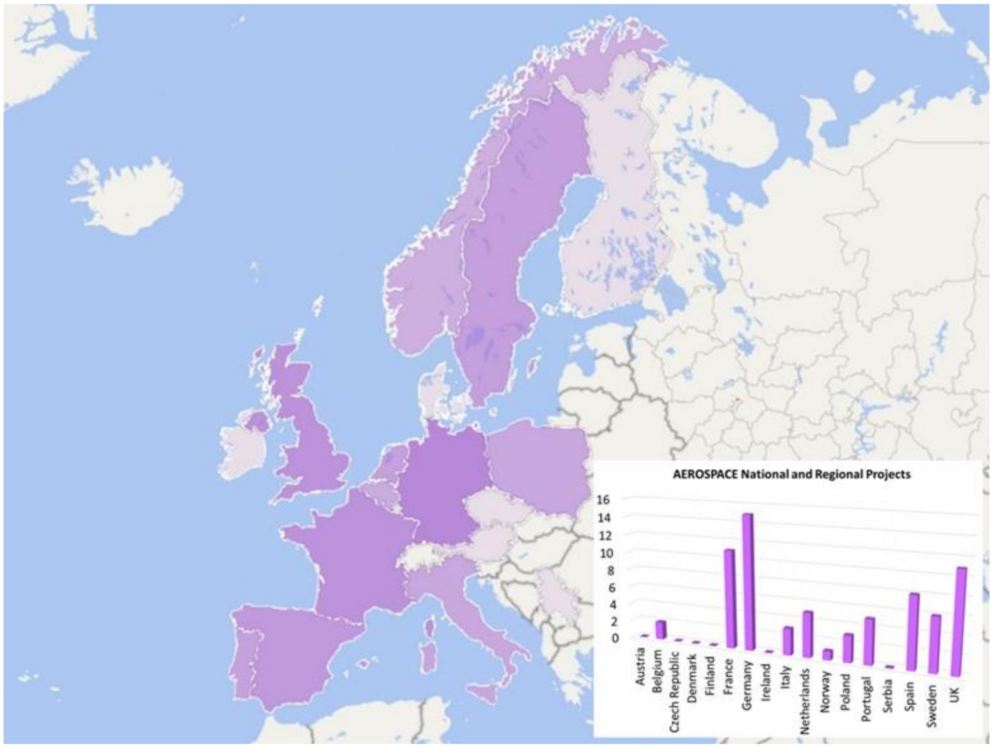


Figure 4.8: *AEROSPACE - Map of National and Regional Projects*

The complete list of national and regional projects divided by country can be found in ANNEX B.

4.3. Automotive

Automakers have been using AM for almost three decades, and today are progressing to a variety of applications, ranging from design, development, tooling and rapid manufacturing. The industry is the third largest sector for AM as reported by Wohlers[31] and it is poised to become a $4.30 Billion global business by 2025[32].

Rapid prototyping has historically been the most common use of 3D technology within the automotive sector. The industry has in fact used 3D printers mostly in the pre-production stage, making prototypes/ concept models (an example is shown in Figure 4.9) but also small and complex parts for luxury and antique cars.

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

[32] Frost & Sullivan's Global 360° Research Team (May 2016), *Global Additive Manufacturing Market, Forecast to 2025,* Frost & Sullivan, Mountain View, California

Figure 4.9: *The concept model for a Citroen interior (Courtesy of Materialise)*

The sector is much heavily dependent on mass production of parts, which are significantly cheaper using traditional manufacturing methods, therefore a widespread adoption of metal AM has not yet occurred in the industry. Because of this limitation, the most relevant applications for metal 3D printing technologies in the automotive industry are for high-end car manufacturers.

On the other hand, thanks to the significant developments made in AM technology the industry has grown and is now utilising the benefits of AM in new ways. More companies are in fact adopting 3D printing for jigs and fixtures, lowering costs, providing lighter and more ergonomic tools, and more. Furthermore, it has shown a consistent reduction in lead-time by 40% to 90% and cost reduction up to 60%. 3D printing tooling also allows design teams to save time because they can be more responsive with the ability to create one-off custom components.[33]

The safety requirements on automotive parts are very high as well as other requirements on strength, lightweight and costs while the series often are very large. It must be taken into account that about 20 years ago, the roof-strength requirement to resist rollover crush was roughly the weight of the vehicle. Today, rollover strength is about four times the gross vehicle weight. AM technology could help in this context thanks to topographical optimization, creating parts with maximum strength using minimum weight and material.

Besides unexpected breakthrough on the technical side, changes in the end product itself (Smart/Green cars) might also affect the type of structural components needed.

There are a number of key drivers for the automotive sector for the adoption and development of AM and hence potential areas of impact. These include:

- (Functional) prototyping
- Light weighting
- Design freedom
- Increased efficiency of supply chain
- Increased quality, reliability and reproducibility

[33] *How 3D Printing Is Changing Auto Manufacturing*, MachineDesign (Nov14, 2016) http://www.machinedesign.com/3d-printing/how-3d-printing-changing-auto-manufacturing

- Reducing vehicle carbon emissions
- Cost effectiveness

In conclusion, the typical large series envisaged in automotive have a negative impact on the cost effectiveness of 3D-printed components. In assembly tooling and other manufacturing aids however, this is not a problem and the automotive industry is an early adopter of 3D-printing in these application.

4.3.1. *Target Products*

In the Automotive sector there are a number of **key innovative AM products.** As shown in Figure 4.10, six main product group where identified. The detailed list of products for each group is reported in Table 4.3.

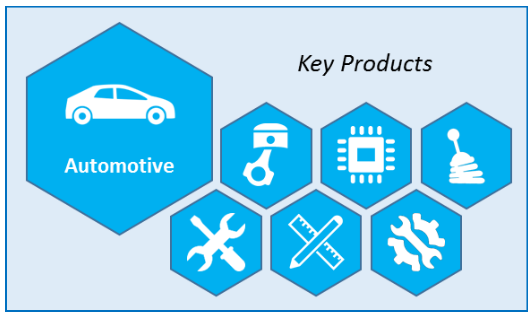


Figure 4.10: *Automotive Key Product Groups*

Table 4.3: *AUTOMOTIVE - Detailed list of key innovative products*

	PRODUCT GROUP	PRODUCTS
	Engine Components	• Chassis Components • Moulding dies repair • Gear box parts • Rotating/ reciprocating parts (small complex) • Conrod • CAM Shafts • Batteries for E-cars
	Auxiliary means of production and supports	• Manufacturing Tools • Tools For Testing And Assembly • Jigs And Fittings • Tooling for precise positioning during assembly
	Embedded electronics	• Sensors
	Concept modelling, prototyping and design	• Carbon Fibre Mouldings • Customised lights - Concepts Lenses and Glass printing
	Niche, low volume parts	• Exclusive And Sports Car Parts • Low Volume Interior Parts • Customized Parts

	PRODUCT GROUP	PRODUCTS
	Spare parts & repair	• New parts to upgrade • Assembly of new sensors • New liquid parts/airducts (plasma)

4.3.2. *Regional Capabilities*

The automotive industry appears as the sector where most of the regions (including Castilla y León, Normandy, Auvergne Rhône Alpes, Noord-Brabant, Thüringen, Västra Götaland, East Wales, as well as Asturias, Navarra, and Valencia) apply AM to one extent or another. The only two regions not categorising the automotive as a dominant AMs sector are Tampere and Occitane.

In the Vanguard Initiative[34], the 3DP demo case on *"3D-Printed Hybrid Components"* focuses on automotive as the main target market (another secondary market is aerospace). The Lead Partner of such demo case is Università di Bologna, UNIBO (Emilia Romagna [IT]). Participating/co-leading regions are: Aragona [ES], Norte [PT], Baden Wurttenberg [DE], Saxony [DE], Lombardy [IT], Rhone-Alpes [FR] and Region Orebro Lan [SW].

Moreover, the 3DP Vanguard demo case *"3D-Printed automotive components"* focuses on the development of AM large and complex components, targeting specifically the automotive sector, but with applications also in aeronautics, shipbuilding and railway construction sectors. The leader partner is AITIIP (Aragon [ES]. Participating/co-leading regions are: Emilia Romagna [IT], Norte [PT], Baden-Wurttemberg [DE], Lombardy [IT], Thuringia [DE], Northrine Westphalia [DE], Asturias [ES], Madrid [ES], Cambridgeshire [UK], Piedmont [IT], Bucharest-Ilfov [RO], Kanton Aargau [CH], Warwickshire [UK], Brussels Capital [BE], Berkshire [UK], País Vasco [ES], Gloucestershire [UK], Attica [GR], Luxembourg [L] and Alpnach [CH].

Here below (Figure 4.11) is reported a map showing the national and regional activity (based on number of projects) in the Automotive sector.

Germany, Portugal and UK are the countries with higher number of projects related to the automotive sector. As for the aerospace sector Germany and UK projects' focus mainly optimisation of processes for the development high performances parts, while projects' from Portugal deal with rapid prototyping in general.

[34] https://s3vanguardinitiative.eu/cooperations/high-performance-production-through-3d-printing; https://www.s3vanguardinitiative.eu/sites/default/files/docs/general/vanguard_initiative_flyer_3dp_0_002_0.pdf

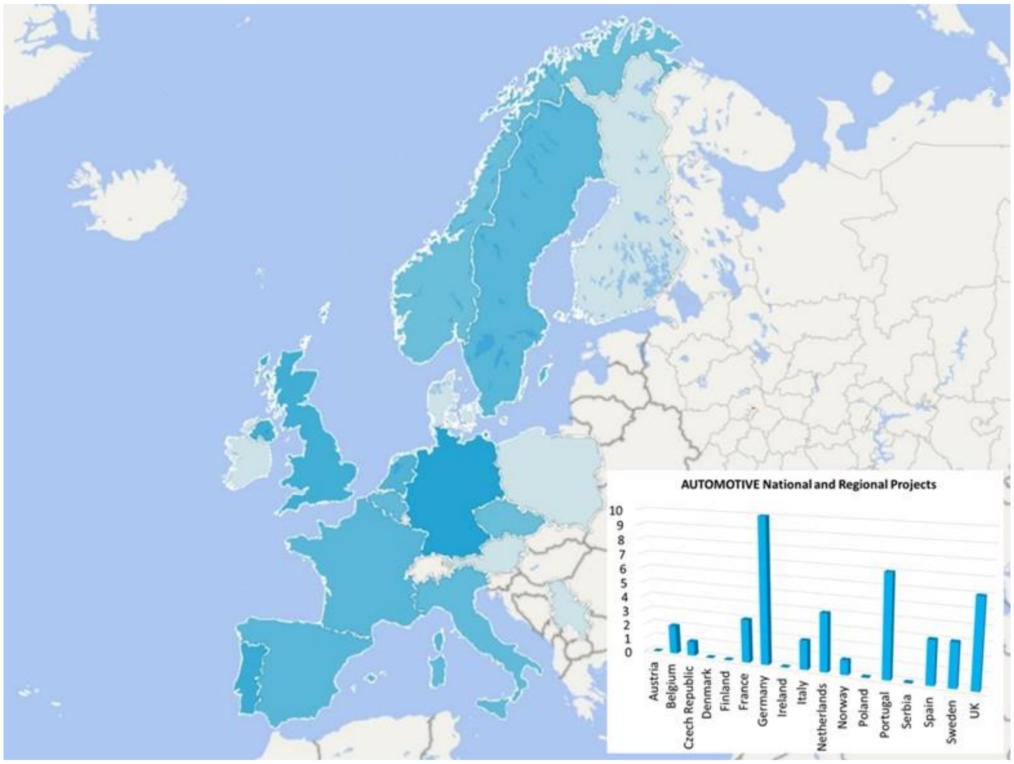


Figure 4.11: *AUTOMOTIVE - Map of National and Regional Projects*

The complete list of national and regional projects divided by country can be found in ANNEX B.

4.4. Consumer Goods and Electronics

Consumer goods and electronics is the fourth largest sectors using AM. Revenue from 3D-printed electronics and consumer products accounted for 13% of the AM industry, with a share of $681 million, in 2015[35].

In this sector, 3D printing is being explored to design, develop, prototype and manufacture a variety of consumer products, spanning from clothes, jewellery and other fashion products, digital accessories, to home gadgets and decoration.

Although making prototypes remains the main use of additive fabrication, the technology has increasingly spread into 'rapid manufacturing'. 3DP is capable of creating intricate design or geometric free structure, enabling artists, designers, jewellers and fashion designers to make one off bespoke pieces[36](Figure 4.12). In addition, AM opens a door to offer mass customization at lower cost. Moreover, additive manufacturing enables companies to build nonstandard electronics, complex assemblies, and intricate or curvilinear shapes. In this way, AM designers are free to design innovative electronic objects that could not have been produced through conventional means, and they can optimize product designs for functionality with fewer manufacturing constraints.[37]

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

[36] Scudamore, R. J. (2015). *POSITIONING PAPER:The Case for Additive Manufacturing. UK: AM Strategy Development Group.* Sheffield

[37] M. Mahto, B. Sniderman, *3D opportunity for electroni.* Deloitte Insights https://www2.deloitte.com/insights/us/en/focus/3d-opportunity/additive-manufacturing-3d-printed-electronics.html#endnote-sup-11

Figure 4.12: *Stool named OneShot by the designer Patrick Jouin for MGX by Materialise.*

A new market that is currently adopting AM and the possibility for mass customisation is in eyewear. Spectacles have an enormous impact on the look of the person wearing them. Not surprisingly, the fashion industry plays an important role within this market. It was only a matter of time for AM to break into this market. Furthermore, the adoption of CAD software among designers is opening the way to AM for manufacturing in the jewellery sector. Annual revenues from 3D-printed hardware, materials, services and software used in the jewellery industry is expected to reach $900 Million in 2026[38].

There are a number of key drivers for the consumer goods/electronic sector for the adoption and development of AM and hence potential areas of impact:

- Tailored products
- Customisation
- Increased efficiency of supply chain
- Increased functionality
- Enhanced materials
- Sustainability of raw materials
- Higher demand for colourful items
- Demand for innovative products

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4.4.1. *Target Products*

[38] SmarTech Publishing, "*3D Printing Opportunities in the Jewelry Industry – 2017: An Opportunity Analysis and Ten-Year Forecast*" https://www.smartechpublishing.com/reports/3dp-jewelry-industry/

In the Consumer and Electronics sector there are a number of **key innovative AM products.** As shown in Figure 4.13, nine main product group where identified. The detailed list of products for each group is reported in Table 4.4

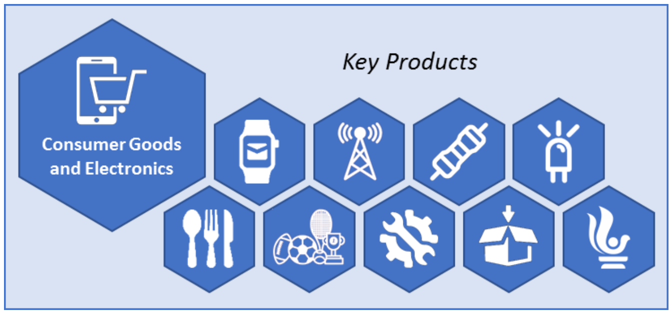

Figure 4.13: *Consumer Goods and Electronics Key Product Groups*

Table 4.4: *CONSUMER GOODS AND ELECTRONICS - Detailed list of key innovative products*

	PRODUCT GROUP	PRODUCTS
	Wearables	• Glasses / Eyewear • (Fashion) Clothing • Sports Products • Shoes • Jewellery • Accessories • Protective masks (sport/professional)
	Household utensils	• Light Fixtures • Vases • Furniture • Cutlery
	Sensors and Antennas	• Sensors integrated in 3D printed parts • Exo selections
	Entertainment	• Toys • Musical instruments • Consoles accessories
	Basic electronic components	• Resistors • Capacitors • Inductors • Diodes • Circuits
	Spare Parts & Repair	• Plastic covers • Repair parts • Objects/parts no longer fabricated • Conformal cooling inserts • Multimaterial inserts (eg, Fe-Cu) • Aluminium inserts for small batches

	PRODUCT GROUP	PRODUCTS
	Other Electronics	• Cooling of Electronic and LED lamps • Audio components
	Packaging	• Smart packaging for consumer goods/electronic parts, • On-demand and customised packaging
	Art	• Complex Sculptures

4.4.2. *Regional Capabilities*

In terms of AM used in the crafting consumer goods, a large number of the regions are active in this field, including Castilla y León, Catalonia, Rhone-Alpes, East Wales, Normandy, Tampere, Navarra, Thüringen, Basque Country, Valencia, Norte and Asturias .

Especially the value chain surrounding consumer goods, a number of regions have had the need to indicate further activity in this sector and hence, a few regions have indicated that they also see the sector of creative goods as a dominant sector where the application of AM plays a central role. Three regions operate in the consumer goods sector, with Asturias and Tampere specifying AM related engagement in the creative goods sector and Normandy working on luxury-related industries. While not identifying themselves with consumer goods, the regions of Flanders and Noord-Brabant are also active users of AM in the creative sector.

In the Vanguard Initiative[39], the 3DP demo case on *"Creative industries - Mass-customized consumer products"* is at its infancy and aims at working on cross-regional cooperation in the areas of furniture/toys, footwear, wearables, etc. The lead region is Norte [PT] with co-leading regions such as Lombardy [IT] and Catalonia [ES].

Moreover, the recently identified Vanguard demo case *"3DP in Textile"* is planned to be focused on Fused deposition modelling (FDM) on Fabrics. The lead region is Lombardy [IT] with co-leading regions such as Flanders [BE] and Nord-Pas-de-Calais [FR].

The only three regions not categorising the consumer goods as a dominant AMs sector are Emilia Romagna, Västra Götaland and Occitane.

Here below is reported a map showing the national and regional activity (based on number of projects) in the Consumer Goods and Electronics sector.

France has the highest number of projects related mostly to 3D printed electronics (e.g. circuit boards and transistors) while in UK, that has the second highest number of projects the focus is more on developing processes and materials for wearables applications (e.g. high performance shoes).

[39] https://s3vanguardinitiative.eu/cooperations/high-performance-production-through-3d-printing; https://www.s3vanguardinitiative.eu/sites/default/files/docs/general/vanguard_initiative_flyer_3dp_0_002_0.pdf

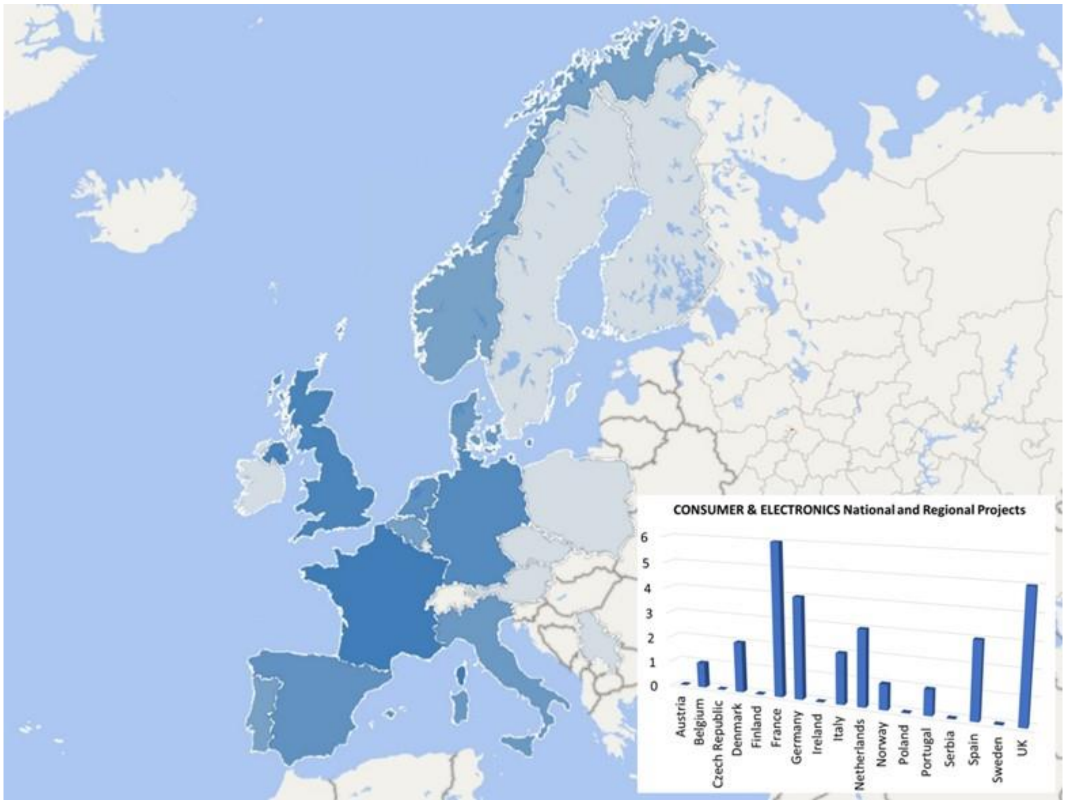

Figure 4.14: *CONSUMER GOODS AND ELECTRONICS - Map of National and Regional Projects*

The complete list of national and regional projects divided by country can be found in ANNEX B.

4.5. Industrial Equipment and Tooling

This sector includes industrial and business machines as well as all kinds of tooling. According to the Wohlers report it's the largest AM sector accounting for nearly 20% of AM related revenue.

AM industrial equipment is a significant sector and a growing one for the European market. In March 2016, as many as 28 companies in Europe were manufacturing and selling AM equipment. Eight of these are metal powder bed fusion system manufacturers. Wohlers reports industrial machines as those selling for more than $5,000 which aims to provide the distinction between 'industrial' and 'desktop'. Within Europe these equipment manufacturers include ARCAM, Sweden (acquired by GE); Concept Laser, Germany (75% acquired by GE); DWS, Italy; Envisiontec GmbH, Germany; EOS, Germany; Lithoz, Austria; Mcor, Ireland; Prodways, France; Realizer, Germany (acquired by DMG MORI); Renishaw, UK; Sisma, Italy; SLM Solutions, Germany; Trumpf, Germany and Voxeljet, Germany[40]. Many of these companies are also developing new AM systems to bring to the market. A total of 12,558 industrial systems unit sales were estimated worldwide during 2015. In 2015, Europe position in system unit sales grew to 31.7% in 2015.

AM can be used to produce tooling, moulds, fixtures and patterns with enhanced functionality. Moreover, temperature regulation is a key issue for industrial equipment in the process industry and injection moulding. Because AM enables the ability to produce parts with complex internal structures improve heat transfer can be applied. For example, conformal cooling channels inside moulds can reduce

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

cycle times up to 40% when using AM. This is particularly important when equipment needs to operate at very high temperatures (e.g. burners) and internal cooling channels are able to cool the parts improving the life span of the parts and the mechanical properties of the part when operating at these high temperatures. Product examples are special heat exchangers and manifolds for the process industry, robot grippers and test rigs. An example of a special 'heat exchanger' (cooling plate) is given below in Figure 4.15: *Cooling plate-Thermal stabilised table by means of free form cooling structure (source TNO)*. The cooling plate is equipped with a grid of thermal pixels each having individual supply of cooling liquid that can keep the temperature gradient of the plate within very narrow limits.

Figure 4.15: *Cooling plate-Thermal stabilised table by means of free form cooling structure (source TNO)*

As a secondary service market, tooling produced using AM grew from 13.1% to $1.859 billion in 2015[41]. As a horizontal industry, tooling is a major industrial sector producing endless products to be assembled using various jigs, fixtures and moulds. To produce these parts conventional CNC machining is widely used, however these techniques can be expensive with long lead times. This is where more manufacturers are now looking to AM for a more cost effective method particularly for producing low volume or one off complex parts. Equally, this opens the opportunity for improving tooling design which in turn offer improved functionality of the products produced.

4.5.1. *Target Products*

In the Industrial Equipment and Tooling sector there are a number of **key innovative AM products including** industrial equipment itself. As shown in Figure 4.16, nine main product groups where identified. The detailed list of products for each group is reported in Table 4.5

[41] Wohlers Report 2016: 3D Printing and AM state of the industry. Annual worldwide progress report.

Figure 4.16: *Industrial Equipment and Tooling Key Product Groups*

Table 4.5: *IND. EQUIPMENT AND TOOLING - Detailed list of key innovative products*

	PRODUCT GROUP	PRODUCTS
	Mould Inserts	• Hot Summers • Large Molds (>Ø250mm) Copper/Steel Parts • Re-Configured Moulds • Insert With Enhanced Materials • Conformal Cooling Inserts • Multimaterial Inserts (Eg, Fe-Cu) • Aluminium Inserts For Small Batches
	Subsea/Deep Sea Industrial Equipment	• Motor & generator parts; • High pressured pumps; • Drilling, cutting, moving, transporting equipment • Welding robots
	Scientific & Measurement Instruments	• Gauges, • Fixing devices for temperature measurement, chemical analysis etc, with special features, eg, cooling. • Microscopes accessories • Thermometers
	Tooling and guides	• Assembly Jigs • Drills And Cutting Guides • Other Templates • Indexable Inserts (Cutting Tools) • Pressing Dies & Punches • Fixtures
	Integrated Electronics	• Sensors integrated in 3D printed parts
	Industrial AM Equipment	• Hybrid AM machines • Grippers • mixers (mixing chemicals) • High deposition rate systems for 2x2x2meter components.
	Industrial AM Software	• Solutions to enable sintering processes also for prototyping • Topology optimisation with capability to create shell structures/sandwich structures

	PRODUCT GROUP	PRODUCTS
		• Solutions for designing customised parts; for hybrid manufacturing, graded materials; designed engineering metals (ultra high cooling rates…) • 3D Printing of smart materials
	Spare Parts & Repair	• Parts to replace broken parts in existing industrial equipment. Audio components
	High Performance Tool Materials	• AM Hard Materials for Tooling (powders & granules): Hardmetals/cemented carbides; tool steels/metal matrix composites; engineering ceramics; enabling technologies • Materials specialised in high wear

4.5.2. *Regional Capabilities*

AM is also used extensively in the crafting of industrial equipment and tools, and is subsequently a dominant sector for 13 of the regions, including for Asturias, Castilla y León, Catalonia, Emilia-Romagna, Flanders, Occitanie, Basque Country, Rhone-Alpes, Noord-Brabant, Tampere, Thüringen, Basque Country and Norte.

In Noord-Brabant the sector is supported by the availability of industrial machine builders, while in Emilia-Romagna all relevant companies are equipped with AM machinery for prototyping, which has led to the region placing a growing focus on applying AM in the tooling and spare part business. In Rhone-Alpes 40 of the key actors identified specified that they work with AM within the industrial equipment and tooling sector. Furthermore, eight of the actors are focused only on industrial equipment and tooling.

In the Vanguard Initiative[42], the 3DP demo case *"Machinery, Tooling and Complex Shapes"* is a European network of experience, competences and resources covering all aspects of AM, from redesign to pre-production, supporting with tangible facts the technical and economical validation on real life applications**.** The platform is focused on mature AM technologies implementation. The lead region is Wallonia [BE], with participant regions such as Lombardy [IT] , Aragon and Catalonia [ES], Norte [PT] , Tampere [FI], Rhone-Alpes [FR], Trentino [IT]; South Netherlands [NL].

Another Vanguard 3DP demo case relevant for the analysed sector is the one entitled "Additive-Subtractive platform", which aims at integrating additive & subtractive technology production flows to enable a quick, professional analysis of several production process set-ups by the participating companies. The objective is to develop a digitally connected network of pilot lines / production hubs able to produce in a cost effective way one piece or small product series with an extreme high precision, high finish and added value, combining additive and subtractive technologies. The lead region South-Netherlands [NL], with participant regions such as Baden-Württemberg [DE], Emilia-Romagna [IT], Flanders [BE], Lombardy [IT], Trentino [IT] and Saxony [DE].

Here below (Figure 4.17) is reported a map showing the national and regional activity (based on number of projects) in the Industrial Equipment and Tooling sector.

[42] https://s3vanguardinitiative.eu/cooperations/high-performance-production-through-3d-printing; https://www.s3vanguardinitiative.eu/sites/default/files/docs/general/vanguard_initiative_flyer_3dp_0_002_0.pdf

The sector has the overall highest number of projects in the list, accounting for the 25% of the total, reflecting the fact that the industry is the largest AM sector.

Portugal, UK , Germany and France are the countries with higher number of projects related to the industrial equipment and tooling sector. In particular, most of the projects from Portugal focus on moulds and hybrid technologies, while in UK projects are more concentrated on solutions (both from the point of view of HW and SW) for improving the surface finishing of AM components. Hybrid technologies are also the focus of different project from Germany, together with the development of wire-based technologies for 3D printing of metal. In France a number of projects focus on development of software solutions and moulds.

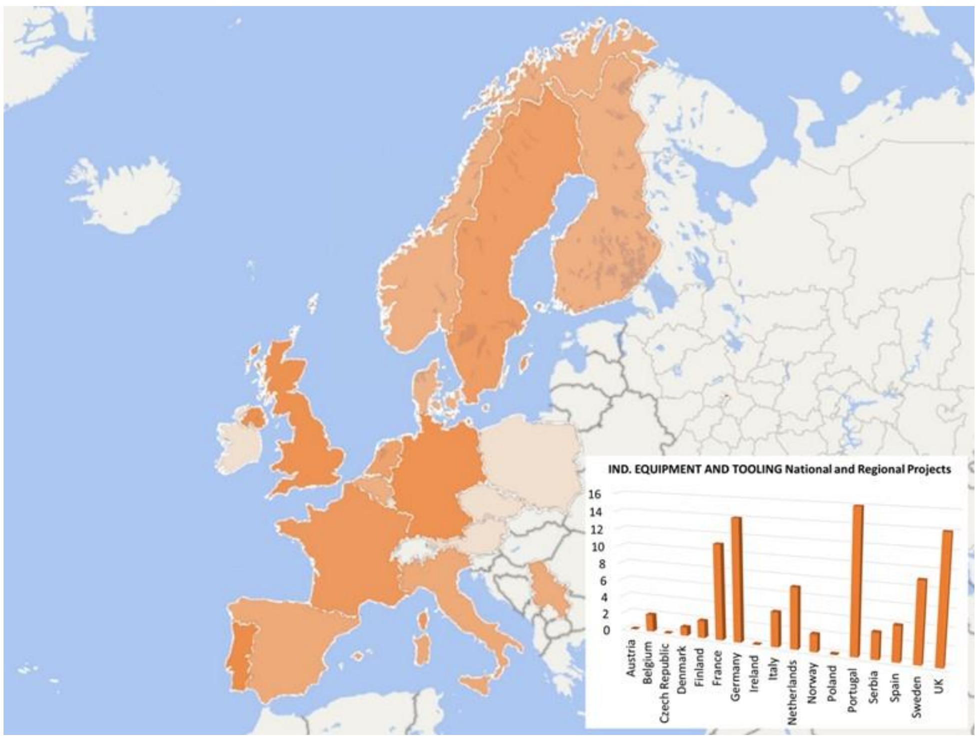

Figure 4.17: *IND. EQUIPMENT AND TOOLING - Map of National and Regional Projects*

The complete list of national and regional projects divided by country can be found in ANNEX B.

4.6. Construction

Additive manufacturing is gaining ground in the construction industry, manly owing to the potential to improve on current construction methods. The construction industry has been recognized as one industry that consumes considerable amount of resources and poses significant environmental stresses. Over the past few decades, studies on construction innovations have been conducted to address the productivity, environmental, and other issues in terms of two forms. One form of construction innovations is a response to external needs (e.g. the clients' needs) and the other form of construction innovations originates from other industries. However, the main emphasis for innovation strategy in the construction industry is to use technology from elsewhere to reinforce other competitive advantages[43].

Freedom of forms, unconventional buildings, curves, innovative designs and personalized creations are some of the features that AM can bring to this sector. In construction virtually every wall, floor, panel, partition, structure and facade is unique in dimension, which means either standard sized materials are cut down to fit, or bespoke moulds are created to form each component. In the latter case economies of scale drive the need to design multiple copies of identical elements on a project. There is a clear cost-based opportunity to save time and materials by reducing waste and the need for formwork/mould making. There is also significant potential to reduce the quantity of materials used through optimisation of form and the implementation of additional 'engineering function' within components. The computational design environment promises the freedom to design around individuals and the environment. Furthermore, AM may remove the need for replication of components, giving designers freedom to make each part unique[44].

A complicating factor for application of 3D-printing in the construction area is that the requirements in this sector are tough with respect to e.g. durability (typical required life span 50 years), safety and strength (compressive stress) while some parts of the building are exposed to outside weather conditions and heavy loads. Another issue is the sizes of buildings. These are often in the range of tenths of meters which is enormous compared with the building area of most traditional 3D-printers that have working areas in the range of e.g. 300 mm. This means that the volume of workpiece material used in buildings can be in the order of 1 million higher compared to 'traditional' parts produced by AM. Developments concerning these issues are already taken place.

Experimental applications of AM in the construction industry started appearing in the late 1990's[45]. These initial proof-of- concept applications helped identify potential benefits and challenges for AM technologies in construction. Currently there are three large-scale AM processes targeted at construction and architecture in the public domain, namely: Contour Crafting[46], D-Shape[47] and Concrete Printing[48]. All three have proven the successful manufacture of components of significant size and are suitable for construction and/or architectural applications.

The integration of AM technologies in the construction sector has the main advantages:

- Manufacturing of new structures, complex shapes, integrated channels with flexibility and adaptability:
- To build more accurately and with a better final appearance
- Pollution reduction and consumption of natural goods.
- Decreasing energy consumption and waste products obtained while manufacturing.
- Decreasing of the manufacturing and production time, with a manufacturing processes automation, obtaining by this way functional structures faster with a lower cost.

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[43] Wu, P., Wang, J. & Wang, X. Automation in Construction, *A critical review of the use of 3-D printing in the construction industry,* Autom. Constr. (2016)
[44] Lim, S. *et al.* Developments in construction-scale additive manufacturing processes. *Autom. Constr.* **21,** 262–268 (2012).
[45] Pegna, J. Exploratory investigation of solid freeform construction.**,** 427–437 (1997).
[46] B. Khoshnevis, D. Hwang, K. Yao, Z. Yeh, Mega-scale fabrication by contour crafting, International journal of Industrial and System Engineering Vol 1 (no. 3) (2006) 301–320
[47] D-Shape Technology. Available at: http://d-shape.com/what-is-it/.
[48] Freek Bos, Rob Wolfs, Zeeshan Ahmed & Theo Salet (2016) Additive manufacturing of concrete in construction: potentials and challenges of 3D concrete printing, Virtual and Physical Prototyping, 11:3, 209-225. https://doi.org/10.1080/17452759.2016.1209867

- Decreasing of labourer's accident hazards due the increase of automation.
- Total process control while manufacturing layer by layer any structure. Can be checked at every second all variables of the constructive process.

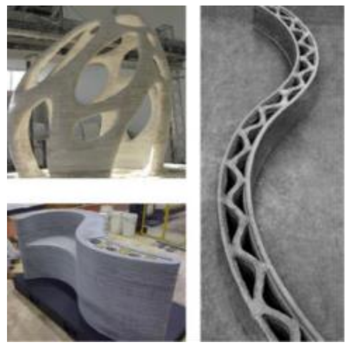

Figure 4.18: *Examples of full scale builds from each process: D-Shape, top left; Contour Crafting, right; Concrete Printing, bottom left*

4.6.1. *Target Products*

In the Construction sector there are a number of **key innovative AM products.** As shown in Figure 4.19, five main product groups where identified. The detailed list of products for each group is reported in Table 4.6

Figure 4.19: *Construction Key Product Groups*

Table 4.6. CONSTRUCTION - Detailed list of key innovative products

	PRODUCT GROUP	PRODUCTS
	Unconventional buildings (prototypes, decorative façades, art, design, heritage reconstruction)	• Mock ups and 1:1 proto types • Sewage water treatment component • Ergonomics and customizations in unconventional buildings • Restauration, local substitute elements combine with scanning • Restauration historical building details • Integrated facades / insulation

	PRODUCT GROUP	PRODUCTS
	Structural parts like bridges, floors, walls	• Precise precast with no moulds • Nodes (steel) for steel frame works build on site • Bespoke plastic fittings • Reinforced "concrete" structures (potentially build on site) • Structural component for freeform building • Reinforced / locally reinforced structures • Complex joints (hinges) • Combined load bearing, piping, acoustics, insulation, aesthetics and other function integration
	Low risk parts with complex shapes e.g. for garden and landscape decoration	• Low risk parts for e.g. garden decoration, landscape, art • Special elements to close gaps
	Special buildings (army, nuclear disaster, army buildings, lunar base)	• Temporary emergency building (after disaster) • Quick solutions in case of emergencies (cracks / broken pipes / etc.) • Customized components optimised for temporary needs
	Organic shaped complex (structural) parts with integrated functions	• Light weighting topological optimised organically esthetical shaped structural free form elements • Topologically optimized structures • Indoor partitions (walls, flexible rooms, indoor enclosures, etc.) with integrated functionalities for temporary functions • Panels with integrated functions (thermal insulation, acoustic insulation, lighting, daylight, etc.) • Kinematic structures out of flexible and stiff materials • Special solar elements

4.6.2. *Regional Capabilities*

In the process of emerging, the market of 3D-Printed houses and buildings is facing key technical challenges. AM appears, in fact, to play a less dominant role in the construction sector. As a result, less than half of the regions work actively with AM technology in their construction sector, including Asturias, Castilla y León, Catalonia, Occitanie, Thüringen, Basque Country and Norte.

Here below (Figure 4.20) is reported a map showing the national and regional activity (based on number of projects) in the Construction sector.

As demonstrated by the chart, the sector has the lowest number of listed projects. Furthermore, the focus of the projects is more general and tackle overall processes and new materials development (wood, concrete, composites, etc…).

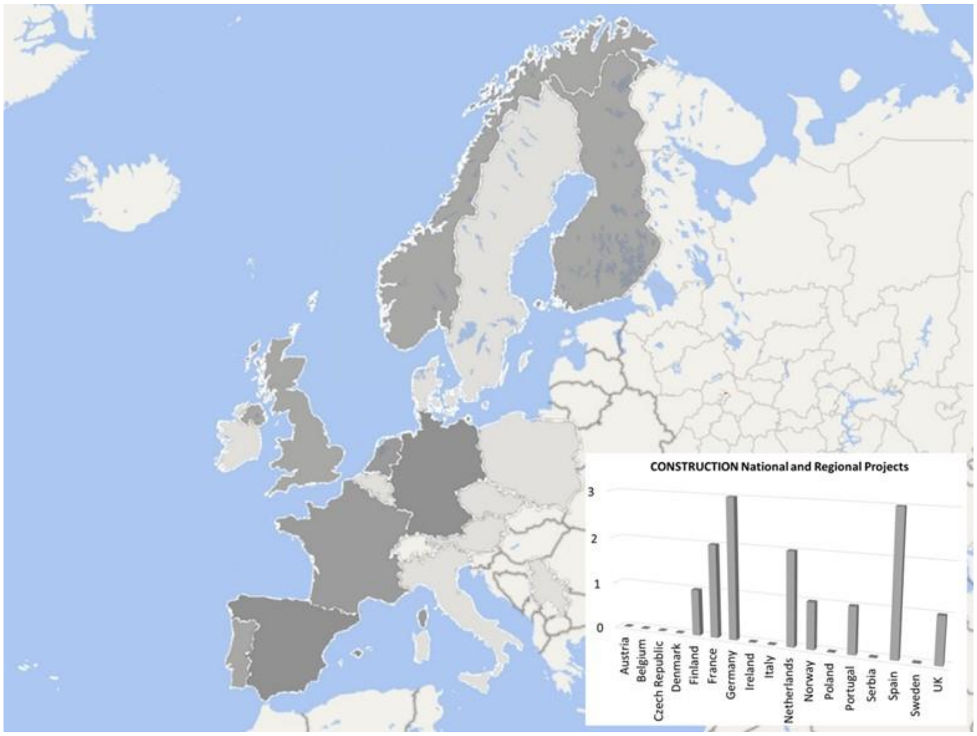

Figure 4.20: *CONSTRUCTION - Map of National and Regional Projects*

The complete list of national and regional projects divided by country can be found in ANNEX B.

4.7. Energy

Energy consumption is still growing worldwide and projected to increase further. Two thirds of the worldwide energy development was generated by fossil sources in 2010. The global turbine market was valued at USD 135.68 billion in 2013 and is expected to reach USD 191.87 billion by 2020 at a CAGR of 4.89% from 2014 to 2020[49]. The Energy branch is focused on production of energy and its transport and distribution. The topic of energy storage is also being covered and seems to be substantial for further development of the renewable energy system.

There are a number of key drivers for the energy sector for the adoption and development of AM and hence potential areas of impact. These include:

- Energy usage (improved fuel efficiency)
- Reductions of emissions
- Complex parts
- Life cycle cost
- High performance materials
- New opportunities for product development process e.g. validation in full scale tur-bine tests
- Improvement of MRO (Maintenance, Repair and Overhaul)
- Production costs

[49] http://www.transparencymarketresearch.com/turbines-market.html

- AM process efficiency

Reliable, efficient and clean fossil power systems needs innovative technologies. By using innovative fossil power systems, scarce resources can be exploited with maximum efficiency and fossil power generation as environmentally friendly as possible. The development of AM processes in recent years offers the opportunity to produce complex parts by AM with a high accuracy and improved material properties for the use in power turbines[50].

With the AM technology the repair and production of parts for industrial gas turbines can be faster and with full freedom of design possibilities. Within the last years, AM has emerged and is revolutionizing the manufacturing of components. This technology allows design improvement and rapid manufacturing of components, thus enabling quick upgrading of existing assets to the latest part design.

There is great potential for AM to create value by reducing greenhouse gas emissions, use less resources in the production process, reducing the development time, offering flexibility for design of parts, faster repairs, reduction of lead time and using new fuel mixes. Recently, a key development was achieved with the production of additively manufactured turbine blades with a conventional design at full engine conditions[51], standing extreme temperatures.

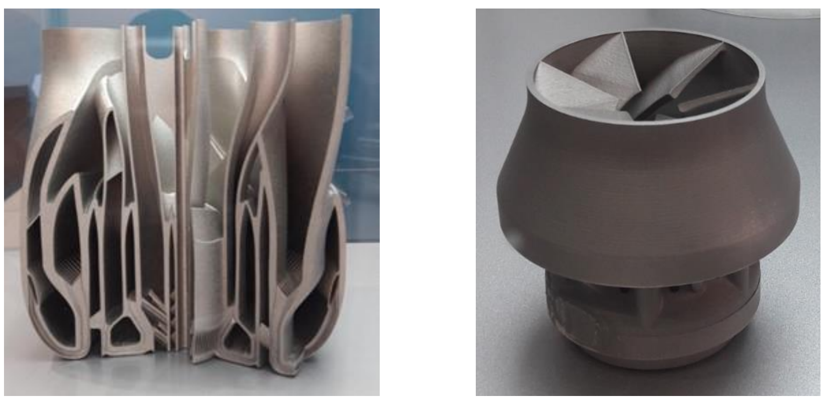

Figure 4.21: *A new SLM manufactured burner front consists of one component and two welds. (Source: Siemens; «Gas Tur-bine World) and 3D printed Swirler (Source: Siemens)*

While the nuclear sector is also developing Additive Manufacturing knowledge and applications[52], it is believed that the Oil and Gas Industry will be the next big adopter of AM technologies to become more efficient in the current low oil price era. Companies are actively exploring the use cases for both rapid prototyping as well as field production of parts The possibility of printing metal components and increasing opportunities for large print volumes is one of the key drivers[53].

The freedom to design specific types of valves in shapes was never possible with traditional molding techniques. For instance, intricate shapes, hollow structures, and woven meshes are able to be realized in designs. Additionally manufacturing time can be aved.

AM technologies are also gaining interest in the renewable energy sector and in particular in wind energy. Major players in the wind industry are currently investigating how AM can contribute to the

[50] http://www.energy.siemens.com/us/en/fossil-power-generation/
[51] https://3dprint.com/164121/siemens-gas-turbine-blades/
[52] https://energy.gov/sites/prod/files/2016/05/f31/2016%20ADVANCED%20METHODS%20FOR%20MANUFACTURING.pdf
[53] https://www.smartechpublishing.com/reports/additive-manufacturing-opportunities-in-oil-gas-markets-2016-a-ten-year-for

development and manufacturing of wind turbine components. [54]. Similarly, the relatively new sector of ocean energy could benefit in the future of progress in AM technologies.

Lux Research developed a methodology to score use cases for this industry based on the value generated by printing them and their suitability for being printed. The analysis identified use cases such as pipeline pigs and sand control screens as forthcoming and liner hanger spikes and drill bits as high-potential applications. Profitable use cases included 3D printing chemical injection stick tools and nozzles for downhole cleanout tools[55].

4.7.1. *Target Products*

In the Energy sector there are a number of **key innovative AM products.** As shown in Figure 4.22, eight main product groups where identified. The detailed list of products for each group is reported in Table 4.7

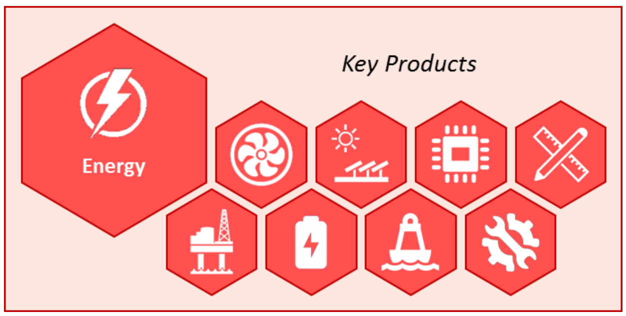

Figure 4.22: *Energy Key Product Groups*

Table 4.7: ENERGY - *Detailed list of key innovative products*

	PRODUCT GROUP	PRODUCTS
	Turbines parts	• Static Vanes • Turbine Blades (rotating) • Nozzles • Burners • Swirls
	Oil and gas industry products	• Chemical Injection Stick Tools • Nozzles For Downhole Cleanout Tools • Valves • Connectors • Interface parts (T-connections) • Push button • Propellers, Impellers and pumps components • Filters • Heat Exchangers • Flow control parts (including Subsea Xmas tree, valves, seals) • Subsea processing equipment

[54] http://www.windpowermonthly.com/article/1421837/additive-manufacturing-will-gamechanger#box
[55] http://www.luxresearchinc.com/content/assessing-opportunity-additive-manufacturing-oil-and-gas-industry

	PRODUCT GROUP	PRODUCTS
	Renewable Energy industry components	• Solar Cells (including films and flexible PV) • Solar thermal Plant towers (including Mirrors Frames) • Windmill towers • Wind Turbine Blades
	Energy storage	• Batteries (including microbatteries) • Fuel cells • Geothermal piping
	Electromechanical and 3D electronic components	• Sensor system for temp; • Visual analysing; • Smart Control Devices
	Floating Platforms components	• Anchors • Connections • Mooring • Floats
	Concept modelling, prototyping and design	• Heat exchanger injection function integration
	Spare parts & repair	• Repair of complex or obsolete parts • Burner repair • Swirler repair • Turbine blades, vanes • Processing equipment • Fin seals

4.7.2. *Regional Capabilities*

European capabilities in the area of Additive Manufacturing for Energy are currently scattered, and as for the construction sector, only a few of the regions categorise the energy sector as dominant for AM application. Almost the same list of regions indicate that they apply AM in the energy sector, including Asturias, Castilla y León, Catalonia, Occitanie, Thüringen, Basque Country and finally, joined by Rhone-Alpes.

Here below (Figure 4.23) is reported a map showing the national and regional activity (based on number of projects) in the Energy sector, where Germany is the most active country in terms of projects related to the Energy Sector.

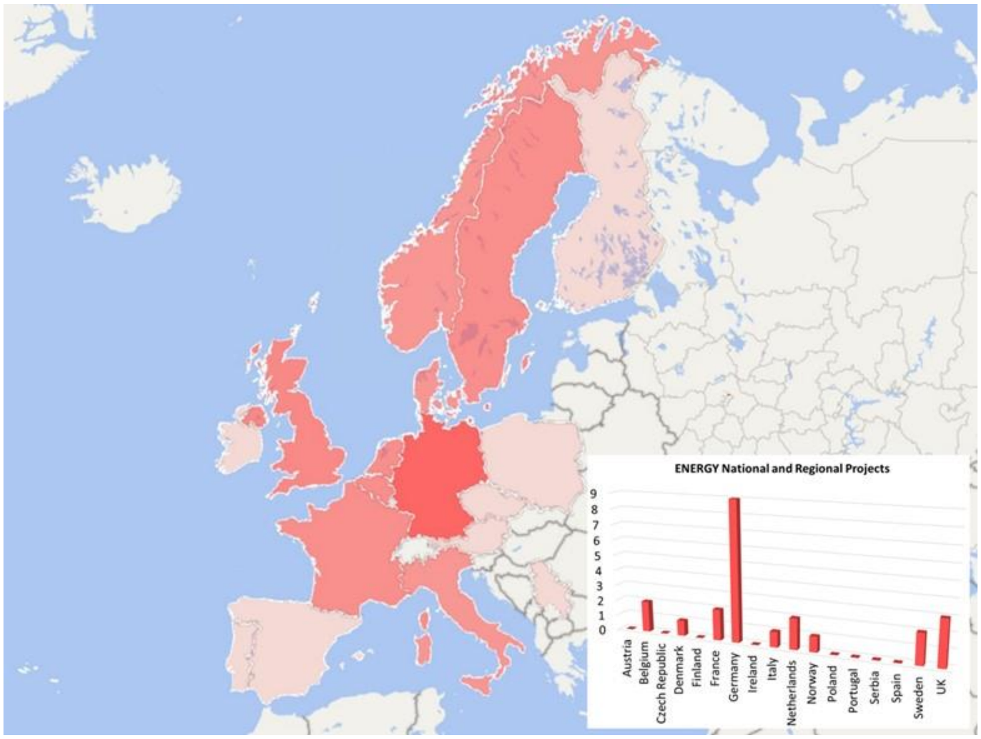

Figure 4.23: *ENERGY - Map of National and Regional Projects*

The complete list of national and regional projects divided by country can be found in ANNEX B.

5. AM-MOTION identified actions

The present chapter provides AM-MOTION roadmaps on identified actions to foster AM development and market uptake. Such actions are divided into cross-cutting technological and non technological ones, and actions segmented by sector.

For each identified actions, the relevance for the different steps of the value chain have been emphasised in the roadmaps. The actions are segmented into short-term actions (suggested actions to be started in 2019-2021), medium term actions (2022-2024), long-term actions (2025-2028), in order to deliver by 2030 the foreseen vision.

For sectorial roadmaps, each action is linked also to specific target product groups, described in Chapter **Error! Reference source not found.**. Moreover, the type of foreseen activity has been highlighted, n line with H2020 topics: research and innovation actions (RIA) are actions where the core of activities is in fact research and development with target TRL in general up to 5; innovation actions (IA) are suggested topics which are more focused on validation and demonstration activities, with target TRL up to 6-7. Coordination and support actions (CSA) are suggested topics result in enhanced coordination of research initiatives and findings rather than in research outputs.

Details of each action in terms of identified gap with the description of the current context, description of proposed activities, initial and target TRL, foreseen impact in terms of key performance indicators are reported in annex D.

5.1. CROSS-CUTTING TECHNOLOGICAL actions

A number of technical actions to solve cross-sectorial challenges were identified as reported in the roadmaps shown in Figure 5.1 and in Figure 5.2, focusing on short term and on medium to long term, respectively. Such actions include also standardisation and certification-related topics.

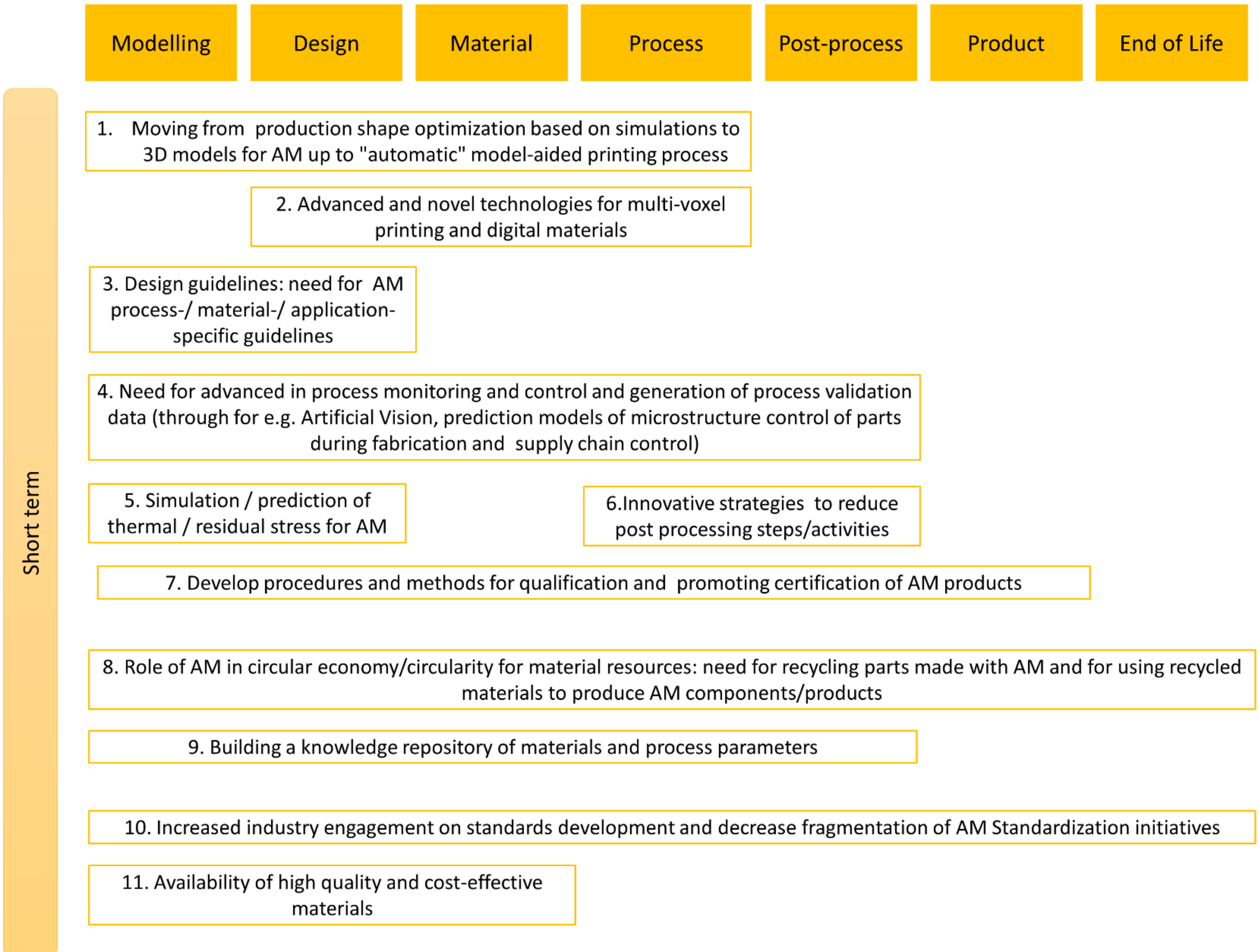

Figure 5.1 *AM-MOTION Roadmap on cross-cutting technical actions (short-term focus)*

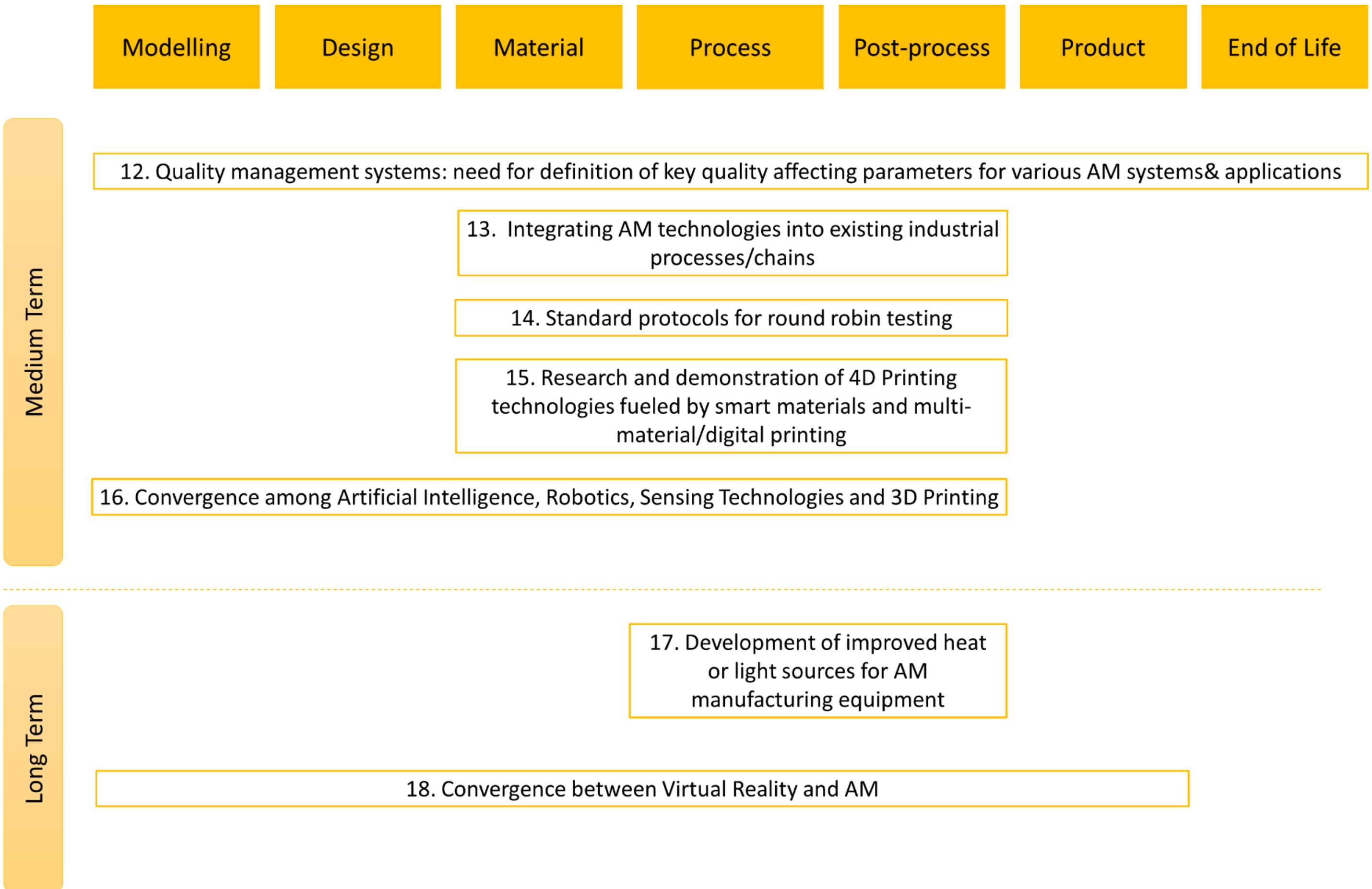

Figure 5.2: *AM-MOTION Roadmap on cross-cutting technical actions (medium and long-term focus)*

5.3. CROSS-CUTTING NON-TECHNOLOGICAL actions

A number of cross-cutting non-technical actions were identified as reported in the roadmap shown in Figure 5.3. Such actions cover different topics such safety, communication, education and training, business models, IPR and financing issues.

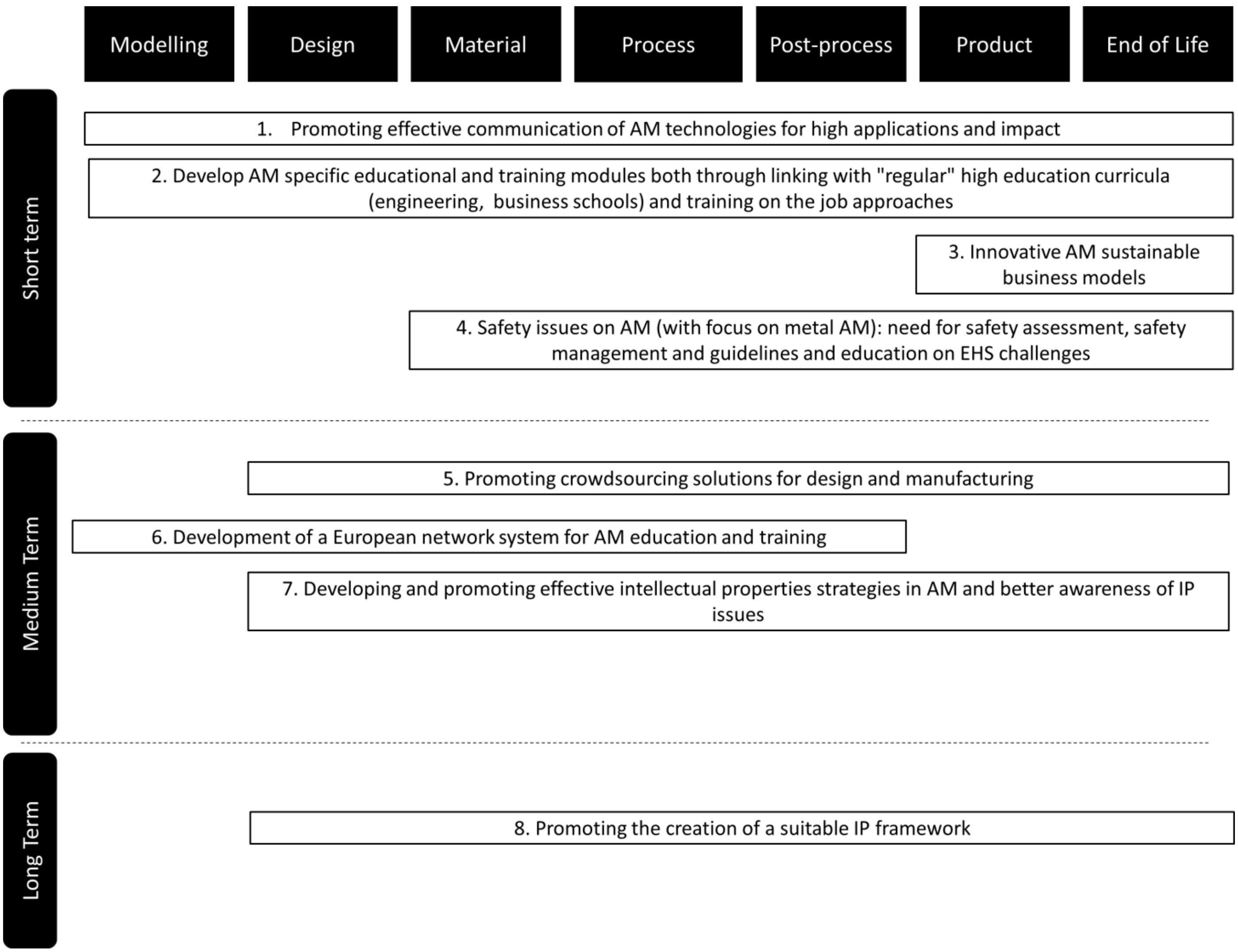

Figure 5.3: *AM-MOTION Roadmap on cross-cutting non-technical actions*

5.4. HEALTH gaps and actions

Health-specific actions were identified as reported in the roadmap shown in Figure 5.4. Key actions details (type of activity, initial and target TRL, related target product groups) are reported in Table 5-1. The roadmap reports only the key target products linked to each specific action, whilst the table list all the relevant target products.

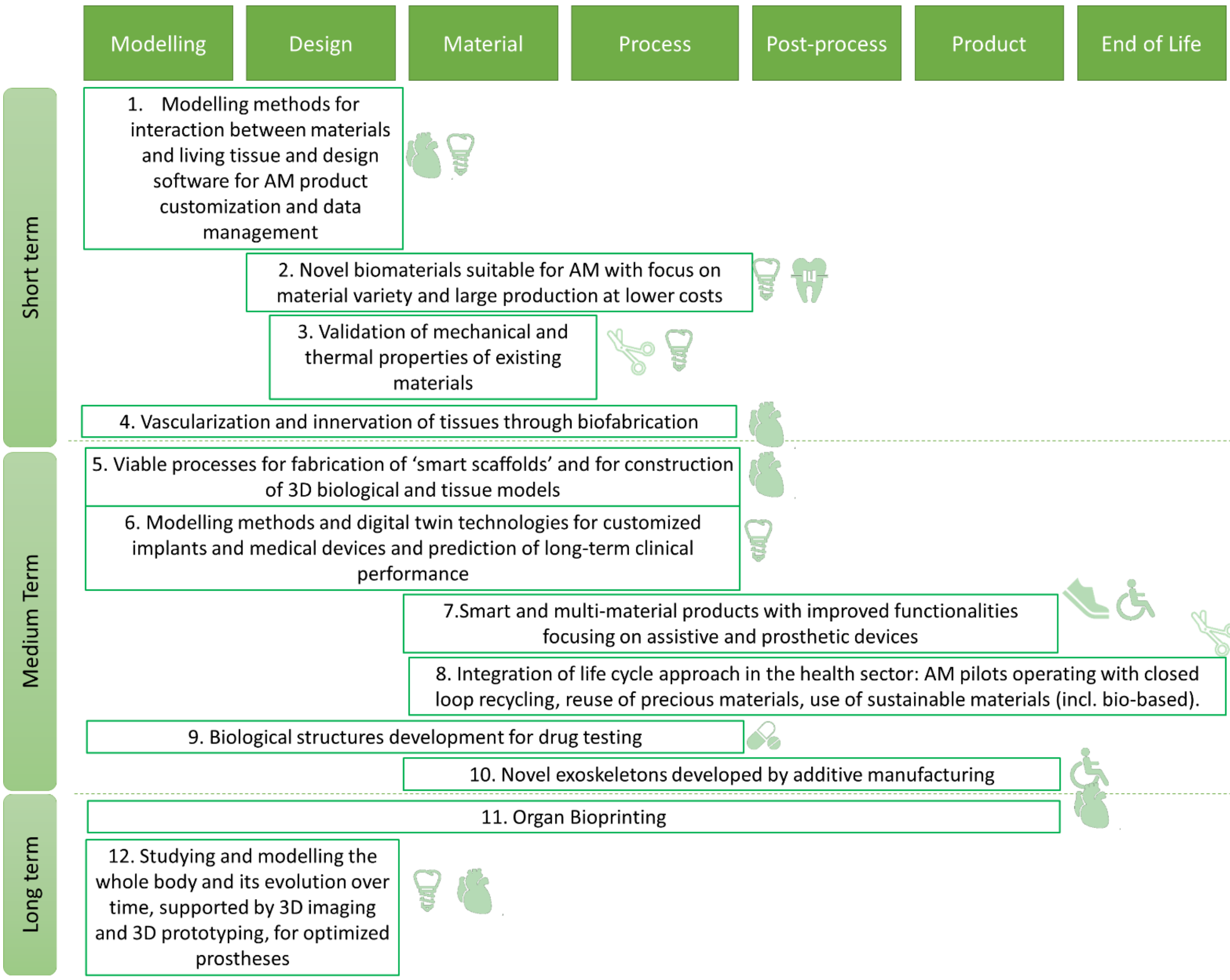

Figure 5.4 *AM-MOTION Health Roadmap*

Table 5-1 *AM-MOTION Health actions details*

N.	Action name	Type of Activity	TRL		Target Products							
			Initial TRL	Target TRL	Assistive and prostetic devices	Surgical guides, tools and models	Medical implants	Other dental products	Other customised products	Living tissues and organs	Pharmaceutical products	Food
1	Modelling methods for interaction between materials and living tissue and design software for AM product customization and data management	RIA	3-4	5-6			X			X		
2	Novel biomaterials suitable for AM with focus on material variety and large production at lower costs	IA	4-5	6-7		X	X	X	X	X		X
3	Validation of mechanical and thermal properties of existing materials	IA	5-6	7-8	X	X	X	X		X		
4	Vascularization and innervation of tissues through biofabrication	RIA	1-2	3-4						X	X	
5	Viable processes for fabrication of ‘smart scaffolds’ and for construction of 3D biological and tissue models	IA	2-3	4-5						X	X	
6	Modelling methods and digital twin technologies for customised implants and medical devices and prediction of long-term clinical performance	RIA	3-4	5-6		X	X			X	X	
7	Smart and multi-material products with improved functionalities focusing on assistive and prosthetic devices	RIA	2-3	4-5	X	X	X	X		X		
8	Integration of life cycle approach in the health sector: AM pilots operating with closed loop recycling, reuse of precious materials, use of sustainable materials (including bio-based ones).	RIA	2-3	4-5	X	X	X	X				X
9	Biological structures development for drug testing	RIA	2-3	4-5						X	X	
10	Novel exoskeletons developed by additive manufacturing	RIA	2-3	4-5	X							
11	Organ Bioprinting	RIA	2-3	4-5						X		
12	Studying and modelling the whole body and its evolution over time, supported by 3D imaging and 3D prototyping, for optimized prostheses	RIA	1-3	2-4			X			X	X	

5.5. AEROSPACE gaps and actions

Aerospace-specific actions were identified as reported in the roadmap shown in Figure 5.4 ***AM-MOTION Health Roadmap***Figure 5.5 . Key actions details (type of activity, initial and target TRL, related target product groups) are reported in Table 5-2.

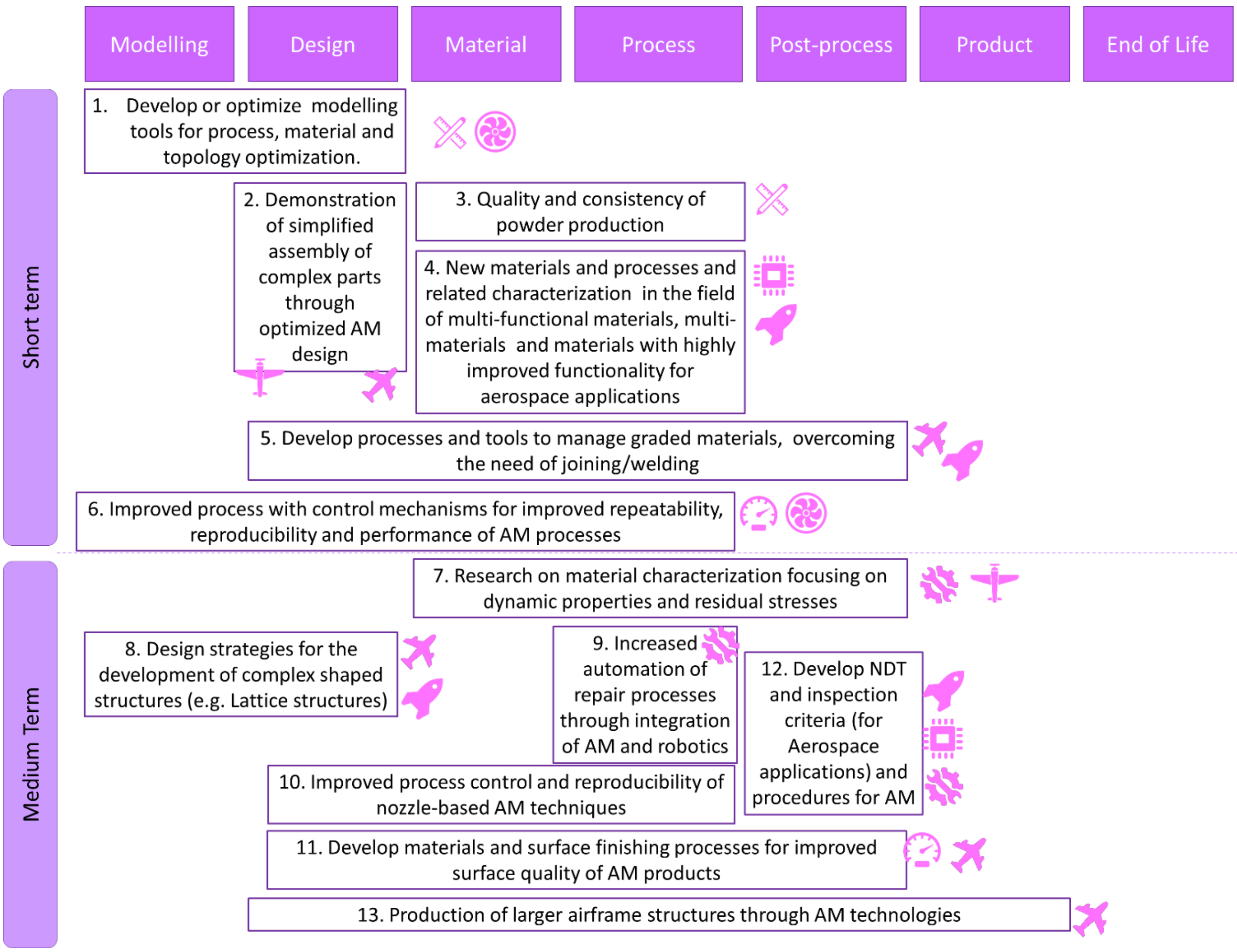

Figure 5.5: *AM-MOTION Aerospace Roadmap*

Table 5-2: *AM-MOTION Aerospace actions details*

N.	Action Name	Type of Action	TRL		Target Products								
			Initial TRL	Target TRL	Turbine Parts / Engine	Small aircraft wings and fuselage and their components	Cabin & Cockpit parts	Other complex parts	Components of large aircraft wings and fuselage	Spare parts & repair	Concept modelling, prototyping and advanced moulds	Niche, low volume parts	Embedded electronics
1	Develop or optimize modelling tools for process, material and topology optimization.	RIA/CSA	5-6	7	X	X		X	X	X	X	X	X
2	Demonstration of simplified assembly of complex parts through optimzed AM design	IA	6	7	X			X	X	X	X	X	X
3	Quality and consistency of powder production	IA	6	7	X	X		X	X	X	X	X	X
4	New materials and processes and related characterisation in the field of multi-functional materials, multi-materials and materials with highly improved functionality for aerospace applications	IA	4-6	7	X	X	X	X	X	X		X	X
5	Develop processes and tools to manage graded materials, overcoming the need of joining/welding	RIA	2-3	5	X	X		X	X	X		X	
6	Improved process with control mechanisms for improved repeatability, reproducibility and performance of AM processes	IA	4-6	7	X	X	X	X	X	X	X	X	X
7	Research on material characterization focusing on dynamic properties and residual stresses	RIA	4-5	6	X	X	X	X	X		X		
8	Design strategies for the development of complex shaped structures (e.g. Lattice structures)	IA	5-6	7	X	X		X	X		X		
9	Increased automation of repair processes through integration of AM and robotics	IA	5-6	7				X		X		X	X
10	Improved process control and reproducibility of nozzle-based AM techniques	RIA	4-5	6	X	X	X	X	X	X	X	X	X
11	Develop materials and surface finishing processes for improved surface quality of AM products	IA	6	7	X	X	X	X	X	X		X	
12	Develop NDT and inspection criteria (for Aerospace applications) and procedures for AM	CSA/IA	6	7	X	X	X	X	X	X			X
13	Production of larger airframe structures through AM technologies	RIA	3-4	6					X		X		

5.6. AUTOMOTIVE gaps and actions

Automotive-specific actions were identified as reported in the roadmap shown inFigure 5.6 . Key actions details (type of activity, initial and target TRL, related target product groups) are reported in Table 5-3.

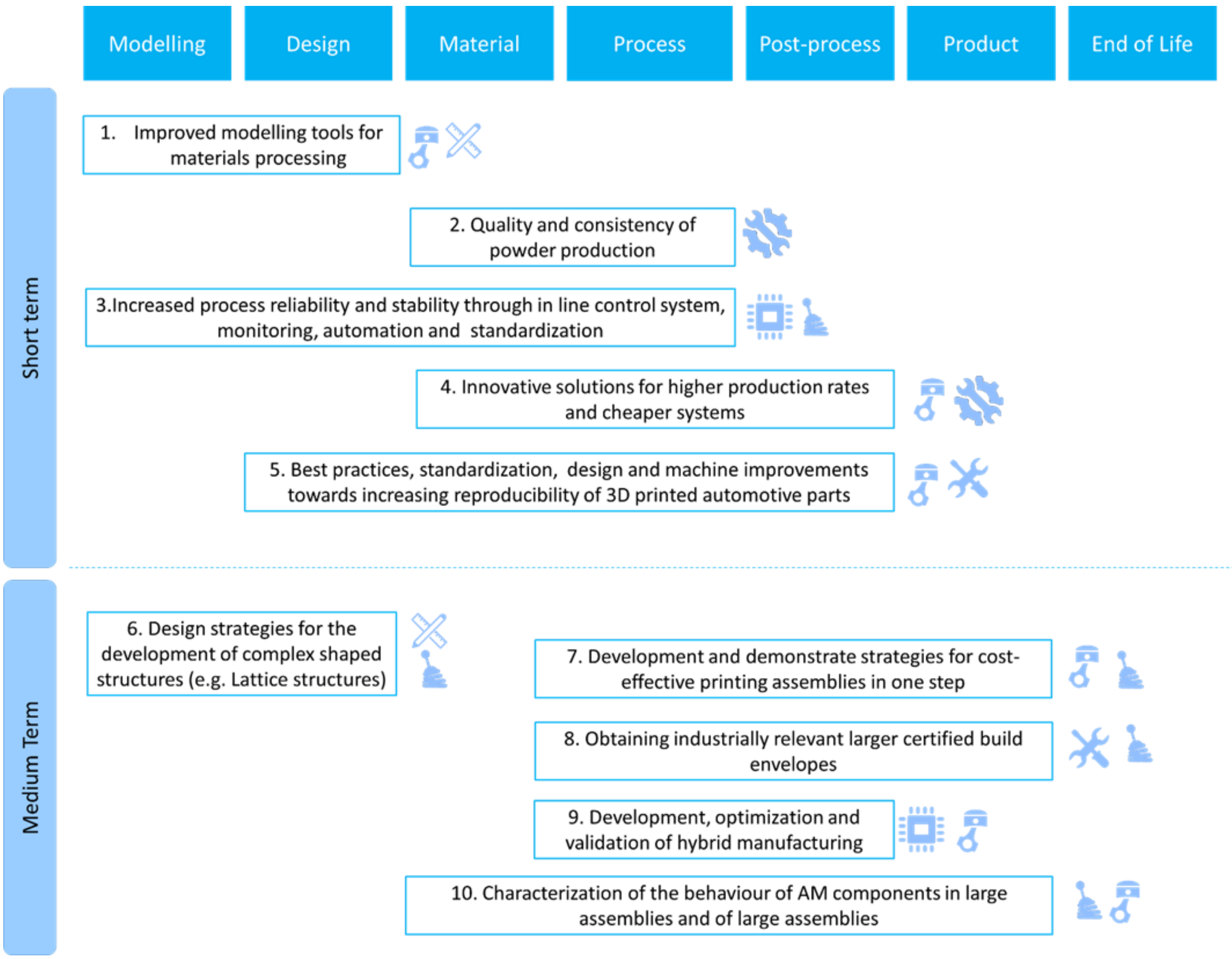

Figure 5.6: *AM-MOTION Automotive Roadmap*

Table 5-3: *AM-MOTION Automotive actions details*

N.	Action Name	Type of Activity	TRL		Target Products					
			Initial TRL	Target TRL	Engine Components	Embedded electronics	Auxiliary means of production and supports	Concept modelling, prototyping and design	Spare parts & repair	Niche, low volume parts
1	Improved modelling tools for materials processing	RIA	4-5	6	X	X	X	X	X	X
2	Quality and consistency of powder production	IA	5-6	7	X	X	X	X	X	X
3	Increased process reliability and stability through in line control system, monitoring, automation and standardization	IA	6	7	X	X	X	X	X	X
4	Innovative solutions for higher production rates and cheaper systems	IA	4-5	6	X	X	X	X	X	X
5	Best practices, standardization, design and machine improvements towards increasing reproducibility of 3D printed automotive parts	IA/CSA	6	7	X	X	X	X	X	X
6	Design strategies for the development of complex shaped structures (e.g. Lattice structures)	IA	5-6	7				X		X
7	Development and demonstrate strategies for cost-effective printing assemblies in one step	IA	6	7	X	X	X	X	X	X
8	Obtaining industrially relevant larger certified build envelopes	CSA/IA	5-6		X	X	X		X	X
9	Development, optimization and validation of hybrid manufacturing	RIA	4-5	6	X	X	X	X	X	X
10	Characterization of the behavior of AM components in large assemblies and of large assemblies	IA	5-6	7	X			X		X

5.7. CONSUMER and ELECTRONICS gaps and actions

Consumer and electronics-specific actions were identified as reported in the roadmap shown in Figure 5.7 . Key actions details (type of activity, initial and target TRL, related target product groups) are reported in Table 5-4.

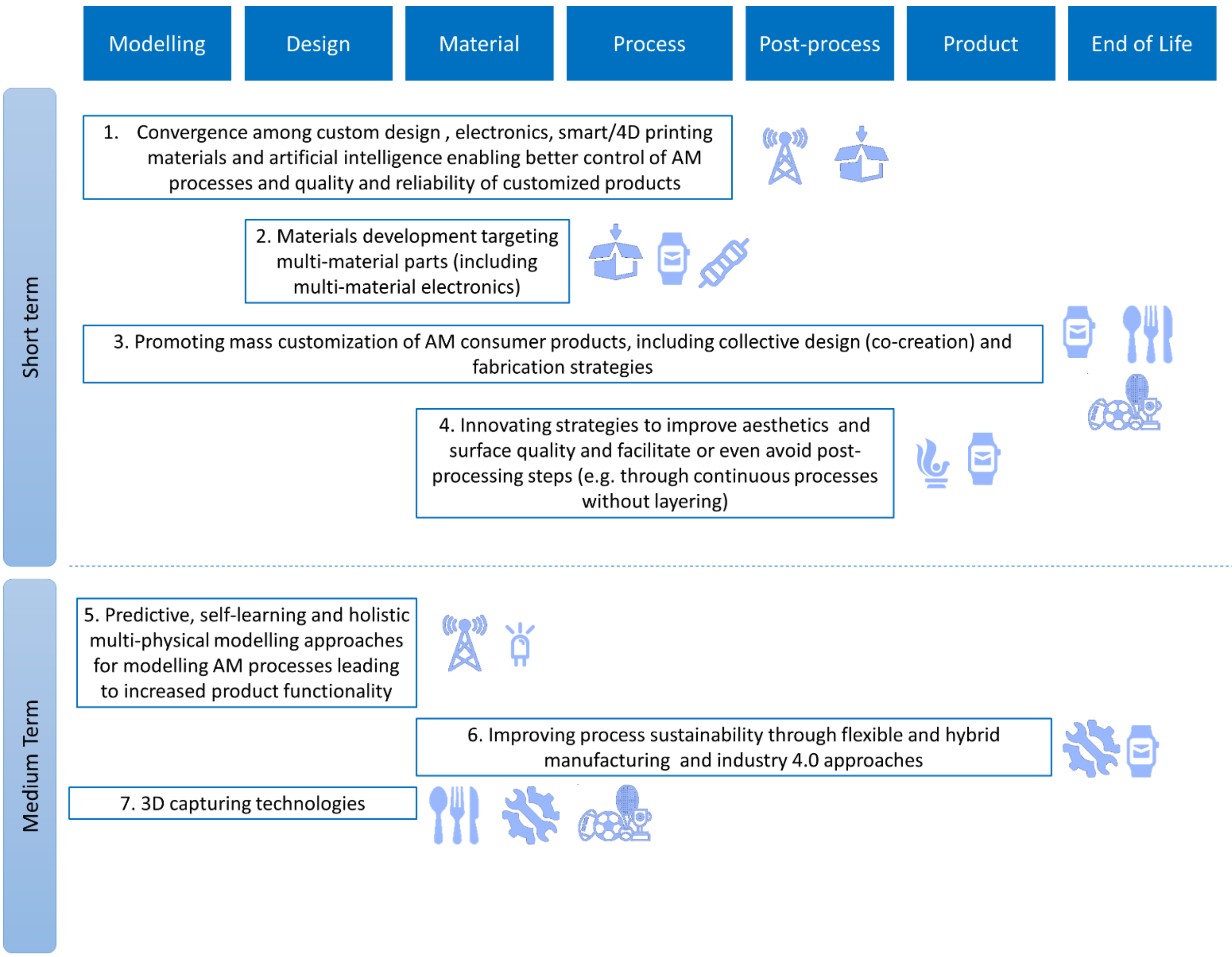

Figure 5.7: *AM-MOTION Consumer and Electronics Roadmap*

Table 5-4: *AM-MOTION Consumer and Electronics actions details*

N.	Action Name	Type of Activity	TRL		Target Products								
			Initial TRL	Target TRL	Wearebles	Sensors and Antennas	Basig electronic components	Other electronic parts	Household utensils	Entertainment	Spare parts and repair	Packaging	Art
1	Convergence among custom design , electronics, smart/4D printing materials and artificial intelligence enabling better control of AM processes and quality and reliability of customized products	RIA	4-5	6	X	X	X	X	X	X	X	X	X
2	Materials development targeting multi-material parts (including multi-material electronics)	RIA	4-5	6	X	X	X	X	X	X	X	X	X
3	Promoting mass customization of AM consumer products, including collective design (co-creation) and fabrication strategies	IA/CSA	5-6	7	X		X		X	X	X	X	X
4	Innovating strategies to improve aesthetics and surface quality and facilitate or even avoid post-processing steps (e.g. through continuous processes without layering)	IA	6	7	X	X	X	X	X	X	X	X	X
5	Predictive, self-learning and holistic multi-physical modelling approaches for modelling AM processes leading to increased product functionality	IA	5-6	7	X	X	X	X	X	X	X	X	X
6	Improving process sustainability through flexible and hybrid manufacturing and industry 4.0 approaches	RIA	4-5	6	X	X			X	X	X	X	
7	3D capturing technologies	IA	5-6	7	X	X			X	X	X	X	X

5.8. INDUSTRIAL EQUIPMENT and TOOLING gaps and actions

Industrial equipment and tooling-specific actions were identified as reported in the roadmap shown inFigure 5.8. Key actions details (type of activity, initial and target TRL, related target product groups) are reported in Table 5-5.

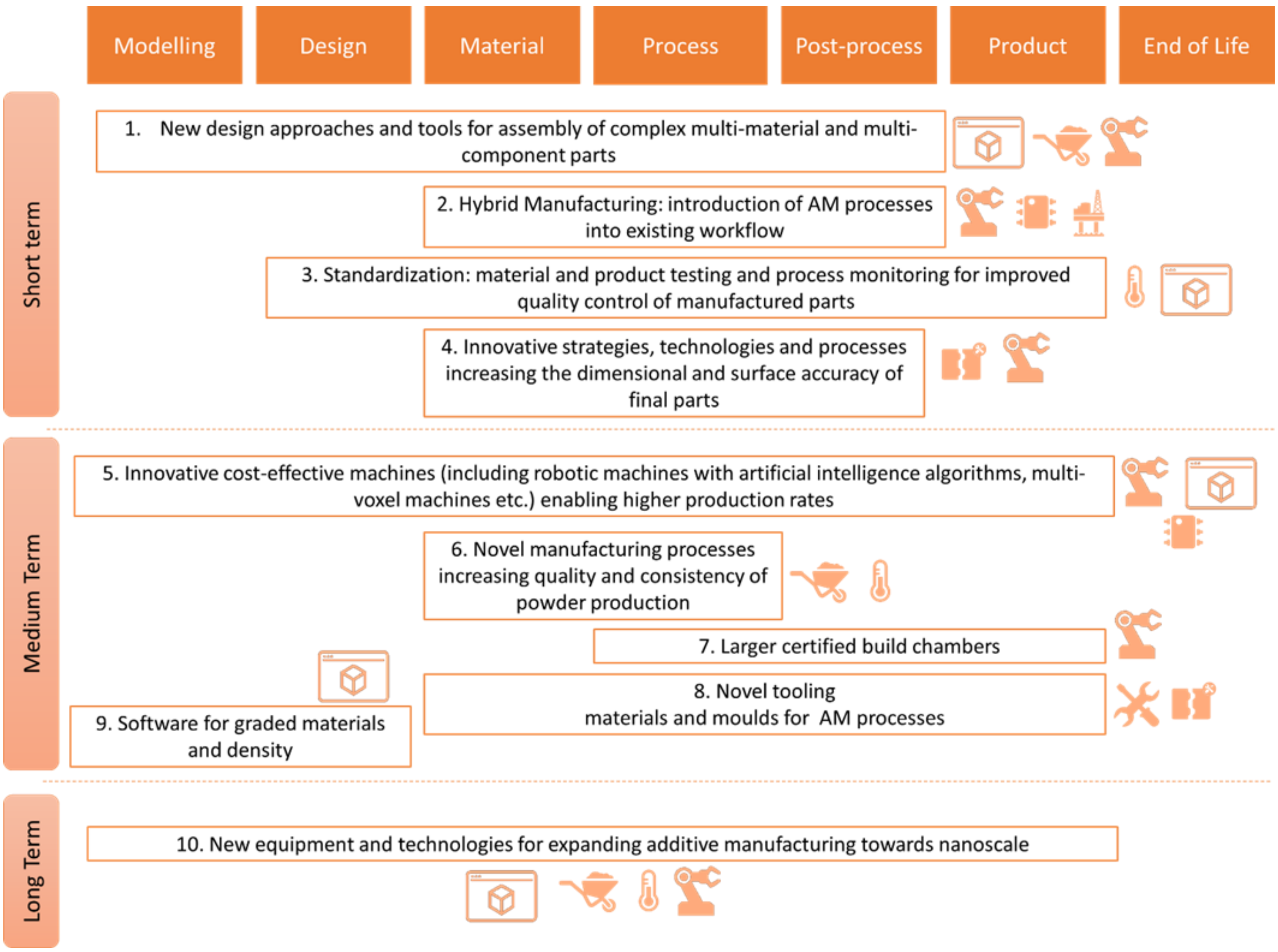

Figure 5.8: *AM-MOTION Industrial equipment and tooling Roadmap*

Table 5-5: *AM-MOTION Industrial equipment and tooling actions details*

N.	Action Name	Type of Activity	TRL		Target Products								
			Initial TRL	Target TRL	Mold inserts	Subsea/Deep Sea Industrial Equipment	Tooling and guides	Scientific & Measurement Instruments	Integrated Electronics	Spare Parts	Industrial AM equipments	High Performance Tool Materials	Industrial AM Software
1	New design approaches and tools for assembly of complex multi-material and multi-component parts	IA	5-6	7	X		X	X			X	X	X
2	Hybrid Manufacturing: introduction of AM processes into existing workflow	IA	5-6	7			X	X			X		
3	Standardisation: material and product testing and process monitoring for improved quality control of manufactured parts	IA/CSA	6	7				X			X	X	X
4	Innovative strategies, technologies and processes increasing the dimensional and surface accuracy of final parts	IA	5-6	7	X			X			X		
5	Innovative cost-effective machines (including robotic machines with artificial intelligencealgorithms, multi-voxel machines etc.) enabling higher production rates	RIA	4-5	6							X		
6	Novel manufacturing processes increasing quality and consistency of powder production	IA	6	7				X			X	X	
7	Larger certified build chambers	IA	6	7							X		
8	Novel tooling materials and moulds for AM processes	RIA	4-5	6	X		X					X	
9	Software for graded materials and density	IA	6	7								X	X
10	New equipment and technologies for expanding additive manufacturing towards nanoscale	RIA	4-5	6							X		

5.9. CONSTRUCTION gaps and actions

Construction-specific actions were identified as reported in the roadmap shown inFigure 5.9. Key actions details (type of activity, initial and target TRL, related target product groups) are reported in Table 5-6.

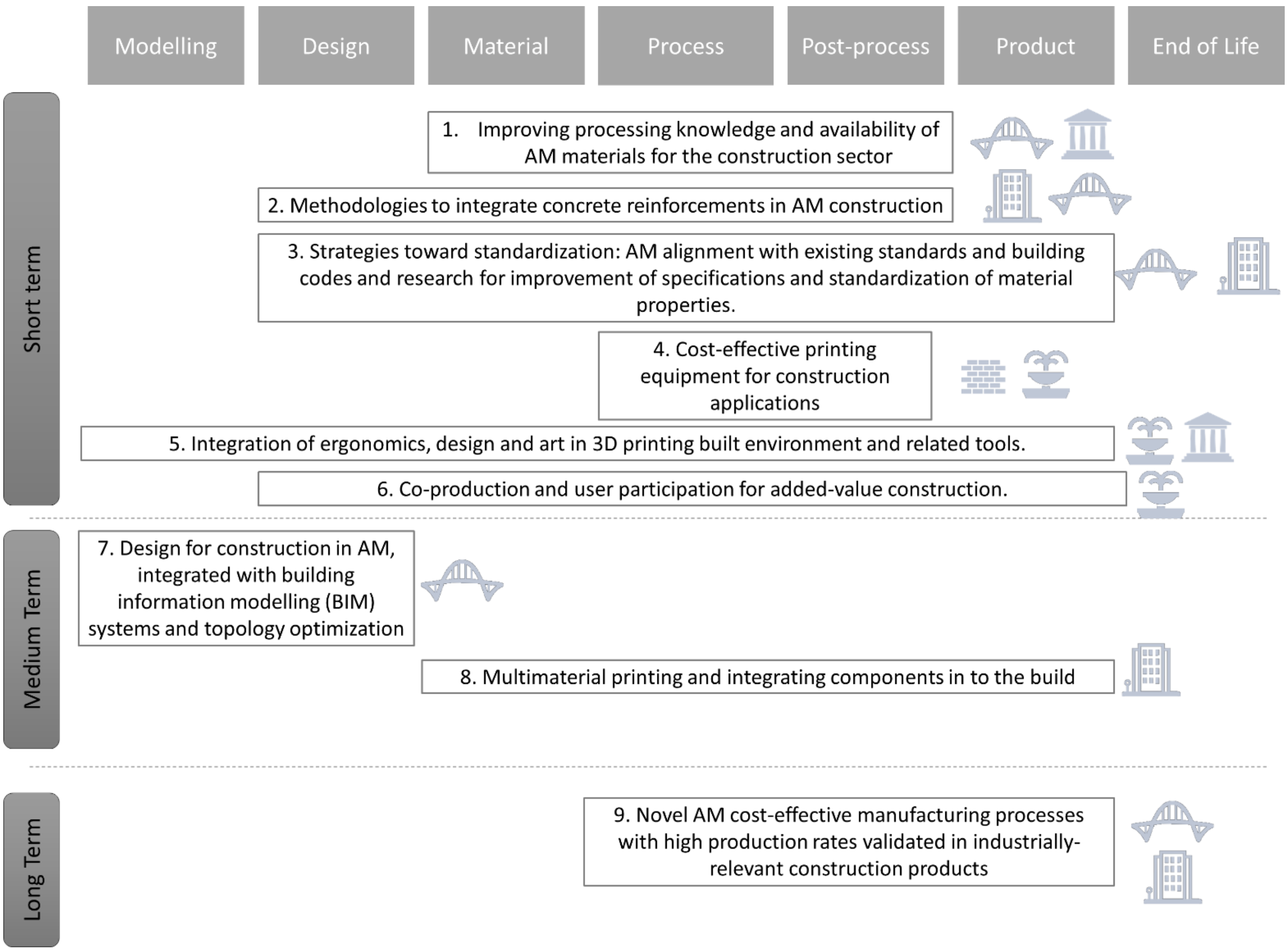

Figure 5.9: *AM-MOTION Construction Roadmap*

Table 5-6: *AM-MOTION Construction actions details*

N.	Action Name	Type of Activity	TRL		Target Products				
			Initial TRL	Target TRL	Low risk parts with complex shapes e.g. for garden and landscape decoration	Unconventional buildings (prototypes, decorative façades, art, design, heritage reconstruction)	Special buildings (army, nuclear disaster, army buildings, lunar base)	Structural parts like bridges, floors, walls	Organic shaped complex (structural) parts with integrated functions
1	Improving processing knowledge and availability of AM materials for the construction sector	RIA	4-5	6	X	X	X	X	X
2	Methodologies to integrate concrete reinforcements in AM construction	RIA	4-5	6		X	X	X	X
3	Strategies toward standardisation: AM alignment with existing standards and building codes and research for improvement of specifications and standardisation of material properties.	RIA	4-5	6	X	X	X	X	X
4	Cost-effective printing equipment for construction applications	RIA	4-5	6	X	X	X	X	X
5	Integration of ergonomics, design and art in 3D printing built environment and related tools.	IA/CSA	5-6	7	X	X		X	X
6	Co-production and user participation for added-value construction.	IA/CSA	5-6	7	X	X	X	X	X
7	Design for construction in AM, integrated with building information modelling (BIM) systems and topology optimisation	RIA	4-5	6		X	X	X	X
8	Multimaterial printing and integrating components in to the build	RIA	3-4	5-6	X	X	X	X	X
9	Novel AM cost-effective manufacturing processes with high production rates validated in industrially-relevant construction products	RIA	4-5	6			X	X	X

5.10. ENERGY gaps and actions

Energy-specific actions were identified as reported in the roadmap shown in Figure 5.10 . Key actions details (type of activity, initial and target TRL, related target product groups) are reported in Table 5-7.

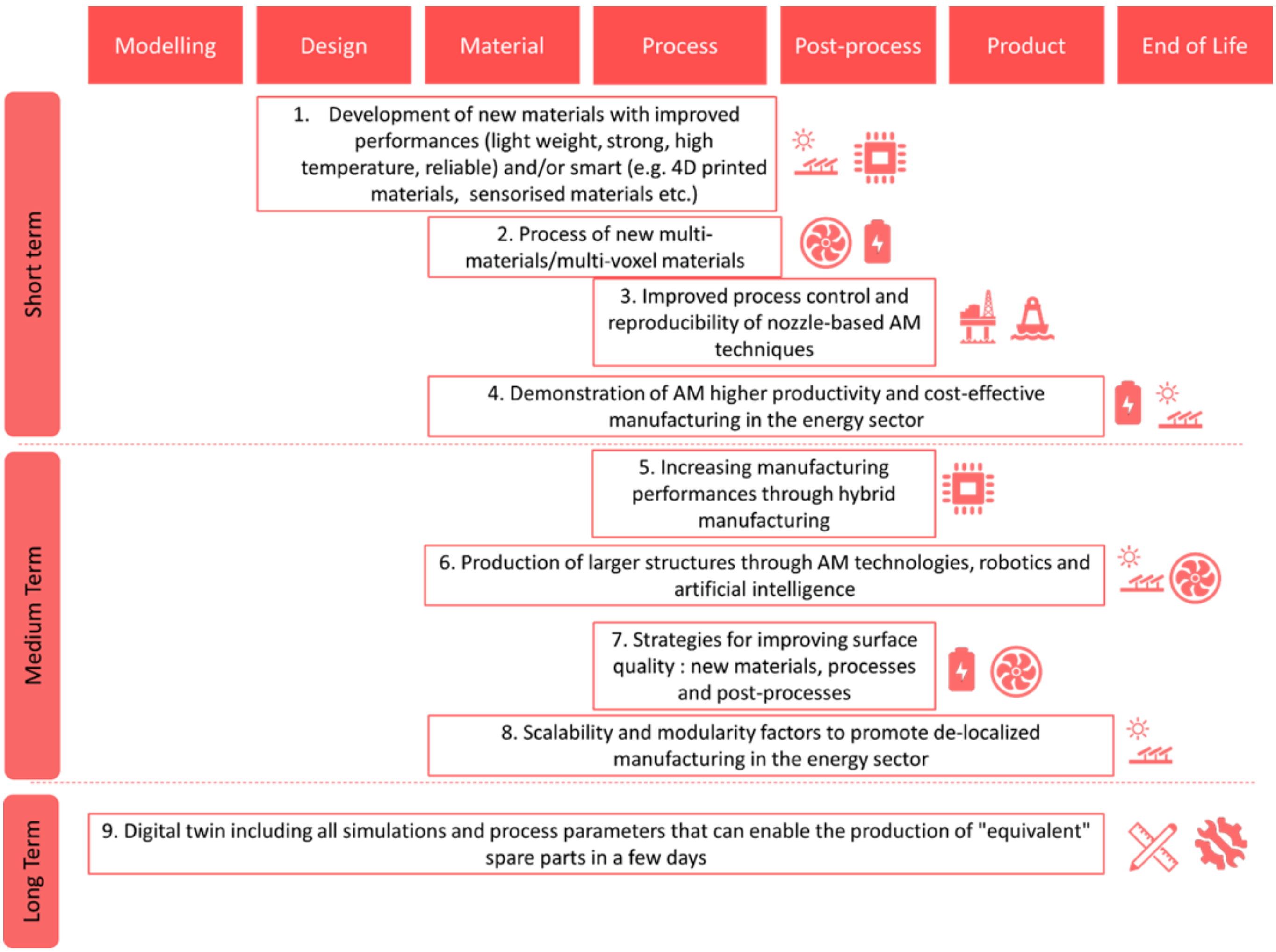

Figure 5.10: *AM-MOTION Energy Roadmap*

Table 5-7: *AM-MOTION Energy actions details*

N.	Action Name	Type of Activity	TRL		Target Products							
			Initial TRL	Target TRL	Turbines parts	Oil and gas industry products	Renewable Energy industry components	Energy storage	Electromechanical and 3D electronic components	Floating Platforms components	Concept modelling, prototyping and design	Spare parts & repair
1	Development of new materials with improved performances (light weight, strong, high temperature, reliable) and/or smart (e.g. 4D printed materials, sensorised materials etc.)	RIA	4-5	6	X	X	X	X	X	X	X	X
2	Process of new multi-materials/multi-voxel materials	RIA	2-3	4-5	X	X	X	X	X	X	X	X
3	Improved process control and reproducibility of nozzle-based AM techniques	IA	4-6	7	X	X	X	X	X	X	X	X
4	Demonstration of AM higher productivity and cost-effective manufacturing in the energy sector	RIA	4-5	6	X	X	X	X	X	X	X	X
5	Increasing manufacturing performances through hybrid manufacturing	IA	5	6-7	X	X	X	X	X	X	X	X
6	Production of larger structures through AM technologies, robotics and artificial intelligence	RIA	4-5	6	X	X	X	X		X	X	X
7	Strategies for improving surface quality : new materials, processes and post-processes	IA	4-5	6	X	X	X	X	X	X	X	X
8	Scalability and modularity factors to promote de-localised manufacturing in the energy sector	RIA	1-3	4-5		X	X	X		X		X
9	Digital twin including all simulations and process parameters that can enable the production of "equivalent" spare parts in a few days	IA/CSA	5	6-7							X	X

6. AM-MOTION expected impact

AM-Motion project has the ambition to develop a strategy and set up the pillars for its efficient implementation that, ultimately, will contribute to reinforcing the European ecosystem of AM. Thanks to the adoption of AM there will be different impacts for Europe in addition to the economic and industrial aspects (already detailed in chapter 4), in particular in terms of better environment, improvement of quality of life, working condition, education, etc.. In detail:

Environment. Reduction of environmental impact is emerging as a critical issue in Europe. The adoption of AM technologies by the European industry would lead to introduce a benign environmental manufacturing. This technology possesses many advantages based on its capability to process only the material that comprises a part avoiding the generation of waste in the form of chips (e.g. subtracting technologies)[56]. The creation of efficient designs would be also possible since designers would be completely free to put material only where needed with a more efficiently use. Moreover, freeform fabrication is expected to provide energy-efficient tooling to the industries working on injection moulds.

Health, quality of life, and working conditions. Building factories based on AM is believed to bring great benefits in health to society. Custom-Made Implants (CMIs) are considered to be a superior solution for the treatment of patients with rare and/or severe clinical conditions and they provide added value for all - patients, surgeons, medical institutions and health insurance funds. However, CMIs currently fail to achieve large-scale commercial success due to high price, long lead times and dominated surgical approach oriented towards standard solutions[57]. CMI production by AM in a reliable and will contribute to reduce significantly CMI-related hospital care, surgery time and eventually the total cost per patient[58]. On the other hand, the AM industrialization would contribute to the further growth of the European industry, making of it an even more knowledge-based industry and employing highly competent professionals. AM-Motion will also have impact on working conditions in factories. Unlike conventional fabrication processes, AM substantially reduce the interface between machines and workers, since machines operate most of the time autonomously. For instance, the global introduction of AM in production chains will shift workers tasks from assembly operations to support, inspect and control tasks and, consequently, the potential risks of accidents at the working place will decrease. Moreover, once the AM technologies are widely implanted in factories as a standard manufacturing process, new venues for shifting from mass-customization towards the mass-production of customized products will be opened, enhancing our quality life.

Education, training and employment. Deployment of AM will have an impact on traditional production models. New jobs will be created, thus new skills will be needed. Training and education establishments will need to preserve and develop the employability of workers, addressing the employer's needs. AM-Motion wants to contribute to educate a new generation of knowledge-based workers by means of raising awareness among key players, analysing industrial needs and educational approaches and facilitating educational tools

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[56] Mélanie Despeisse, Simon Ford. *The Role of Additive Manufacturing in Improving Resource Efficiency and Sustainability.* Shigeki Umeda; Masaru Nakano; Hajime Mizuyama; Hironori Hibino; Dimitris Kiritsis; Gregor von Cieminski. IFIP International Conference on Advances in Production Management Systems (APMS), Sep 2015, Tokyo, Japan.

[57] https://cordis.europa.eu/project/rcn/211141_pl.html

[58] MMI (Medical Manufacturing Innovation). "Medical Additive Manufacturing/3D Printing. Annual Report 2018".

6.1. Expected impact of target actions

Eighteen economic, industrial, environmental and social impact indicators have been identified within AM-MOTION Consortium and Experts and evaluated in terms of relevance to describe the impact of AM related projects and activities. The relevance percentage of KPIs is shown in table 7.1.

Table 6:1: *Relevance of selected KPI*

	KPI	Relevance
Economic	Increased business generated	6%
	Increased number of private companies involved	6%
	New types of ventures started	6%
Industrial	Potential for EU leadership	6%
	Increased IPR protection	6%
	Increased product quality and performances	7%
	Increased production capacity	7%
	Reduced time to market	7%
	Reduced manufacturing cost	6%
Environment	Material resource saving	6%
	Reduction of CO2 emission	5%
	Increased recycling	4%
	Better environment	5%
Social	Increased number of jobs	5%
	Jobs reshoring in EU	6%
	Decrease of inequalities	4%
	Better personal health	5%
	Better quality of life	5%

To better differentiate the impact analysis, the relevance was also calculated for merged Economic & Industrial impacts and Environmental & Social impacts.

Table 6:2: *Relevance of selected KPI (Economic+Industrial and Environmental+Social)*

	KPI	Relevance
Economic & Industrial	Increased business generated	11%
	Increased number of private companies involved	10%
	New types of ventures started	10%
	Potential for EU leadership	10%
	Increased IPR protection	10%
	Increased product quality and performances	12%
	Increased production capacity	13%
	Reduced time to market	13%
	Reduced manufacturing cost	11%

	KPI	Relevance
Environment & Social	Material resource saving	13%
	Reduction of CO2 emission	11%
	Increased recycling	10%
	Better environment	11%
	Increased number of jobs	11%
	Jobs reshoring in EU	13%
	Decrease of inequalities	10%
	Better personal health	11%
	Better quality of life	11%

The identified KPIs were at the base of a qualitative evaluation of the impacts of the different actions for each sector as well as Cross Cutting Technical and Non-Technical actions.

The qualitative evaluation was based on a 1-5 scale, considering:

1: Very Low impact

2: Low Impact

3: Average Impact

4: Relevant Impact

5: Very high impact.

The aim of the analysis was to determine, for each sector:

- the overall higher impacts (for each industrial, economic, environmental and social KPI)
- the actions that, if implemented, could have higher impact for the sector, differentiated for economic & industrial Impacts and Environmental & Social Impacts.
- the overall average impact value of the actions, in terms Economic & Industrial Impacts and Environmental & Social Impacts

Here below are reported the main outcomes of the analysis.

6.1.1. *TECHNOLOGICAL CROSS-CUTTING impacts*

As shown in Figure 6.1, from the analysis of the Technical Cross cutting overall average of KPI, the future actions will have on a strong impact on:

- **Industrial:** Increased product quality and performances - 4,8
- **Economic:** Increased business generated **–** 3,9
- **Environmental:** Material resource saving - 3,6
- **Social:** Increased number of jobs - 3,6

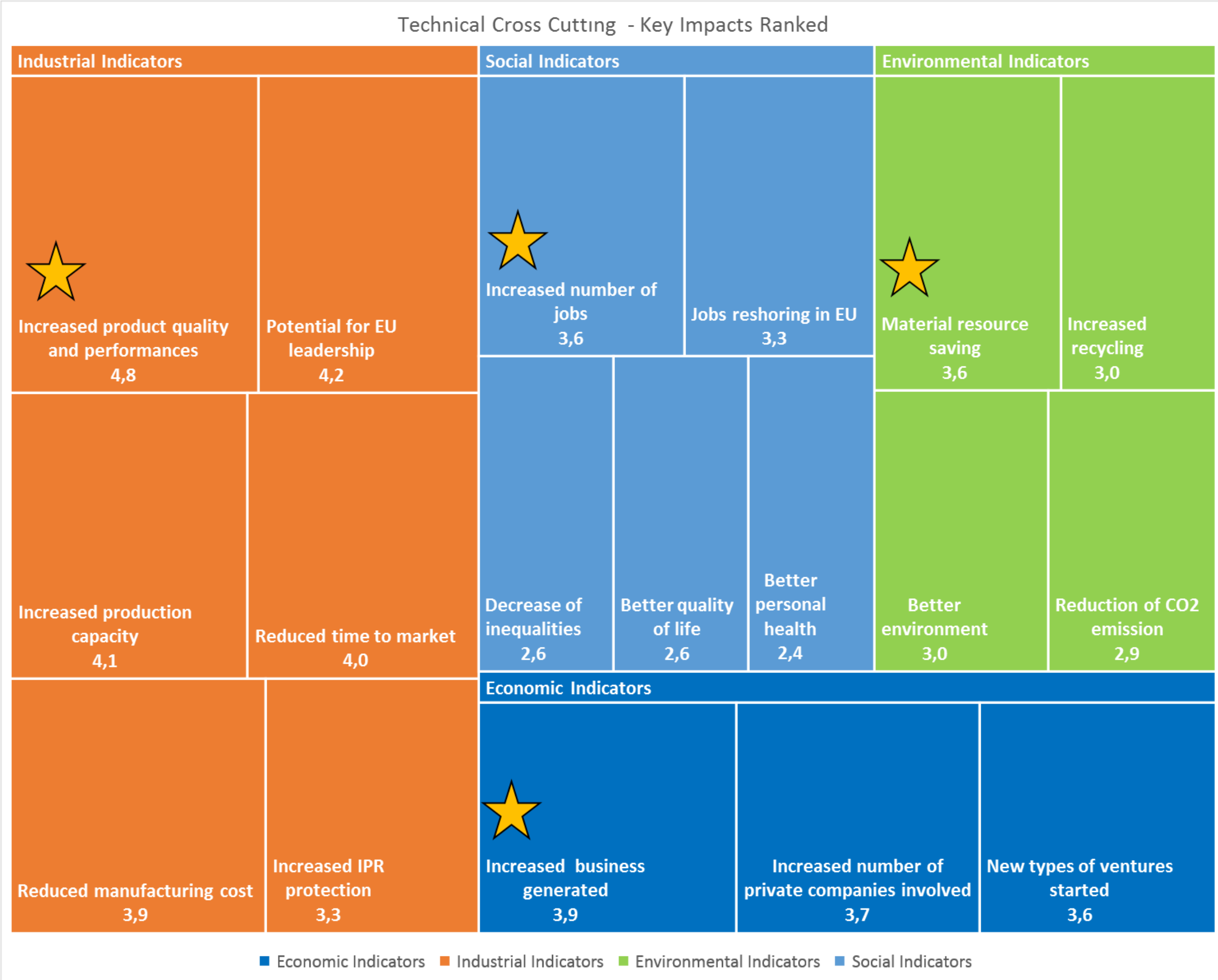

Figure 6.1: *Technical Cross Cutting - Impacts Ranking*

The other outcome of the analysis is related to target actions. The aim was evaluating actions individually and ranking them to understand which ones will have a higher impact in the future within the considered sector. **Error! Reference source not found.** reports the results for each action divided for conomics & Industrial impacts and Environmental & Social impacts, in particular it emerges that:

- **For Economic and Industrial Impacts:** Quality management systems: need for definition of key quality affecting parameters for various AM systems& applications
- **For Environmental and Social Impacts:** Integrating AM technologies into existing industrial processes/chains

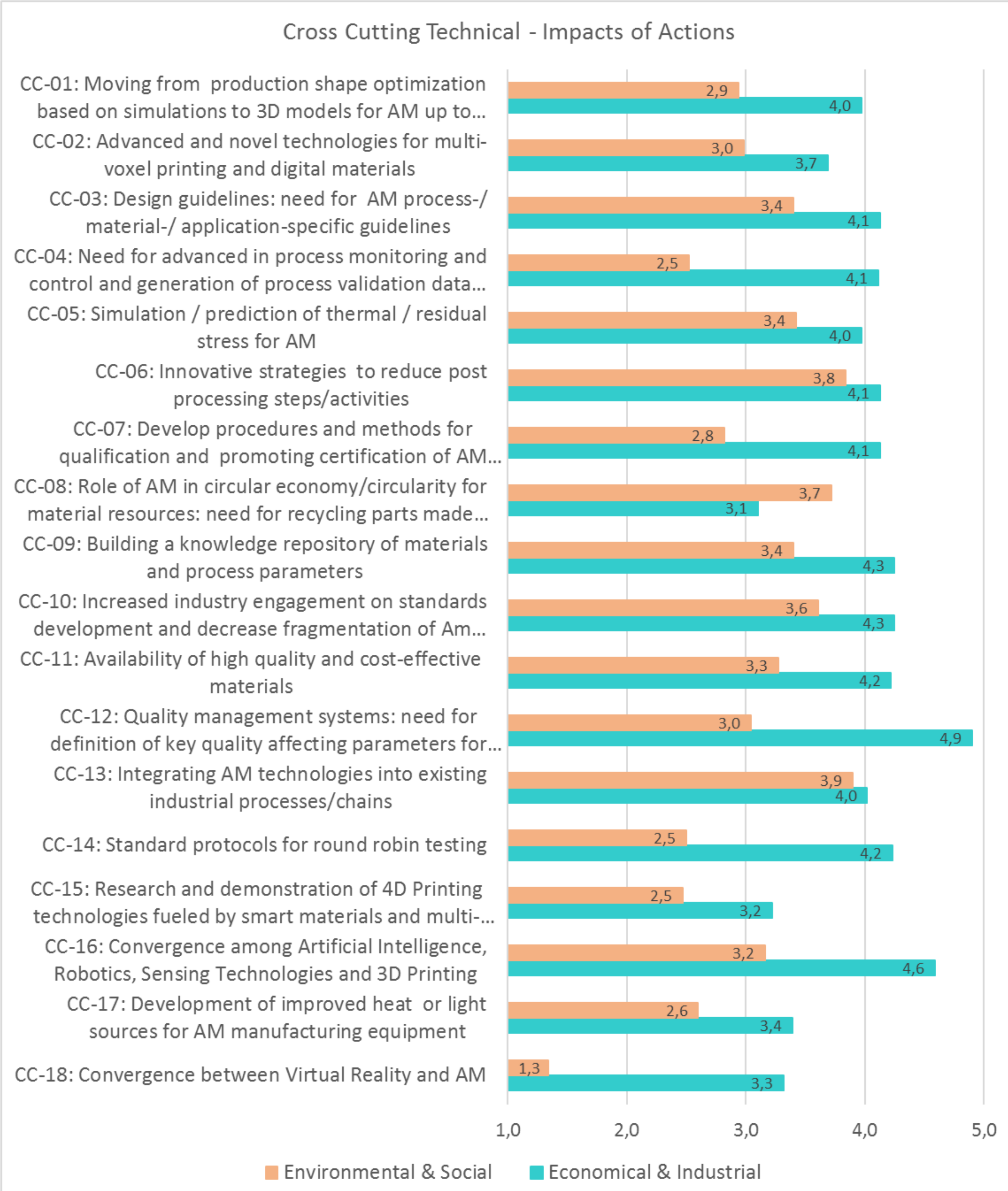

Figure 6.2: *Technical Cross Cutting – Impacts of Action*

Finally, in Figure 6.3 is shown the overall average impact value of the actions, in terms Economic & Industrial Impacts and Environmental & Social Impacts.

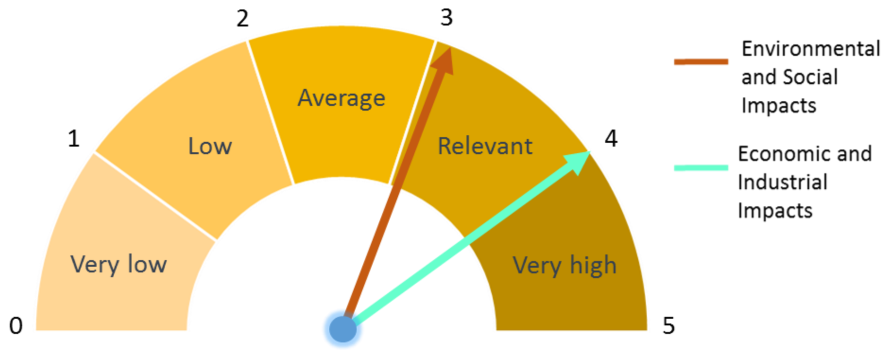

Figure 6.3: *Technical Cross cutting - Overall Average Impacts*

6.1.2. *NON-TECHNOLOGICAL CROSS CUTTING impacts*

As shown in Figure 6.4, from the analysis of the Non-Technical Cross Cutting overall average of KPI, the future actions will have on a strong impact on:

- **Industrial Impacts:** Potential for EU leadership- 4,4
- **Economic Impacts:** Increased business generated **–** 4,4
- **Environmental Impacts:** Material resource saving – 3,9
- **Social Impacts:** Jobs reshoring in EU - 4,5

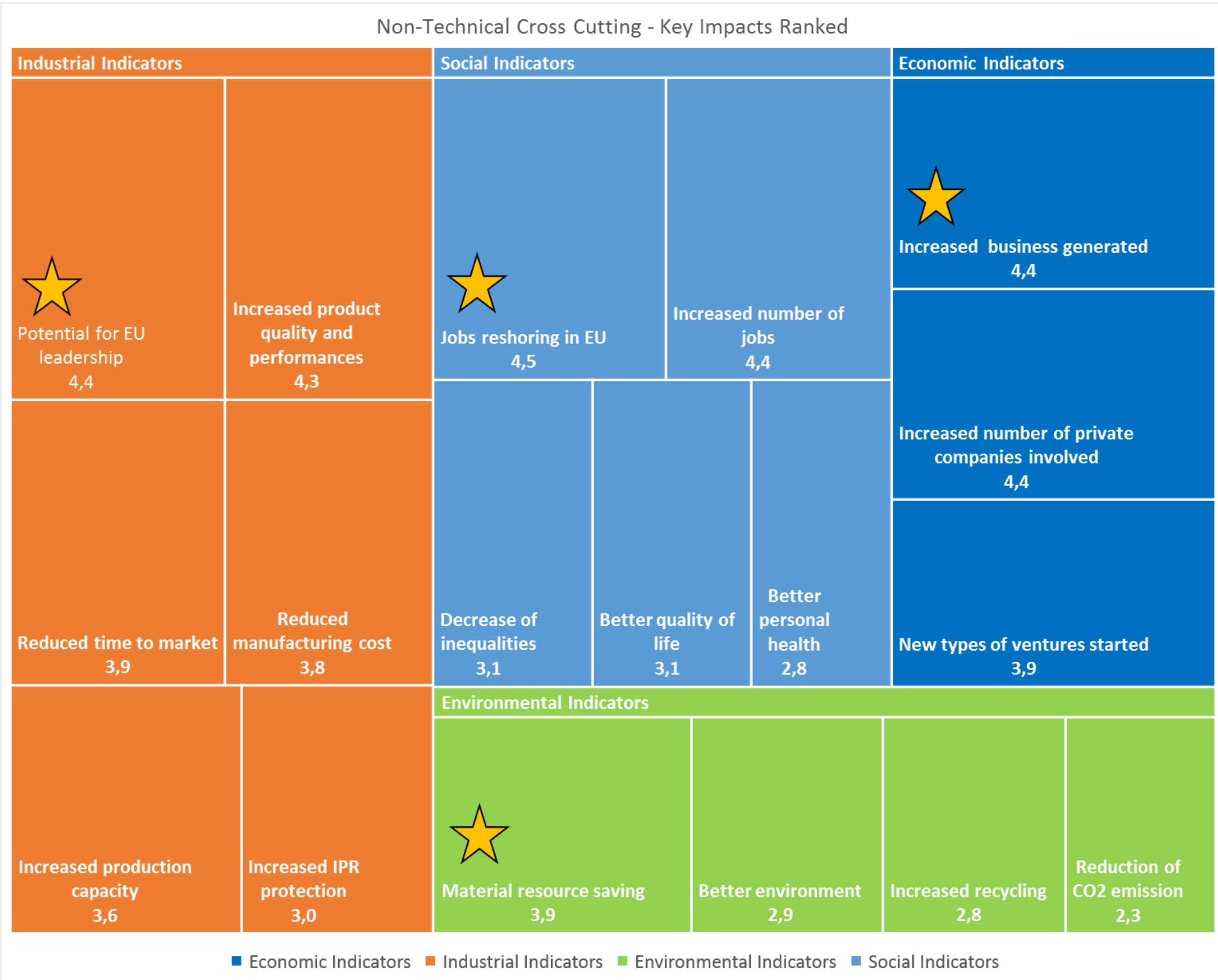

Figure 6.4: *Non-Technical Cross Cutting - Impacts Ranking*

The other outcome of the analysis is related to target actions. The aim was evaluating actions individually and ranking them to understand which ones will have a higher impact in the future within the considered sector. Figure 6.5 reports the results for each action divided for Economics & Industrial impacts and Environmental & Social impacts, in particular it emerges that:

- **For Economic and Industrial Impacts:** Innovative AM sustainable business models
- **For Environmental and Social Impacts:** Innovative AM sustainable business models

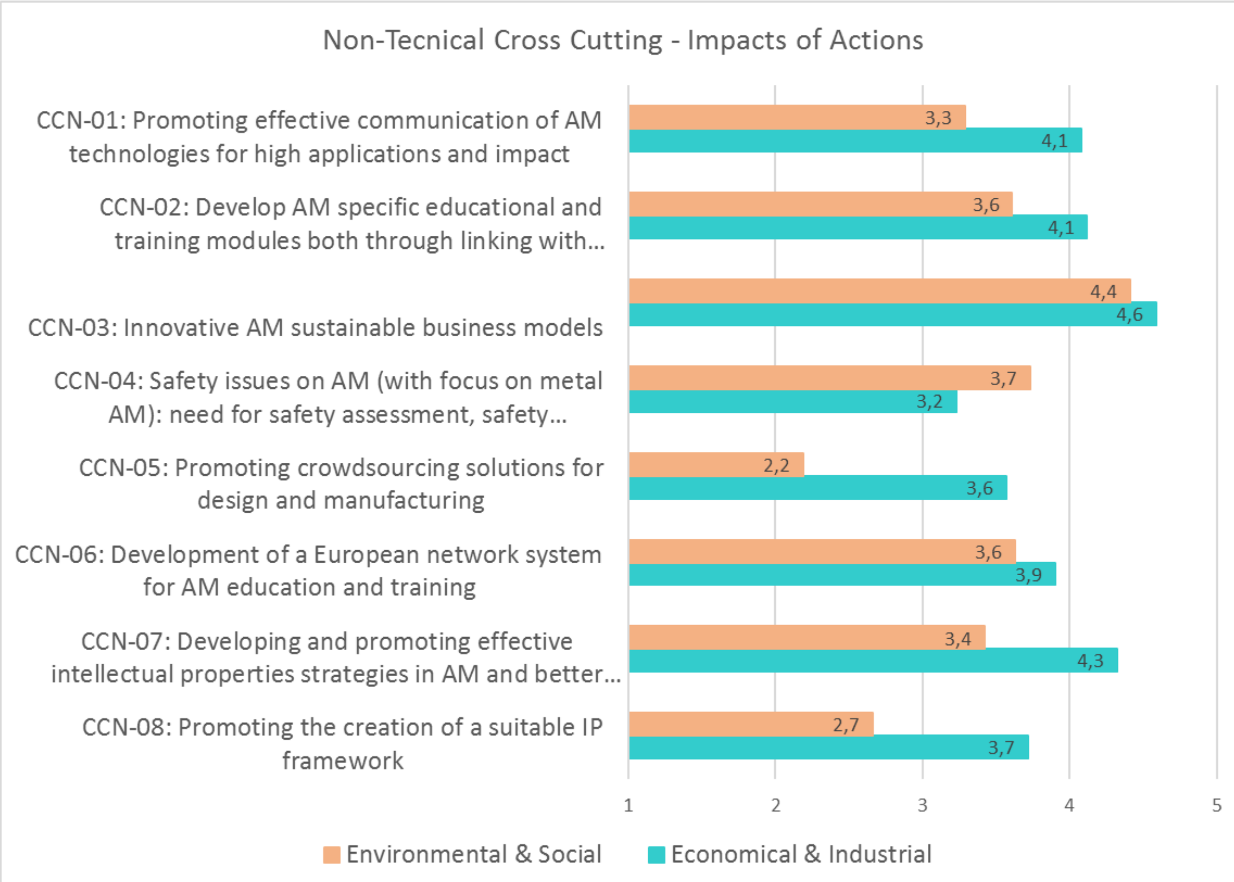

Figure 6.5: *Non-Technical Cross Cutting – Impacts of Action*

Finally, in Figure 6.6 is shown the overall average impact value of the actions, in terms Economic & Industrial Impacts and Environmental & Social Impacts.

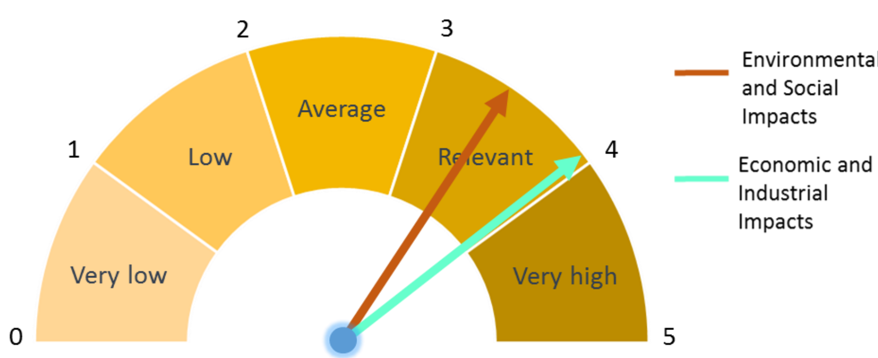

Figure 6.6: *Non-Technical Cross Cutting - Overall Average Impacts*

6.1.3. *HEALTH impacts*

As shown in Figure 6.7, from the analysis of the Health overall average of KPI, the future actions will have on a strong impact on:

- **Industrial Impacts:** Potential for EU leadership - 4,5
- **Economic Impacts:** Increased number of private companies involved **-** 4,3
- **Environmental Impacts:** Material resource saving - 3,6
- **Social Impacts:** Better personal Health - 3,9

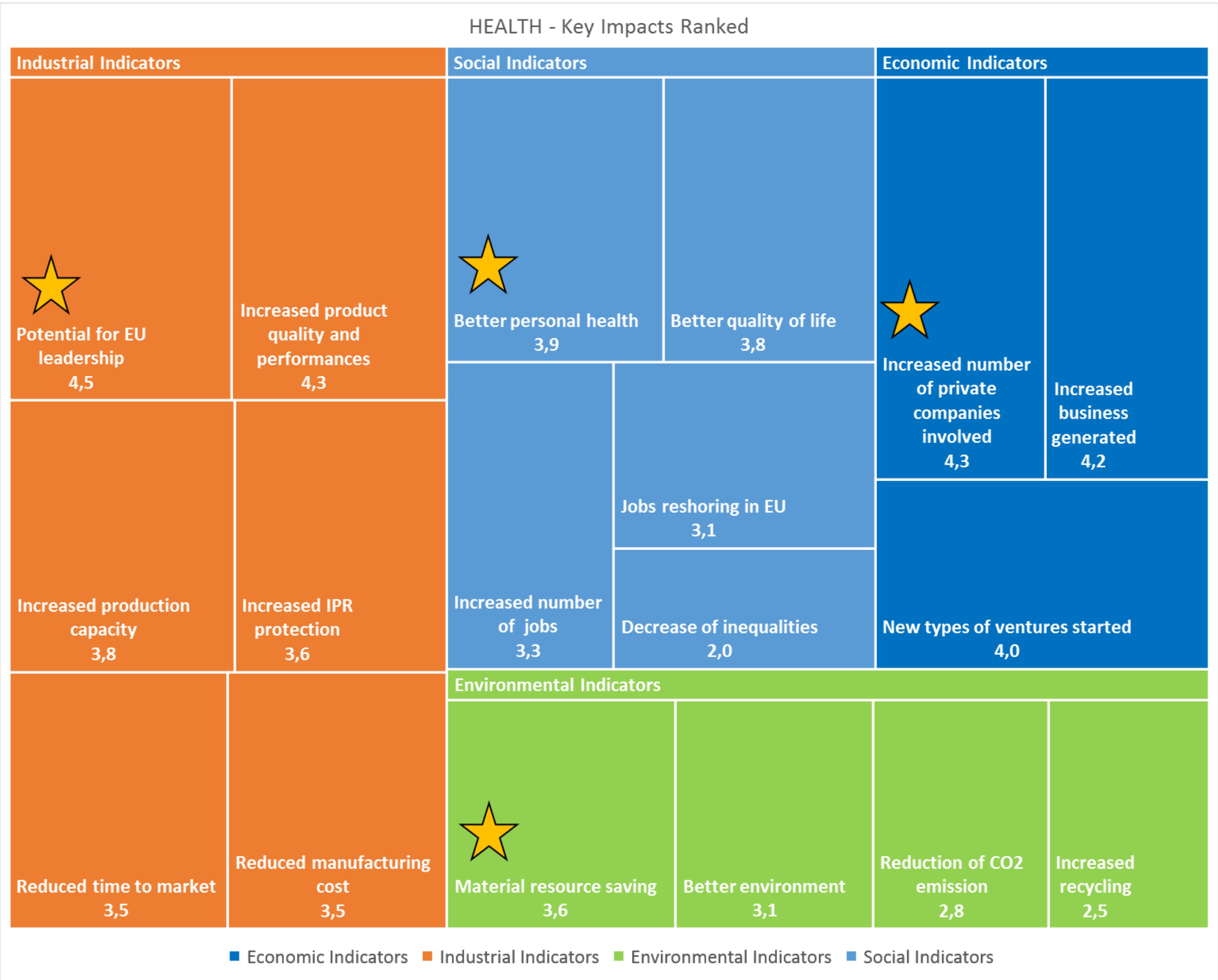

Figure 6.7: *Health - Impacts Ranking*

The other outcome of the analysis is related to target actions. Figure 6.8 reports the results for each action divided for Economics & Industrial impacts and Environmental & Social impacts, in particular it emerges that the higher-impacts actions are:

- **For Economic and Industrial Impacts:** Novel biomaterials suitable for AM with focus on material variety and large production at lower cost
- **For Environmental and Social Impacts:** Smart products with improved functionalities

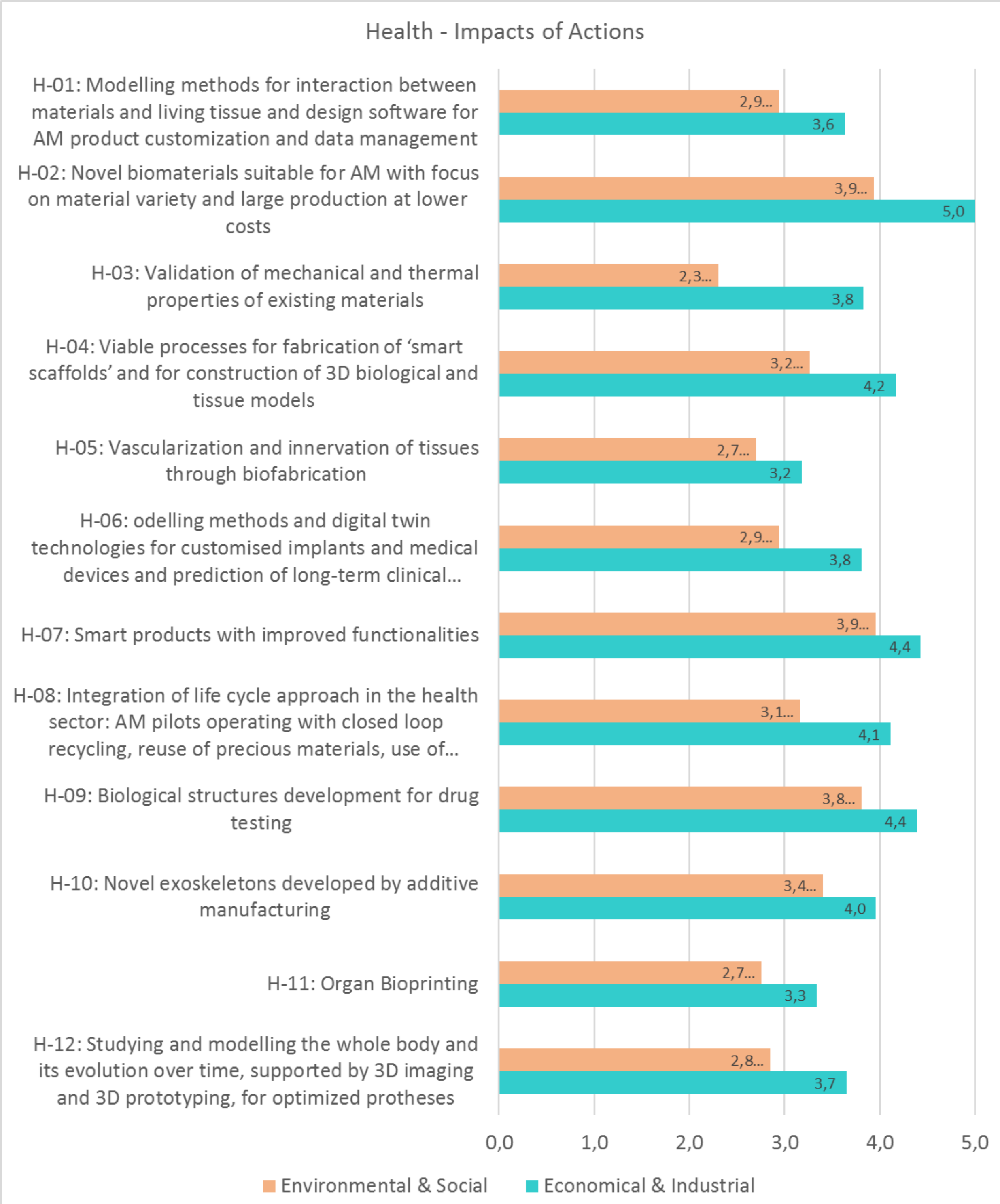

Figure 6.8: *Health – Impacts of Actions*

Finally, in Figure 6.9 is shown the overall average impact value of the actions, in terms Economic & Industrial Impacts and Environmental & Social Impacts.

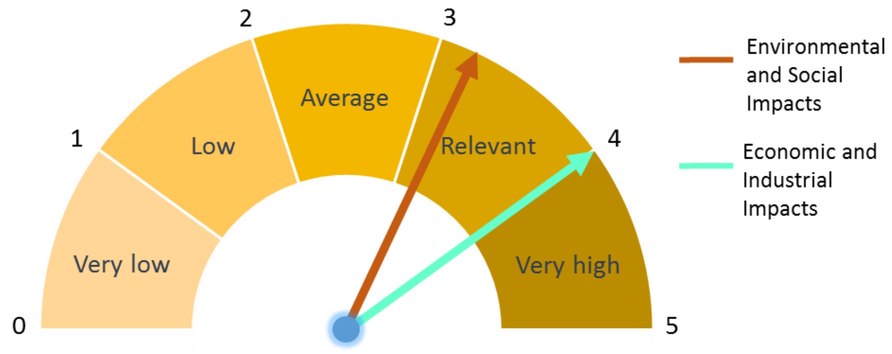

Figure 6.9: *Health - Overall Average Impacts*

6.1.4. *AEROSPACE impacts*

As shown in Figure 6.10, from the analysis of the Health overall average of KPI, the future actions will have on a strong impact on:

- **Industrial Impacts:** - Increased product quality and performances - 4,6
- **Economic Impacts:** Increased business generated **–** 4,2
- **Environmental Impacts:** Material resource saving – 4,2
- **Social Impacts:** Increased number of jobs – 2,8

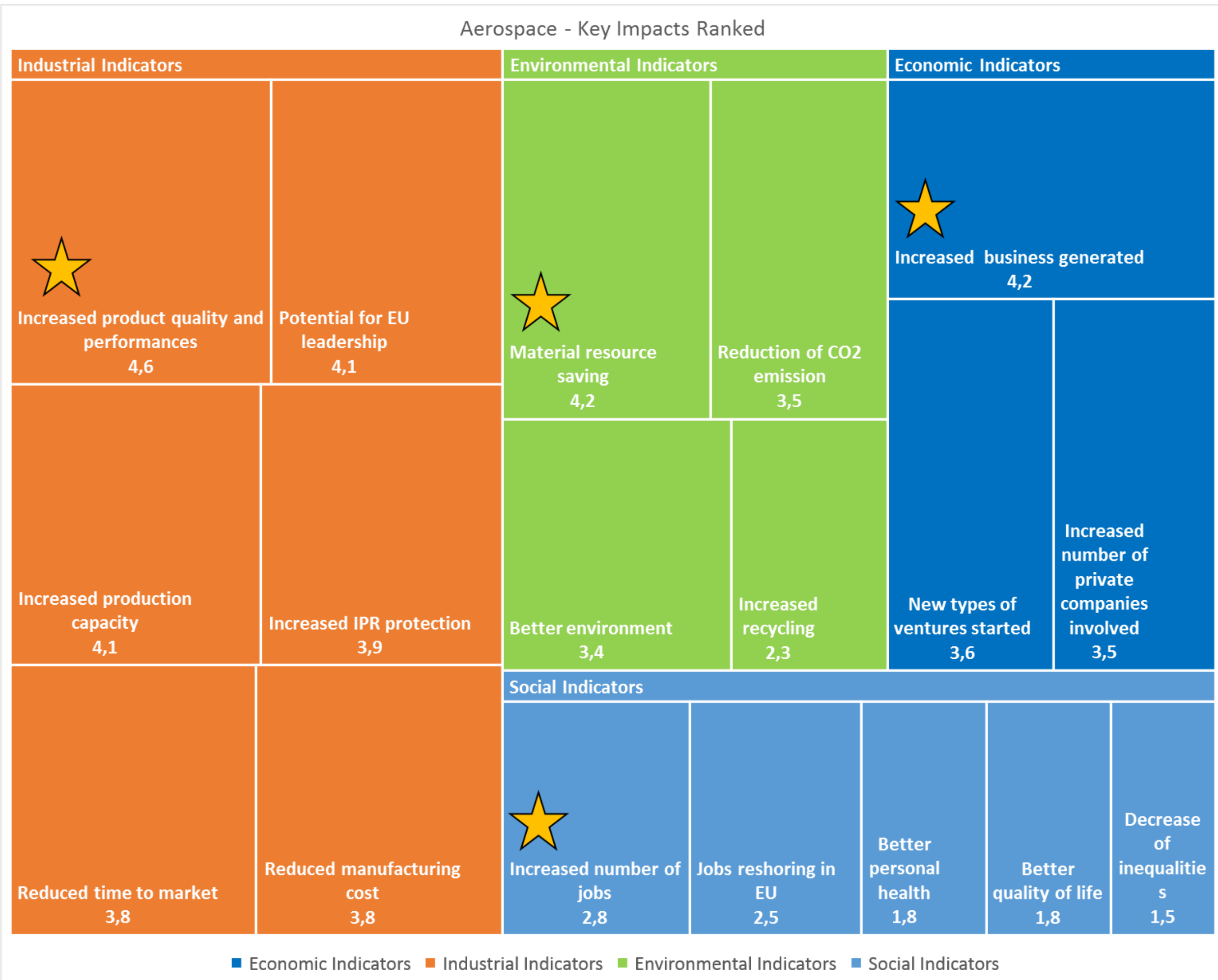

Figure 6.10: *Aerospace - Impacts Ranking*

The other outcome of the analysis is related to target actions. Figure 6.11 reports the results for each action divided for Economics & Industrial impacts and Environmental & Social impacts, in particular it emerges that the higher-impacts actions are:

- **For Economic and Industrial Impacts:** Increased automation of repair processes through integration of AM and robotics; Production of larger airframe structures through AM technologies

- **For Environmental and Social Impacts:** Production of larger airframe structures through AM technologies

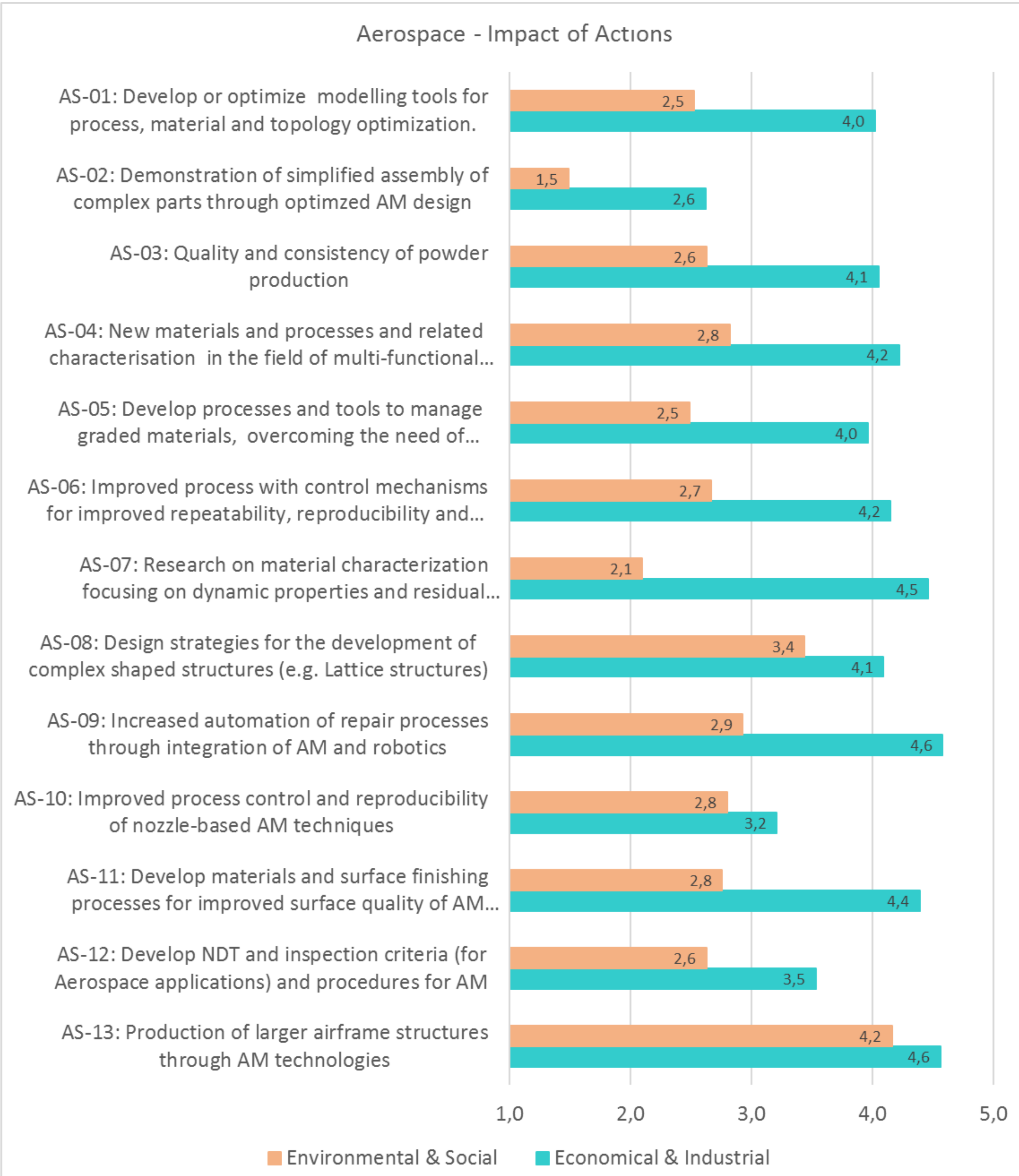

Figure 6.11: *Aerospace - Impacts of Action*

Finally, in Figure 6.12 is shown the overall average impact value of the actions, in terms Economic & Industrial Impacts and Environmental & Social Impacts.

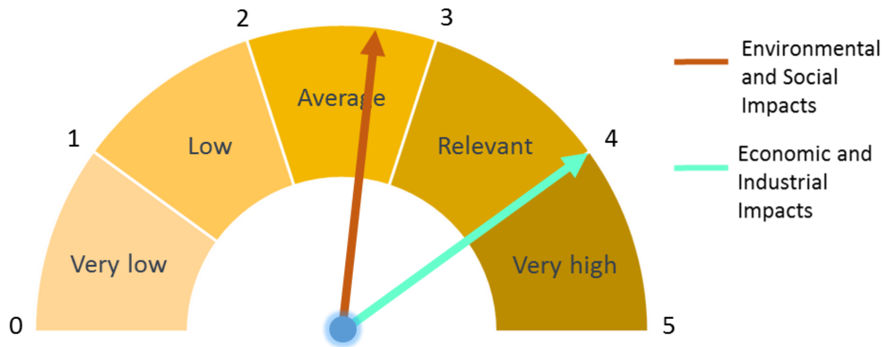

Figure 6.12: *Aerospace - Overall Average Impacts*

6.1.5. *AUTOMOTIVE impacts*

As shown in Figure 6.13, from the analysis of the Health overall average of KPI, the future actions will have on a strong impact on:

- **Industrial Impacts:** - Potential for EU leadership - 4,6
- **Economic Impacts:** Increased business generated **–** 4,3
- **Environmental Impacts:** Material resource saving – 3,3
- **Social Impacts:** Increased number of jobs – 3,9

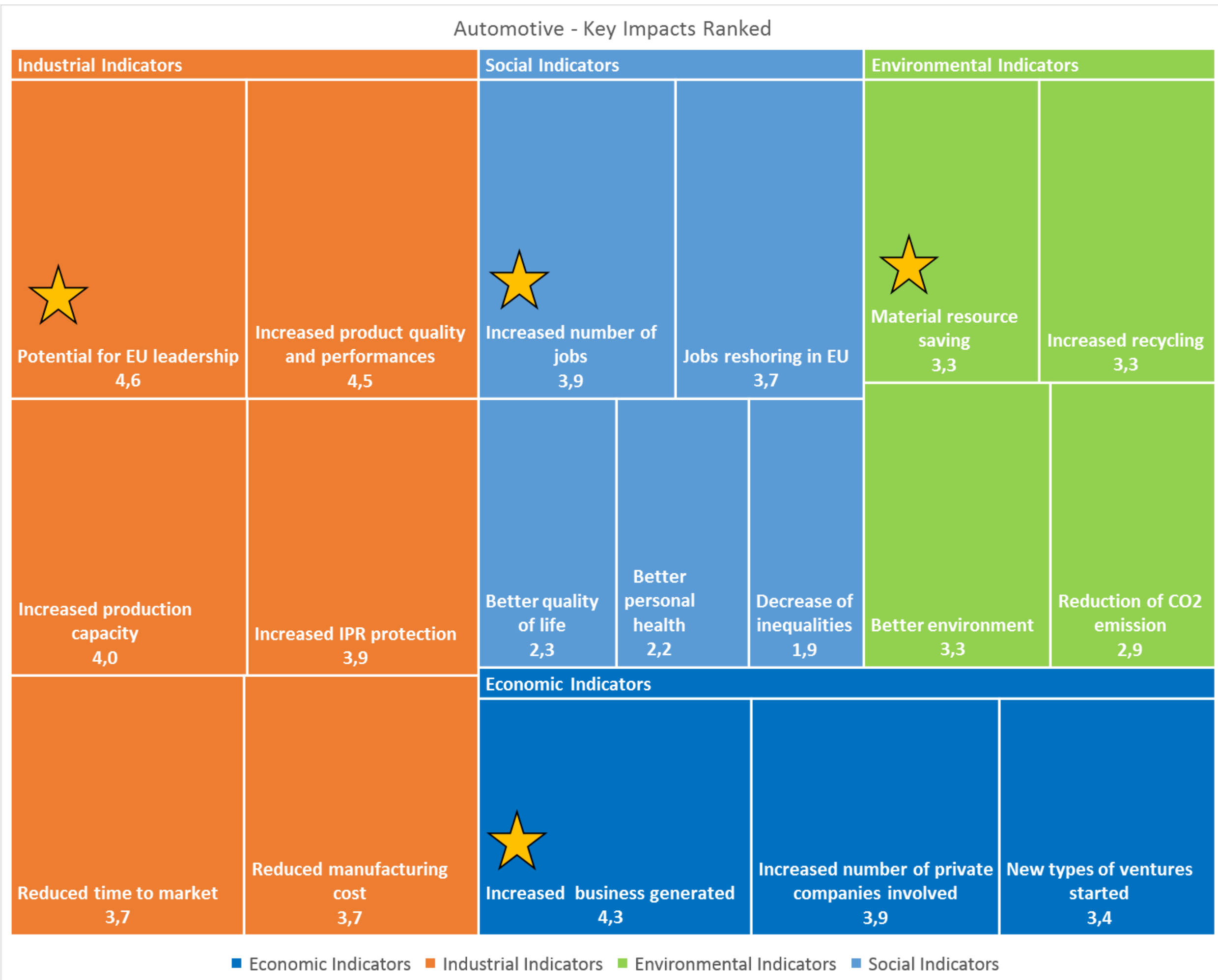

Figure 6.13: *Automotive - Impacts Ranking*

The other outcome of the analysis is related to target actions. Figure 6.14 reports the results for each action divided for Economics & Industrial impacts and Environmental & Social impacts, in particular it emerges that the higher-impacts actions are:

- **For Economic and Industrial Impacts:** Innovative solutions for higher production rates and cheaper systems; Development and demonstrate strategies for cost-effective printing assemblies in one step; Improved modelling tools for materials processing
- **For Environmental and Social Impacts:** Development, optimization and validation of hybrid manufacturing

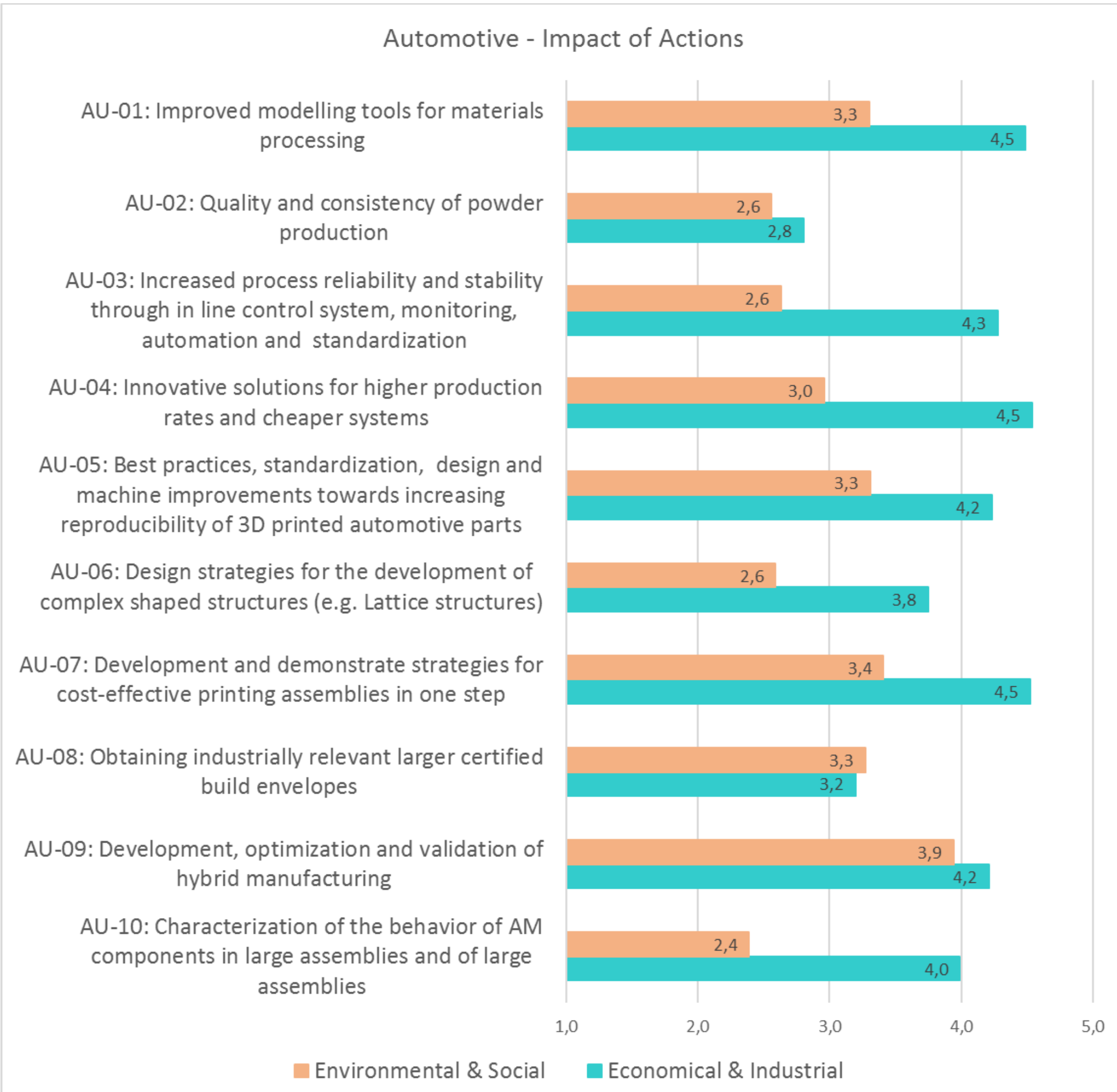

Figure 6.14: *Automotive - Impacts of Action*

Finally, in Figure 6.15 is shown the overall average impact value of the actions, in terms Economic & Industrial Impacts and Environmental & Social Impacts.

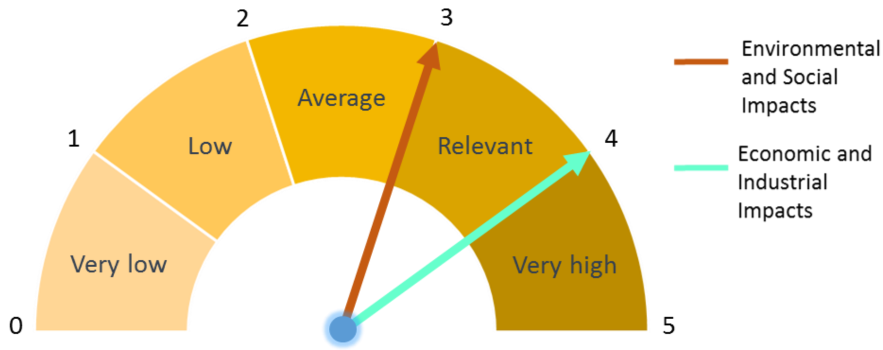

Figure 6.15: *Automotive - Overall Average Impacts*

6.1.6. *CONSUMER GOODS & ELECTRONICS impacts*

As shown in Figure 6.16, from the analysis of the Health overall average of KPI, the future actions will have on a strong impact on:

- **Industrial Impacts:** Product time to market- 3,7
- **Economic Impacts:** Increased business generated; Increased number of private companies involved **–** 4
- **Environmental Impacts:** Material resource saving – 3,4
- **Social Impacts:** Increased number of jobs – 3,3

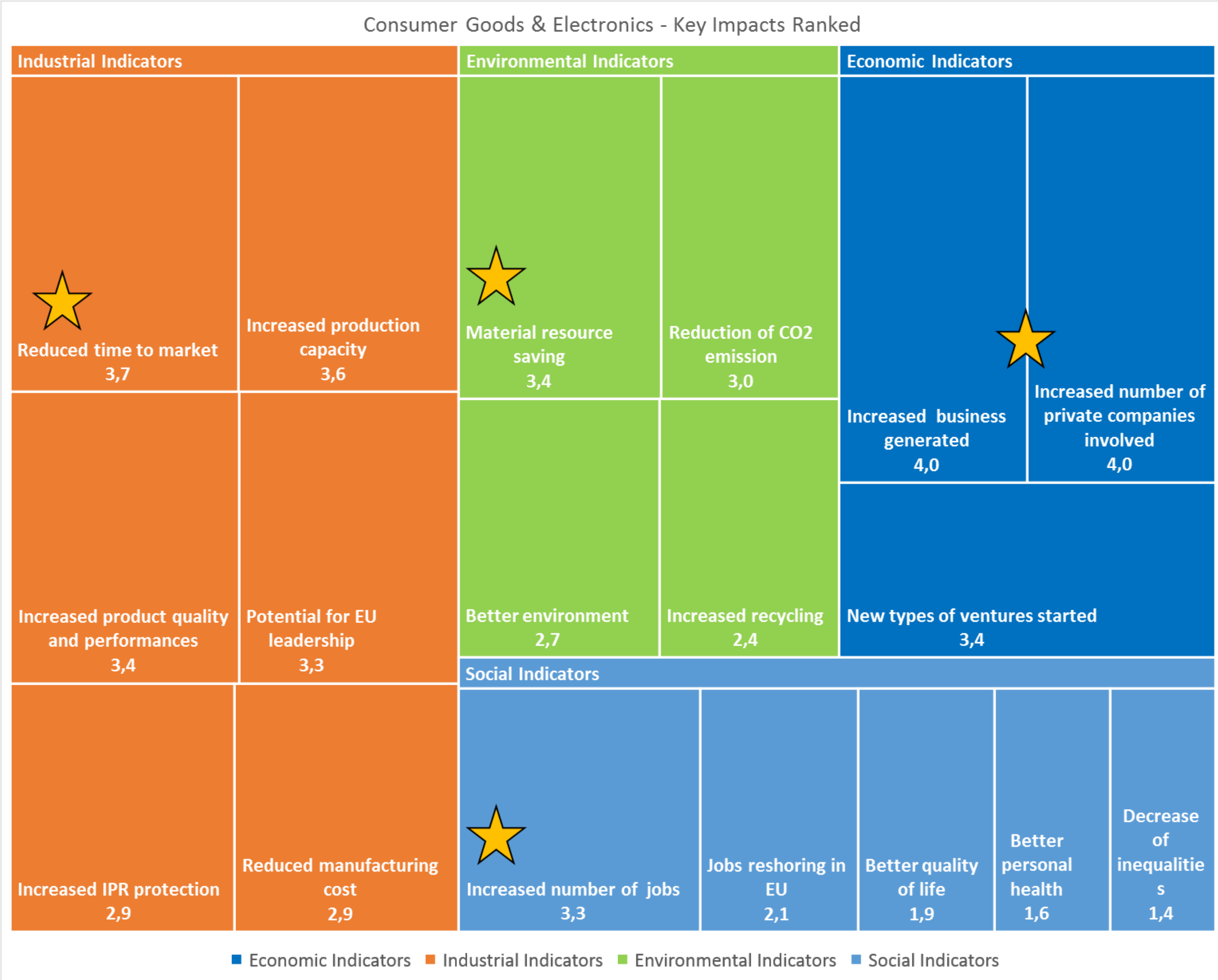

Figure 6.16: *Consumer Goods & Electronics - Impacts Ranking*

The other outcome of the analysis is related to target actions. Figure 6.17 reports the results for each action divided for Economics & Industrial impacts and Environmental & Social impacts, in particular it emerges that the higher-impacts actions are:

- **For Economic and Industrial Impacts:** Promoting mass customization of AM consumer products, including collective design (co-creation) and fabrication strategies; Improving process sustainability through flexible and hybrid manufacturing and industry 4.0 approaches
- **For Environmental and Social Impacts:** Promoting mass customization of AM consumer products, including collective design (co-creation) and fabrication strategies; Improving process sustainability through flexible and hybrid manufacturing and industry 4.0 approaches

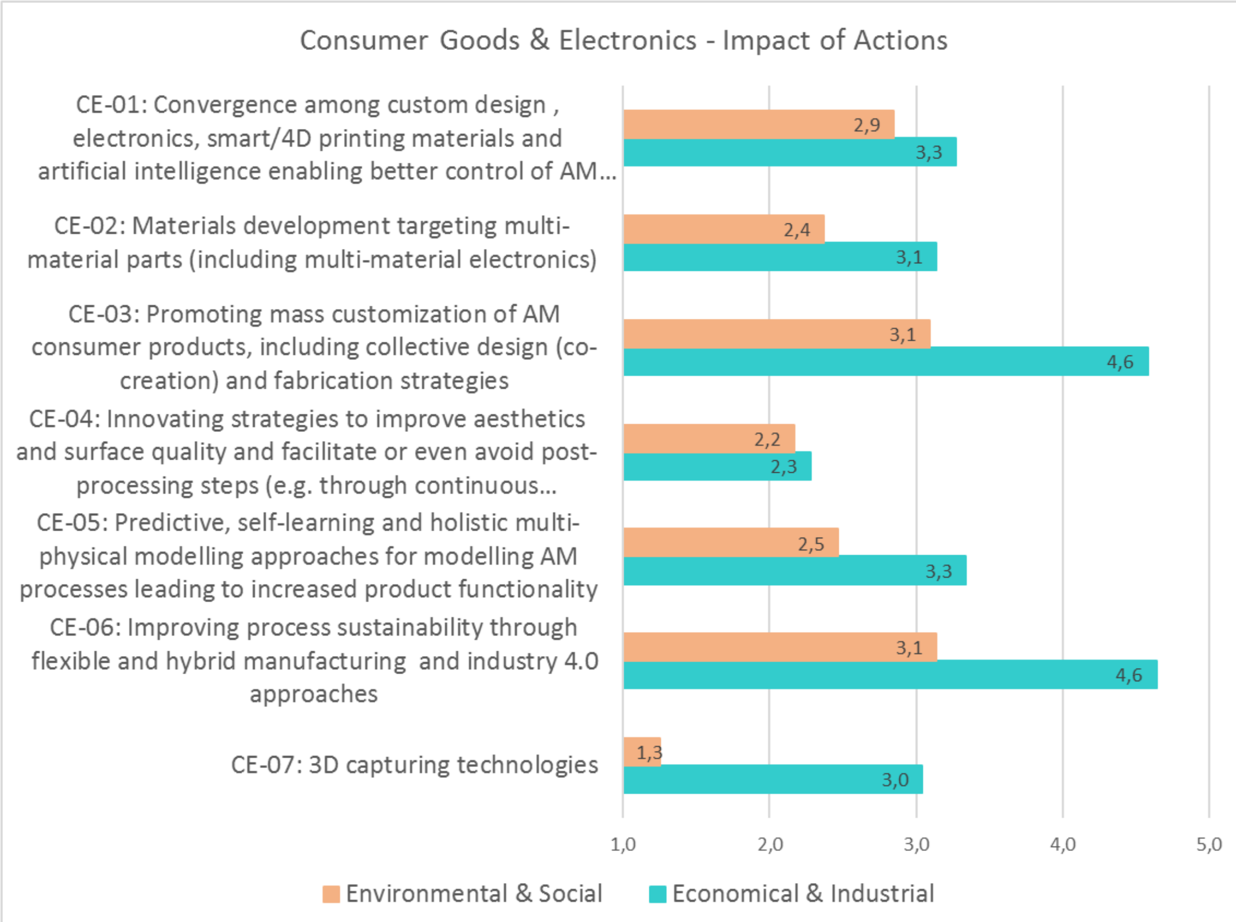

Figure 6.17: *Consumer Goods & Electronics – Impacts of Action*

Finally, in Figure 6.18 is shown the overall average impact value of the actions, in terms Economic & Industrial Impacts and Environmental & Social Impacts.

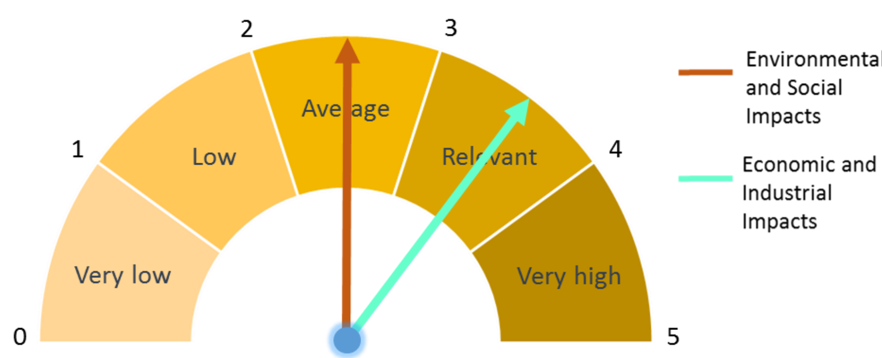

Figure 6.18: *Consumer Goods & Electronics - Overall Average Impacts*

6.1.7. *INDUSTRIAL EQUIPMENT AND TOOLING impacts*

As shown in Figure 6.19, from the analysis of the Health overall average of KPI, the future actions will have on a strong impact on:

- **Industrial Impacts:** Increased product quality and performances; Increased production capacity - 4,2
- **Economic Impacts:** Increased business generated **–** 3,9
- **Environmental Impacts:** Material resource saving – 3,4
- **Social Impacts:** Job reshoring in EU - 3,2

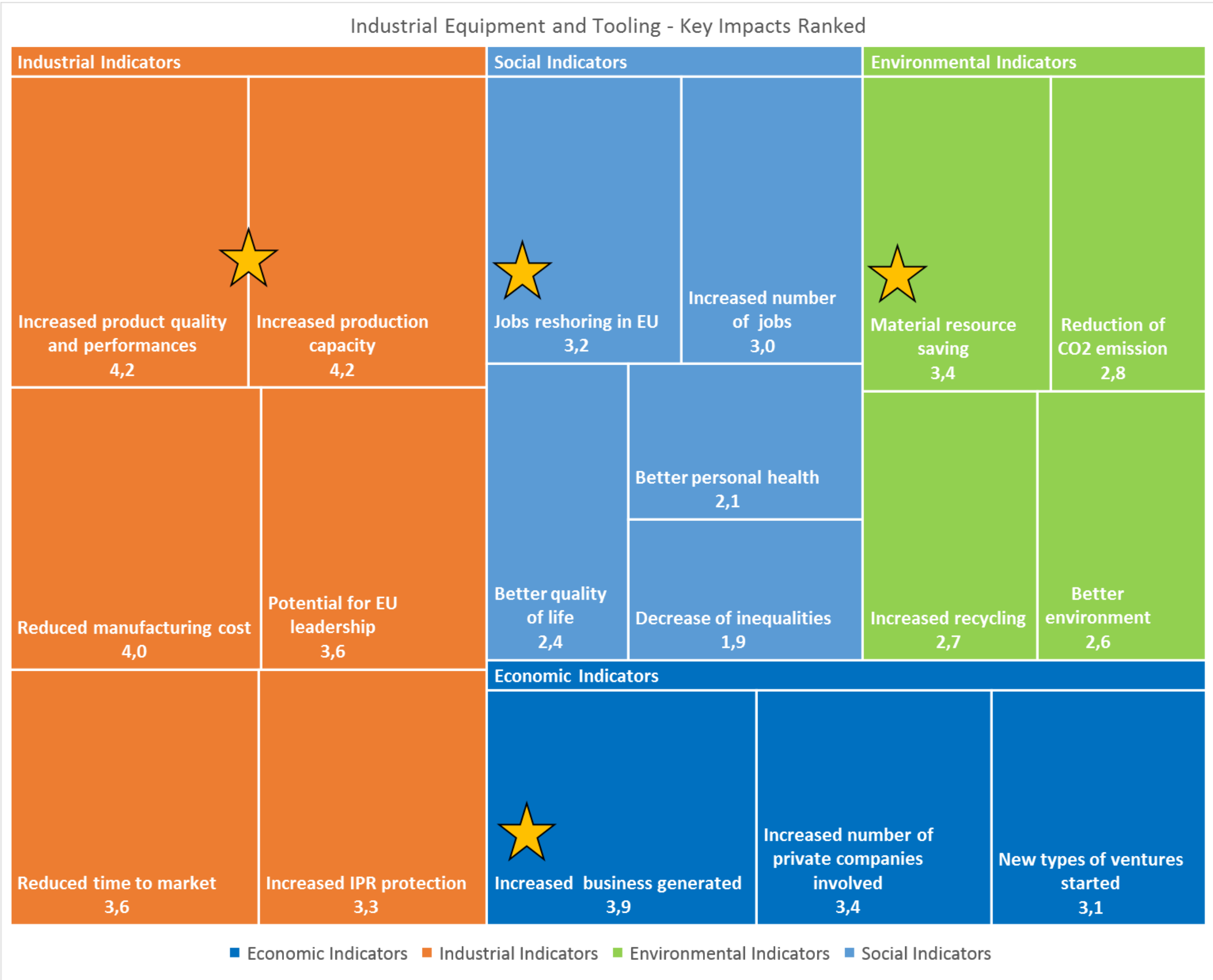

Figure 6.19: *Industrial Equipment and Tooling - Impacts Ranking*

The other outcome of the analysis is related to target actions. Figure 6.20 reports the results for each action divided for Economics & Industrial impacts and Environmental & Social impacts, in particular it emerges that the higher-impacts actions are:

- **For Economic and Industrial Impacts:** Novel tooling materials and moulds for AM processes
- **For Environmental and Social Impacts:** Novel tooling materials and moulds for AM processes

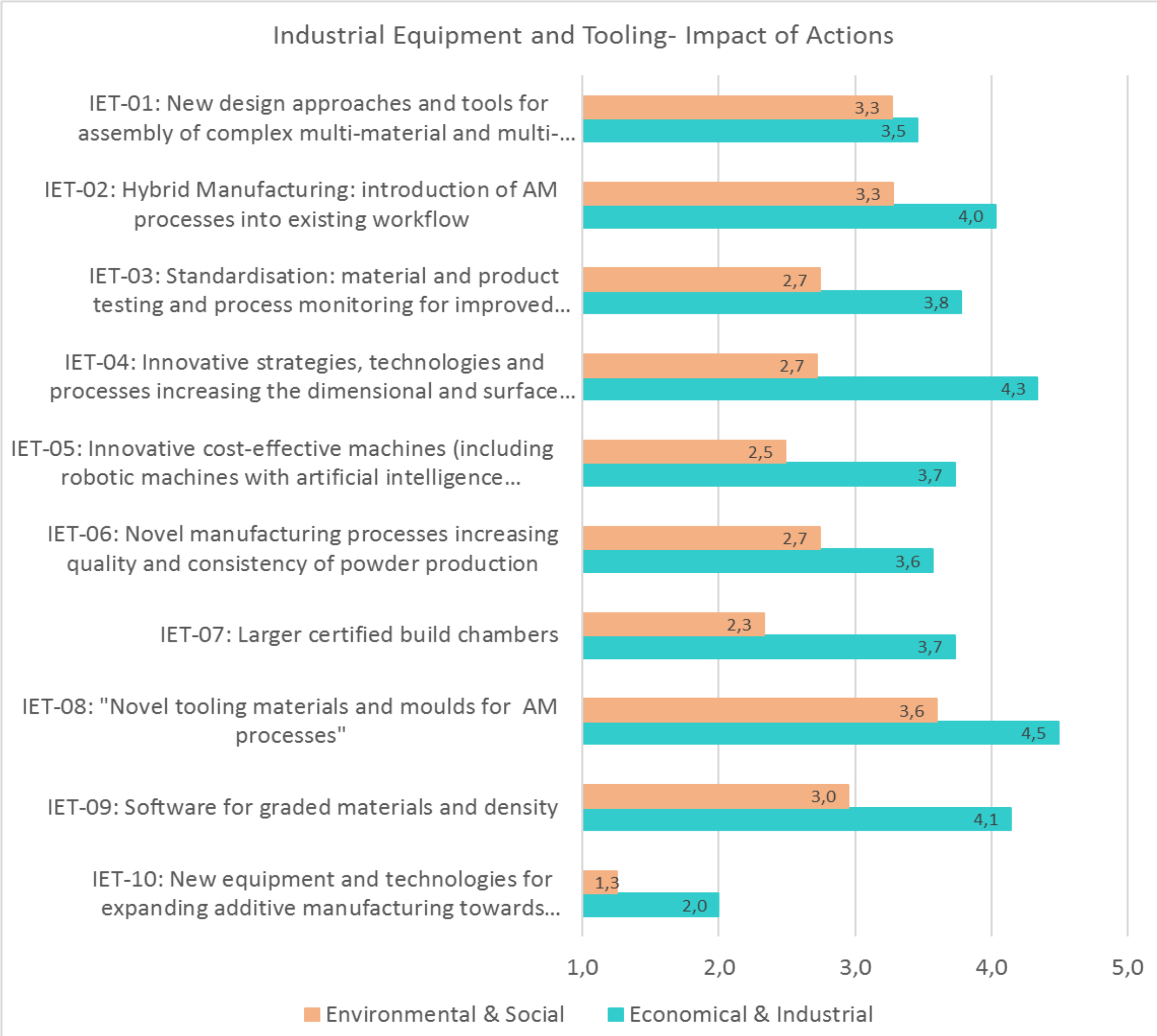

Figure 6.20: *Industrial Equipment and Tooling – Impacts of Action*

Finally, in Figure 6.21 is shown the overall average impact value of the actions, in terms Economic & Industrial Impacts and Environmental & Social Impacts.

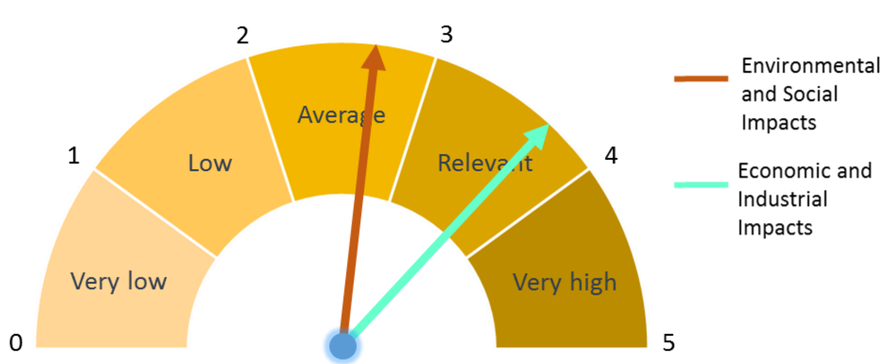

Figure 6.21:*Industrial Equipment and Tooling - Overall Average Impacts*

6.1.8. *CONSTRUCTION impacts*

As shown in Figure 6.22, from the analysis of the Health overall average of KPI, the future actions will have on a strong impact on:

- **Industrial Impacts:** Reduced manufacturing cost – 3,7
- **Economic Impacts:** New types of ventures started **–** 3,3
- **Environmental Impacts:** Material resource saving; Reduction of CO2 emission – 3,0
- **Social Impacts:** Better quality life – 2.9

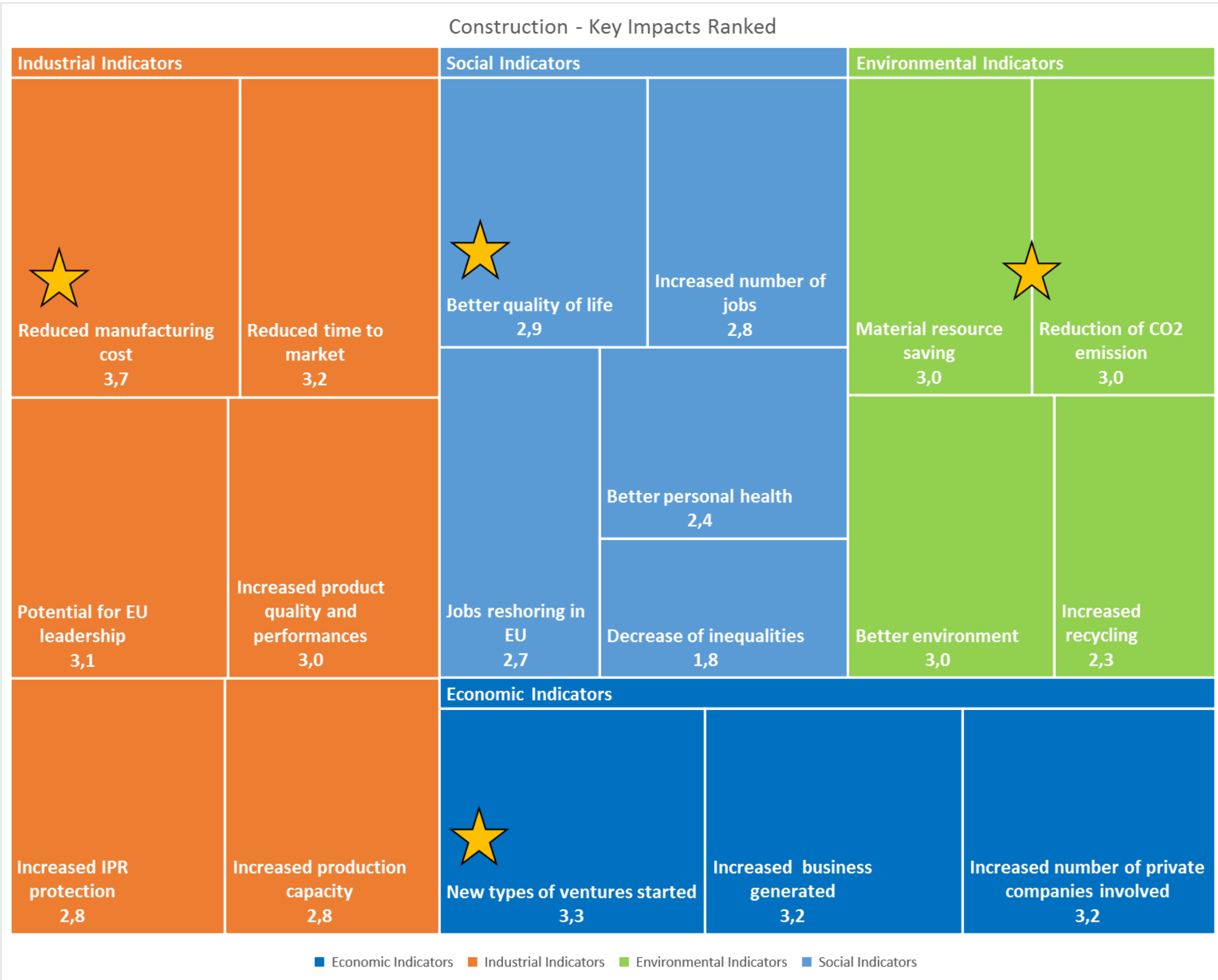

Figure 6.22: *Construction - Impacts Ranking*

The other outcome of the analysis is related to target actions. Figure 6.23 reports the results for each action divided for Economics & Industrial impacts and Environmental & Social impacts, in particular it emerges that the higher-impacts actions are:

- **For Economic and Industrial Impacts:** Methodologies to integrate concrete reinforcements in AM construction
- **For Environmental and Social Impacts:** Multimaterial printing and integrating components in to the build

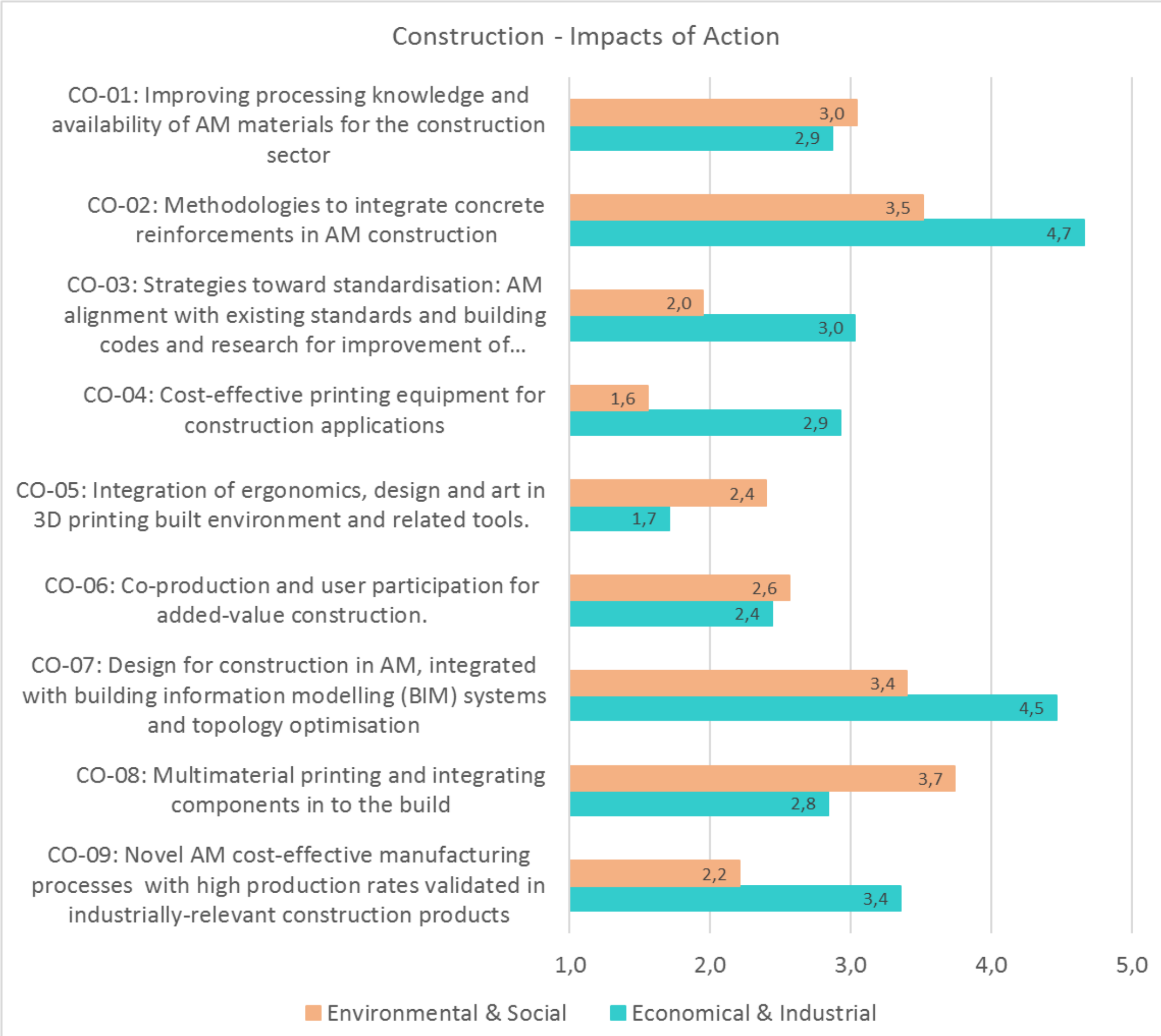

Figure 6.23: *Construction - Impacts of Action*

Finally, in Figure 6.24 is shown the overall average impact value of the actions, in terms Economic & Industrial Impacts and Environmental & Social Impacts.

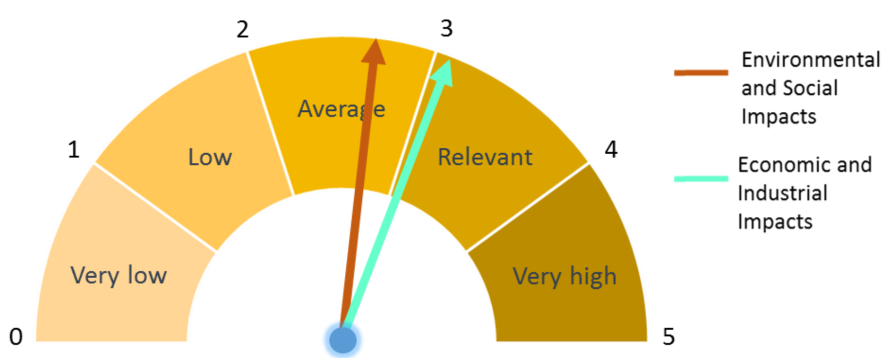

Figure 6.24: *Construction - Overall Average Impacts*

6.1.9. *ENERGY impacts*

As shown in Figure 6.25, from the analysis of the Health overall average of KPI, the future actions will have on a strong impact on:

- **Industrial Impacts:** Increased product quality and performances - 4,6
- **Economic Impacts:** Increased business generated **–** 4,8
- **Environmental Impacts:** Material resource saving – 3,4
- **Social Impacts:** Job reshoring in EU – 3,4

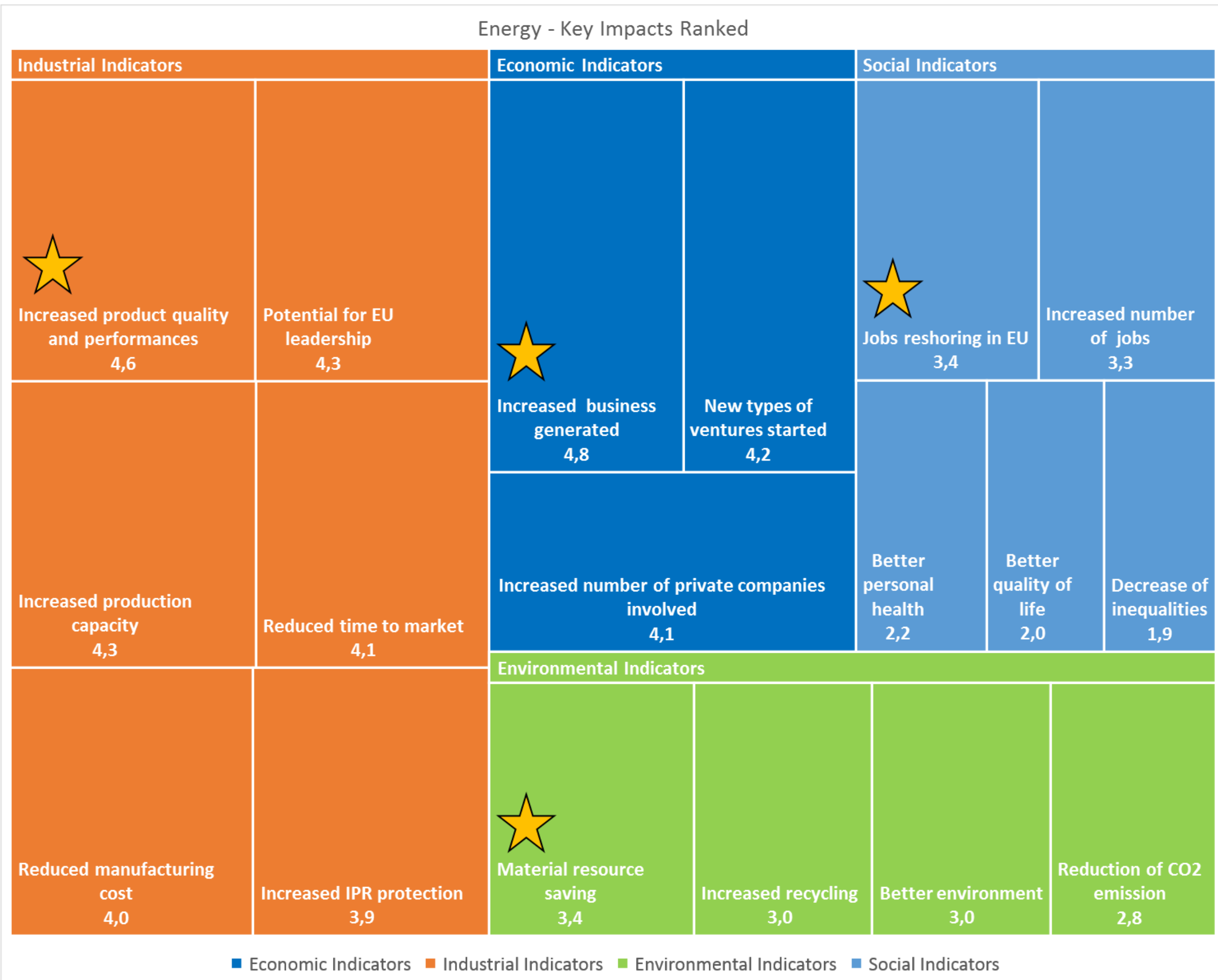

Figure 6.25: *Energy - Impacts Ranking*

The other outcome of the analysis is related to target actions. Figure 6.26 reports the results for each action divided for Economics & Industrial impacts and Environmental & Social impacts, in particular it emerges that the higher-impacts actions are:

- **For Economic and Industrial Impacts:** Demonstration of AM higher productivity and cost-effective manufacturing in the energy sector
- **For Environmental and Social Impacts:** Demonstration of AM higher productivity and cost-effective manufacturing in the energy sector

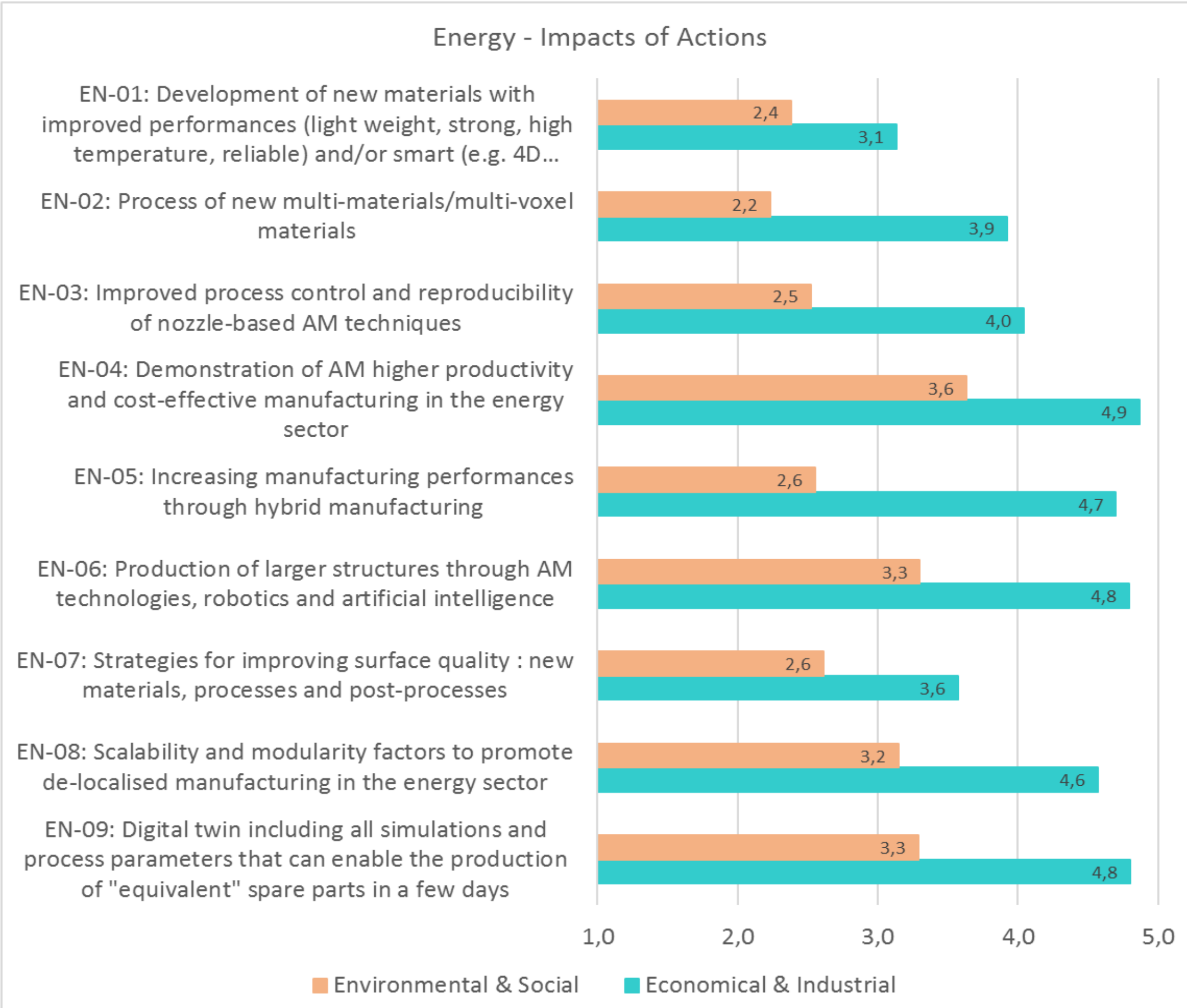

Figure 6.26: *Energy - Impacts of Action*

Finally, in Figure 6.27 is shown the overall average impact value of the actions, in terms Economic & Industrial Impacts and Environmental & Social Impacts.

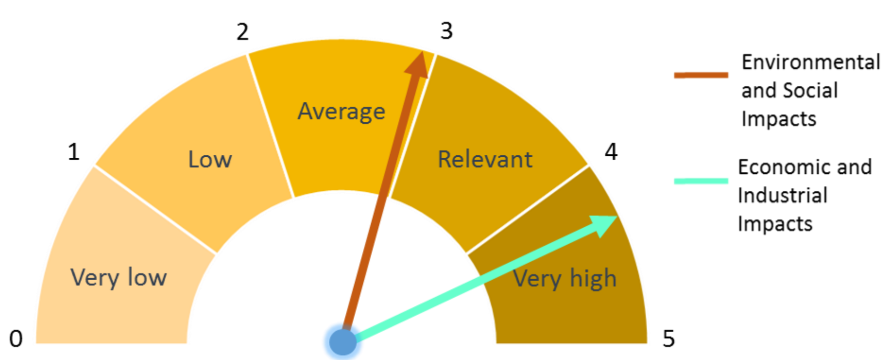

Figure 6.27: *Energy - Overall Average Impacts*

7. Conclusion

The current reports describe the draft AM-MOTION roadmap aimed at identifying future actions for the AM development and successful market uptake. The roadmap focuses on high impact sectors (described in the report) and related target product groups, includes a vision for 2030 and based on identified challenges and opportunities, proposes a set of sectorial and cross-cutting actions for short, medium and long term.

The roadmap has been developed involving around 100 external experts through physical meetings and remote surveys.

The full draft Roadmap will be publicly available at the end of July 2018. In August-September 2018 the whole community will be asked to participate online to a public consultation.

The revision of the roadmap will lead to the release of the Final AM-MOTION Roadmap, to be presented at “AMEF2018 Additive Manufacturing European Forum” (Brussels, 23-24 October). In such revision the results of business model collaboration activities performed in AM-MOTION (WP4, D4.3) will be also integrated in the roadmap.

ANNEX A: List of European AM Related Projects

FP7-PEOPLE: *9 Projects*

Acronym-Project full title	Work programme	ID	Starting date	End date	Total project budget (€) (EU contribution)	Coordinator	Country
D-FOOT PRINT-Personalised insoles via additive manufacture for the prevention of plantar ulceration in diabetes	PEOPLE	329133	14/10/2013	13/10/2015	196.682,10 (196.682,10)	THE GLASGOW CALEDONIAN UNIVERSITY	UK
DiGHiRO-Digital Generation of High Resolution Objects	PEOPLE	256530	01/05/2010	30/04/2014	100.000 (100.000)	AALTO-KORKEAKOULUSAATIO	FI
FlowMat-Exploiting Flow and Capillarity in Materials Assembly: Continuum Modelling and Simulation	PEOPLE	618335	01/09/2013	31/08/2017	100.000 (100.000)	QUEEN MARY UNIVERSITY OF LONDON	UK
INLADE-Integrated numerical modelling of laser additive processes	PEOPLE	230756	01/02/2009	31/01/2013	329.529 (329.529)	THE UNIVERSITY OF MANCHESTER	UK
INTERAQCT-International Network for the Training of Early stage Researchers on Advanced Quality control by Computed Tomography	PEOPLE	607817	01/10/2013	30/09/2017	3.850.553,52	KATHOLIEKE UNIVERSITEIT LEUVEN	BE
PRINT CART -Bioprinting of novel hydrogel structures for cartilage tissue engineering	PEOPLE	272286	01/07/2011	30/06/2014	265.944,80	UNIVERSITAIR MEDISCH CENTRUM UTRECHT	NL
RRD4E2 -Rational Reactor Design for Enhanced Efficiency in the European Speciality Chemicals Industry	PEOPLE	607114	01/10/2013	30/09/2017	668.456,97	LONZA AG	CH
SphereScaff -The Manufacturing of Scaffolds from Novel Coated Microspheres via AM Techniques for Temporomandibular Joint Tissue Engineering	PEOPLE	622414	01/08/2014	31/07/2016	245.897,90	NATIONAL UNIVERSITY OF IRELAND, GALWAY	IE
VINDOBONA -VINyl photopolymer Development Of BONe replacement Alternatives	PEOPLE	297895	01/01/2013	31/12/2014	187.888,20	TECHNISCHE UNIVERSITAET WIEN	AT

H2020-MSCA: *6 Projects*

Acronym-Project full title	Work programme	ID	Starting date	End date	Total project budget (€) (EU contribution)	Coordinator	Country
Bamos-Biomaterials and Additive Manufacturing: Osteochondral Scaffold innovation applied to osteoarthritis	MSCA-RISE	734156	01/01/2017	31/12/2020	828.000 (639.000)	University of Kragujevac (Serbia)	SB
DISTRO-Distributed 3D Object Design	MSCA-ITN	642841	01/01/2015	31/12/2018	3.264.733 (3.264.733)	University of Las Palmas de Gran Canaria	ES
NEXT-3D-Next generation of 3D multifunctional materials and coatings for biomedical applications	MSCA-RISE	645749	01/06/2015	31/05/2017	193.500 (193.500)	UNIVERSITY COLLEGE LONDON	UK

Acronym-Project full title	Work programme	ID	Starting date	End date	Total project budget (€) (EU contribution)	Coordinator	Country
PAM 2-Precision Additive Metal Manufacturing	MSCA-ITN	721383	01/12/2016	30/11/2020	3.944.925,36 (3.944.925,36)	THE UNIVERSITY OF BIRMINGHAM	UK
Revolve-Radio Technologies for Broadband Connectivity in a Rapidly Evolving Space Ecosystem: Innovating Agility, Throughput, Power, Size and Cost	MSCA-ITN	722840	01/01/2017	31/12/2020	1.834.895,07 (1.834.895,07)	KATHOLIEKE UNIVERSITEIT LEUVEN	BE
A_Madam-Advanced design rules for optimMAl Dynamic properties of Additive Manufacturing products	MSCA-RISE	734455	01/01/2017	31/12/2020	468.000 (468.000)	HWU- Heriot-Watt University	UK

FP7-NMP: *35 Projects*

Acronym-Project full title	Work programme	ID	Starting date	End date	Total project budget (€) (EU contribution)	Coordinator	Country
A-FOOT PRINT-Ankle and Foot Orthotic Personalisation via Rapid Manufacturing	NMP	228893	01/10/2009	30/09/2013	5.304.317,66 (3729043)	THE GLASGOW CALEDONIAN UNIVERSITY	UK
ArtiVasc 3D-Artificial vascularised scaffolds for 3D-tissue-regeneration	NMP	263416	01/11/2011	31/10/2015	10.467.338,60 (7800000)	FRAUNHOFER	DE
Bio-Scaffolds-Natural inorganic polymers and smart functionalized micro-units applied in customized rapid prototyping of bioactive scaffolds	NMP	604036	01/06/2013	31/05/2016	2.278.935,20 (1799002)	UNIVERSITAETSMEDIZIN DER JOHANNES GUTENBERG-UNIVERSITAET MAINZ	DE
CompoLight- Rapid Manufacturing of lightweight metal components	NMP	213477	01/11/2008	31/10/2011	4.608.786,66 (3508954)	TEKNOLOGISK INSTITUT	DK
DirectSpare-Strengthening the industries' competitive position by the development of a logistical and technological system for "spare parts" that is based on on-demand production	NMP	213424	01/02/2009	31/01/2012	5.663.047,79 (3576945)	MATERIALISE NV	BE
HydroZones- Bioactivated hierarchical hydrogels as zonal implants for articular cartilage regeneration	NMP	309962	01/01/2013	31/12/2017	13.195.256,71 (9749700)	UNIVERSTAETSKLINIKUM WUERZBURG	DE
IC2-Intelligent and Customized Tooling	NMP	246172	01/10/2010	30/09/2013	4.605.138,52 (3199995)	SINTEF Raufoss Manufacturing AS	NO
IMPALA-Intelligent Manufacture from Powder by Advanced Laser Assimilation	NMP	214380	01/09/2008	31/08/2012	6.376.380,50 (4607490)	TWI LIMITED	UK
LIGHT-ROLLS-High-throughput production platform for the manufacture of light emitting components	NMP	228686	01/07/2009	31/12/2012	5.172.419 (3748323)	FUNDACION PRODINTEC	ES

Acronym-Project full title	Work programme	ID	Starting date	End date	Total project budget (€) (EU contribution)	Coordinator	Country
MULTILAYER-Rolled multi material layered 3D shaping technology	NMP	214122	01/10/2008	31/10/2012	9.032.822,20 (6500000)	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	FR
OXIGEN-Oxide Dispersion Strengthened Materials for the Additive Manufacture of High Temperature Components in Power Generation	NMP	310279	01/02/2013	31/01/2017	5.679.519,75 (3999662)	TWI LIMITED	UK
PILOT MANU-Pilot manufacturing line for production of highly innovative materials	NMP	604344	01/10/2013	30/09/2017	5.354.079 (4014465)	MBN NANOMATERIALIA SPA	IT
PLASMAS-Printed Logic for Applications of Screen Matrix Activation Systems	NMP	604568	01/11/2013	30/04/2017	4.801.521,80 (3635432)	FRAUNHOFER	DE
STEP UP -STEP UP IN POLYMER BASED RM PROCESSES	NMP	213927	01/01/2009	31/12/2012	4.436.178 (3159200)	MBN NANOMATERIALIA SPA	IT
DIGINOVA-Innovation for Digital Fabrication	NMP	290559	01/03/2012	28/02/2014	1.676.173,50 (1265785)	OCE TECHNOLOGIES B.V.	NL
SASAM-Support Action for Standardisation in Additive Manufacturing	NMP	319167	01/09/2012	28/02/2014	682.654,80 (495000)	TNO	NL
3D-HiPMAS -Pilot Factory for 3D High Precision MID Assemblies	NMP-FoF	314293	01/10/2012	30/09/2015	5.350.276,20 (3499600)	HAHN-SCHICKARD-GESELLSCHAFT FUER ANGEWANDTE FORSCHUNG E.	DE
ADDFACTOR-ADvanced Digital technologies and virtual engineering for mini-Factories	NMP-FoF	609386	01/09/2013	31/12/2016	8.919.730,87 (5499959)	SYNESIS-SOCIETA	IT
AMAZE-Additive Manufacturing Aiming Towards Zero Waste & Efficient Production of High-Tech Metal Products	NMP-FoF	313781	01/01/2013	2017-06	18.295.541,46 (10156000)	THE MANUFACTURING TECHNOLOGY CENTRE LIMITED LBG	UK
AMCOR-Additive Manufacturing for Wear and Corrosion Applications	NMP-FoF	314324	01/11/2012	31/10/2015	4.770.044,63 (3000000)	TWI LIMITED	UK
CassaMobile-Flexible Mini-Factory for local and customized production in a container	NMP-FoF	609146	01/09/2013	31/08/2016	8.747.873,19 (5.650.000)	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	DE
FaBiMed-Fabrication and Functionalization of BioMedical Microdevices	NMP-FoF	608901	02/09/2013	01/09/2016	4.133.747,13 (3.010.000)	ASOCIACION DE INVESTIGACION METALURGICA DEL NOROESTE	ES
Factory-in-a-day	NMP-FoF	609206	01/10/2013	30/09/2017	11.111.309,10 (7968232)	TECHNISCHE UNIVERSITEIT DELFT	NL
Hi-Micro-High Precision Micro Production Technologies	NMP-FoF	314055	01/10/2012	30/09/2015	5.194.962,40 (3499997)	KATHOLIEKE UNIVERSITEIT LEUVEN	BE
HiPR-High-Precision micro-forming of complex 3D parts	NMP-FoF	314522	01/11/2012	31/10/2015	5.013.745 (3317932)	D'APPOLONIA SPA	IT

Acronym-Project full title	Work programme	ID	Starting date	End date	Total project budget (€) (EU contribution)	Coordinator	Country
Hyproline-High performance Production line for Small Series Metal Parts	NMP-FoF	314685	01/09/2012	31/08/2015	4.017.939,50 (2538000)	TNO	NL
MANSYS-MANufacturing decision and supply chain management SYStem for additive manufacturing	NMP-FoF	609172	01/07/2013	30/06/2016	4.405.531,92 (2925000)	TWI LIMITED	UK
MEGAFIT-Manufacturing Error-free Goods at First Time	NMP-FoF	285030	01/12/2011	30/11/2014	10.316.668,70 (6911469)	PHILIPS CONSUMER LIFESTYLE B.V.	NL
NANOMASTER-Graphene based thermoplastic masterbatches for conventional and additive manufacturing processes	NMP-FoF	285718	01/12/2011	30/11/2015	6.253.514,31 (4199974)	NETCOMPOSITES LIMITED	UK
Nextfactory-All-in-one manufacturing platform for system in package and micromechatronic systems	NMP-FoF	608985	01/09/2013	31/08/2017	4.758.207,20 (3.483.177)	FRAUNHOFER	DE
OPTICIAN2020-Flexible and on-demand manufacturing of customised spectacles by close-to optician production clusters	NMP-FoF	609251	01/10/2013	30/09/2016	5.770.512,80 (3614999)	FUNDACIO EURECAT	ES
PHOCAM-Photopolymer based customized additive manufacturing technologies	NMP-FoF	260043	01/06/2010	31/05/2013	3.609.446,60 (2455362)	TECHNISCHE UNIVERSITAET WIEN	AT
PLAST 4FUTURE -injection Moulding Production Technology for Multi-functional Nano-structured Plastic Components enabled by NanoImprint Lithography	NMP-FoF	314345	01/01/2013	31/12/2015	9.547.981,11 (6000000)	DANMARKS TEKNISKE UNIVERSITET	DK
SMART LAM-Smart production of Microsystems based on laminated polymer films	NMP-FoF	314580	01/10/2012	31/01/2016	3.633.791,70 (2673000)	KARLSRUHER INSTITUT FUER TECHNOLOGIE	DE
Stellar-Selective Tape-Laying for Cost-Effective Manufacturing of Optimised Multi-Material Components	NMP-FoF	609121	01/09/2013	31/08/2016	4.007.208 (2774266)	NETCOMPOSITES LIMITED	UK

H2020-LEIT NANO +LEIT ADVMANU: *21 Projects*

Acronym-Project full title	Work programme	ID	Starting date	End date	Total project budget (€) (EU contribution)	Coordinator	Country
iBUS – an integrated business model for customer driven custom product supply chains	NMP	646167	01/09/2015	31/08/2019	7.440.361,25 (6065305)	UNIVERSITY OF LIMERICK	IE
DIMAP-Novel nanoparticle enhanced Digital Materials for 3D Printing and their application shown for the robotic and electronic industry	NMP	685937	01/10/2015	30/09/2018	4.997.351,25 (4997351,25)	PROFACTOR GMBH	AT
FAST-Functionally graded Additive Manufacturing scaffolds by hybrid manufacturing	NMP	685825	01/12/2015	30/11/2019	4.916.750 (4916750)	UNIVERSITEIT MAASTRICHT	NL
NANOTUN3D-Development of the complete workflow for producing and using a novel nanomodified Ti-based alloy for additive manufacturing in special applications.	NMP	685952	01/10/2015	31/03/2019	2.936.657 (2936656)	AIDIMME	ES
SYNAMERA-Synergies in Nanotechnologies, Materials and Production in the European Research Area	NMP	645900	01/05/2015	30/04/2017	496.221,25 (496.221,25)	REGION NORD-PAS-DE-CALAIS ET PICARDIE	FR
PRINTCR3DIT-Process Intensification through Adaptable Catalytic Reactors made by 3D Printing	SPIRE	680414	01/10/2015	30/09/2018	5.493.891,00 (5493889)	STIFTELSEN SINTEF	NO
SUPREME-Sustainable and flexible powder metallurgy processes optimization by a holistic reduction of raw material resources and energy consumption.	SPIRE	768612	01/09/2017	2020-08-31	9.810.119 (7959642,89)	CEA	FR
Hyprocell-Development and validation of integrated multiprocess HYbrid PROduction CELLs for rapid individualized laser-based production	FoF	723538	01/11/2016	31/10/2019	6.163.607,50 (3937331)	LORTEK S COOP	ES
Z-Fact0r-Zero-defect manufacturing strategies towards on-line production management for European factories	FoF	723906	01/10/2016	31/03/2020	6.043.018,75 (4206252,88)	ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS CHARILAOU THERMI	GR
4DHybrid-Novel ALL-IN-ONE machines, robots and systems for affordable, worldwide and lifetime Distributed 3D hybrid manufacturing and repair operations	FoF	723795	01/01/2017	31/12/2019	9.429.875 (4990000)	PRIMA ELECTRO SPA	IT
Borealis – the 3A energy class Flexible Machine for the new Additive and Subtractive Manufacturing on next generation of complex 3D metal parts.	FoF	636992	01/01/2015	31/12/2017	7.986.625 (5968875)	Prima Industrie SpA	IT
CerAMfacturing-Development of ceramic and multi material components by additive manufacturing methods for personalized medical products	FoF	678503	01/10/2015	30/09/2018	5.121.799,50 (5.121.799,50)	FRAUNHOFER	DE
HINDCON-Hybrid INDustrial CONstruction through a 3D printing "all-in-one" machine for largescale advanced manufacturing and building processes	FoF	723611	15/09/2016	14/09/2019	4.798.205 (4.798.205)	VIAS Y CONSTRUCCIONES	ES
KRAKEN-Hybrid automated machine integrating concurrent manufacturing processes, increasing the production volume of functional on-demand using high multi-material deposition rates	FoF	723759	01/10/2016	30/09/2019	5.947.836,25 (4711586,25)	FUNDACION AITIIP	ES

Acronym-Project full title	Work programme	ID	Starting date	End date	Total project budget (€) (EU contribution)	Coordinator	Country
LASIMM-Large Additive Subtractive Integrated Modular Machine	FoF	723600	01/10/2016	30/09/2019	4.868.262,50 (4.868.262,50)	EUROPEAN FEDERATION FOR WELDING JOINING AND CUTTING	BE
OpenHybrid-Developing a novel hybrid AM approach which will offer unrivalled flexibility, part quality and productivity	FoF	723917	01/10/2016	30/09/2019	6.643.718,75 (5133381,25)	THE MANUFACTURING TECHNOLOGY CENTRE LIMITED LBG	UK
REProMag-Resource Efficient Production Route for Rare Earth Magnets	FoF	636881	01/01/2015	31/12/2017	5.726.365 (5.726.365)	OBE OHNMACHT & BAUMGARTNER GMBH & CO KG	DE
Symbionica-Reconfigurable Machine for the new Additive and Subtractive Manufacturing of next generation fully personalized bionics and smart prosthetics	FoF	678144	01/10/2015	30/09/2018	7.305.000 (4908750)	THE MANUFACTURING TECHNOLOGY CENTRE LIMITED LBG	UK
ToMAx-Toolless Manufacturing of Complex Structures	FoF	633192	01/01/2015	31/12/2017	3.157.986 (3.157.986)	TECHNISCHE UNIVERSITAET WIEN	AT
AM-motion-A strategic approach to increasing Europe's value proposition for Additive Manufacturing technologies and capabilities	FoF	723560	01/11/2016	31/12/2018	993.052,50 (993.052,50)	FUNDACION PRODINTEC	ES
FoFAM-Industrial and regional valorization of FoF Additive Manufacturing Projects	FoF	636882	01/01/2015	31/12/2016	348.210 (348.210)	FUNDACION PRODINTEC	ES

FP7-ICT: *1 project*

Acronym-Project full title	Work programme	ID	Starting date	End date	Total project budget (€) (EU contribution)	Coordinator	Country
Fabulous-FDMA Access By Using Low-cost Optical Network Units in Silicon Photonics	ICT	318704	01/10/2012	30/06/2016	4.327.394 (2900000)	ISTITUTO SUPERIORE MARIO BOELLA SULLE TECNOLOGIE DELL'INFORMAZIONE E DELLE TELECOMUNICAZIONI	IT

H2020-LEIT ICT: *11 projects*

Acronym-Project full title	Work programme	ID	Startingdate	End date	Total project budget (€) (EU contribution)	Coordinator	Country
AMABLE-AdditiveManufacturABLE	FoF	768775	01/09/2017	31/08/2021	8.217.959 (8001358,75)	FRAUNHOFER	DE
CAXMAN-Computer Aided Technologies for Additive Manufacturing	FoF	680448	01/09/2015	31/08/2018	7.143.300 (7.143.300)	STIFTELSEN SINTEF	NO
Modulase-Development and Pilot Line Validation of a Modular re-configurable Laser Process Head	FoF	723945	01/09/2016	31/08/2019	2.458.465 (2184565)	TWI LIMITED	UK
DREAM-Driving up Reliability and Efficiency of Additive Manufacturing	FoF	723699	01/10/2016	30/09/2019	3.242.435 (3.242.435)	CONSORZIO INTERUNIVERSITARIO NAZIONALE PER LA SCIENZA E TECNOLOGIA DEI MATERIALI	IT
MAESTRO-Modular laser based additive manufacturing platform for large scale industrial applications	FoF	723826	01/10/2016	30/09/2019	3.995.905 (3.995.905)	CENTRE TECHNIQUE INDUSTRIEL DE LA PLASTURGIE ET DES COMPOSITES	FR
PARADDISE-A Productive, Affordable and Reliable solution for large scale manufacturing of metallic components by combining laser-based ADDItive and Subtractive processes with high Efficiency	FoF	723440	01/10/2016	30/09/2019	3.761.402,50 (3.761.402,50)	FUNDACION TECNALIA RESEARCH & INNOVATION	ES
HIPERLAM-High Performance Laser-based Additive Manufacturing	FoF	723879	01/11/2016	31/10/2019	3.756.256,25 (3.756.256,25)	ORBOTECH LTD	IL
Combilaser-COMbination of non-contact, high speed monitoring and non-destructive techniques applicable to LASER Based Manufacturing through a self-learning system	FoF	636902	01/01/2015	31/12/2017	3.439.420 (3.439.420)	HIDRIA AET d.o.o. Slovenia	SL
ENCOMPASS-ENgineering COMPASS	FoF	723833	01/01/2016	31/12/2019	4.040.371 (4.040.371)	THE MANUFACTURING TECHNOLOGY CENTRE LIMITED LBG	UK
DiDIY-Digital Do It Yourself	ICT	644344	01/01/2015	30/06/2017	2.081.767,50 (2.081.767,50)	UNIVERSITA' CARLO CATTANEO - LIUC	IT
SARAFun-Smart Assembly Robot with Advanced FUNctionalities	ICT	644938	01/03/2015	28/02/2018	4.037.266,25 (4.037.266,2)	ABB AB	SE

FP7-TRANSPORT: *2 projects*

Acronym-Project full title	ID	Starting date	End date	Total project budget (€) (EU contribution)	Coordinator	Country
RepAIR -Future RepAIR and Maintenance for Aerospace industry	605779	01/06/2013	31/05/2016	5.979.564,01 (4276277)	UNIVERSITAET PADERBORN	DE
MERLIN- Development of Aero Engine Component Manufacture using Laser Additive Manufacturing	266271	01/01/2011	31/12/2014	7 062 175,83 (4.886.561)	ROLLS ROYCE PLC	UK

H2020-Societal challenge-TRANSPORT: *3 projects*

Acronym-Project full title	ID	Startingdate	End date	Total project budget (€) (EU contribution)	Coordinator	Country
AMOS-Additive Manufacturing Optimization and Simulation Platform for repairing and remanufacturing of aerospace components	690608	01/02/2016	31/01/2020	1.396.188,75 (1.396.188,75)	THE UNIVERSITY OF SHEFFIELD	UK
Bionic Aircraft-Increasing resource efficiency of aviation through implementation of ALM technology and bionic design in all stages of an aircraft life cycle	690689	01/09/2016	31/08/2019	7.968.812 (6.441.062)	LZN LASER ZENTRUM NORD GMBH	DE
EMUSIC-Efficient Manufacturing for Aerospace Components USing Additive Manufacturing, Net Shape HIP and Investment Casting	690725	01/04/2016	31/03/2019	2.193.278,75 (1.799.993,75)	THE UNIVERSITY OF BIRMINGHAM	UK

FP7-SME: *8 projects*

Acronym-Project full title	ID	Starting date	End date	Total project budget (€) (EU contribution)	Coordinator	Country
FastEBM-High Productivity Electron Beam Melting Additive Manufacturing Development for the Part Production Systems Market	729290	01/12/2011	30/11/2013	1.488.264,83	ARCAM AB; TLS TECHNIK GMBH & CO. SPEZIALPULVER KG	DE
HiResEBM-High resolution electron beam melting	286695	01/10/2011	30/09/2015	1.404.732	ARCAM AB	DE
Implant Direct	286762	01/09/2012	31/08/2014	1.497.312,73	TWI LIMITED	UK
INT RAPID-Innovative inspection techniques for laser powder deposition quality control	286577	01/09/2011	31/08/2013	1.442.306,40	TWI LIMITED	UK
KARMA-Knowledge Based Process planning and Design for Additive Layer Manufacturing	283833	01/07/2010	30/06/2013	2.040.417,21	FEMEVAL	ES
Ownerchip-Digital Rights Management Infrastructure For 3D Printed Artifacts	243631	01/10/2014	31/03/2015	71.429	THINGS3D LIMITED	UK
PP-MIPS-An innovative phosphorus rich intumescent oligomer enabling commercially competitive high performance halogen free fire protection of polypropylene	651604	01/11/2010	31/10/2012	1.490.231,80	Advanced Insulation Systems Ltd	UK
TIALCHARGER-Titanium Aluminide Turbochargers – Improved Fuel Economy, Reduced Emissions	262308	01/02/2013	30/06/2015	1.548.216,28	TWI LIMITED	UK

H2020-SME: *1 project*

Acronym-Project full title	ID	Starting date	End date	Total project budget (€) (EU contribution)	Coordinator	Country
3DT Tool-Next Generation of Cutting Tools Using Additive Manufacturing Technology I, Phase 1	729290	01/06/2016	30/09/2016	71.429 (50.000)	DANSKE VAERKTOEJ APS	DK

FP7-ERC: *4 projects*

Acronym-Project full title	ID	Starting date	End date	Total project budget (€) (EU contribution)	Coordinator	Country
CombiPatterning-Combinatorial Patterning of Particles for High Density Peptide Arrays	277863	01/11/2011	31/10/2016	1.494.600	KARLSRUHER INSTITUT FUER TECHNOLOGIE	DE
CopyMe3D: High-Resolution 3D Copying and Printing of Objects	632200	01/09/2014	31/08/2015	1,66166 357,20	TECHNISCHE UNIVERSITAET MUENCHEN	DE
M&M's: New Paradigms for MEMS & NEMS Integration	277879	01/11/2011	31/10/2017	1.495.982	KUNGLIGA TEKNISKA HOEGSKOLAN	SE
ShapeForge: By-Example Synthesis for Fabrication	307877	01/12/2012	30/11/2017	1.301.832	INSTITUT NATIONAL DE RECHERCHE ENINFORMATIQUE ET AUTOMATIQUE DOMAINE DE VOLUCEAU ROCQUENCOURT	FR

H2020-ERC: *2 projects*

Acronym-Project full title	ID	Starting date	End date	Total project budget (€) (EU contribution)	Coordinator	Country
3D2DPrint-3D Printing of Novel 2D Nanomaterials: Adding Advanced 2D Functionalities to Revolutionary Tailored 3D Manufacturing	681544	01/10/2016	30/09/2021	2.499.942	THE PROVOST, FELLOWS, FOUNDATION SCHOLARS THE COLLEGE OF THE HOLY & UNDIVIDED TRINITY OF QUEEN ELIZABETH NEAR DUBLIN	IE
BIO-ORIGAMI-Meta-biomaterials: 3D printing meets Origami	677575	01/02/2016	31/01/2021	1.499.600	TECHNISCHE UNIVERSITEIT DELFT	NL

FP7-JTI: *7 projects*

Acronym-Project full title	ID	Starting date	End date	Total project budget (€) (funding)	Coordinator	Country
AEROBEAM- Direct Manufacturing of stator vanes through electron beam melting	323476	01/10/2012	30/09/2013	134.601,30 (100.950,98)	ASOCIACION DE INVESTIGACION DE LAS INDUSTRIAS METALMECANICAS, AFINES Y CONEXAS	ES
AeroSim- Development of a Selective Laser Melting (SLM) Simulation tool for Aero Engine	287087	01/05/2012	31/07/2015	966.476,40 (700.290)	TECHNISCHE UNIVERSITAET MUENCHEN	DE
ASLAM- Advanced materials for lean burn combustion tiles using laser-Additive Layer Manufacturing (L-ALM)	619993	01/10/2013	31/08/2016	995 398 (745.619)	MATERIALS SOLUTIONS LIMITED	UK
Hi-StA-Part- High Strength Aluminium Alloy parts by Selective Laser Melting	325931	01/02/2013	31/03/2015	120.646,52 (89.711)	TWI LIMITED	UK
MALT - Multilaser Additive Layer Manufacturing of Tiles	336560	01/06/2013	31/12/2016	2.399.662,79 (1.319.664,6)	MATERIALS SOLUTIONS LIMITED	UK
SIMCHAIN- Development of physically based simulation chain for microstructure evolution and resulting mechanical properties focused on additive manufacturing processes	326020	01/07/2013	31/08/2016	946.471,40 (616.305)	UNIVERSITAET BAYREUTH	DE
TIFAN- Manufacturing by SLM of Titanium FAN wheel. Comparison with a conventional manufacturing process	620093	01/10/2013	31/03/2015	199.989,20 (142.000)	LORTEK S. COOP	ES

<u>H2020-JTI:</u> *<u>4 projects</u>*

Acronym-Project full title	ID	Starting date	End date	Total project budget (€) (funding)	Coordinator	Country
BARBARA- Biopolymers with advanced functionalities for building and automotive parts processed through additive manufacturing	745578	01/05/2017	30/04/2020	2.711.375 (2.603.861,25)	FUNDACION AITIIP	ES
Ascent AM- Adding Simulation to the Corporate ENvironmenT for Additive Manufacturing	714246	01/08/2016	31/07/2019	699.375 (699.375)	TECHNISCHE UNIVERSITAET MUENCHEN	DE
DISTRACTION- Design against DISTortion of metallic aerospace parts based on combination of numeRical modelling ACTivities and topology optimisatION	686808	04/01/2016	03/01/2019	449.420 (449.420)	LORTEK S. COOP	ES
ALFORAMA-Innovative Al alloy For aircraft structural parts using Additive MAnufacturing technology	755610	01/07/2017	30/06/2020	598.447,50 (598.447,50)	LORTEK S. COOP	ES

<u>ERASMUS+:</u> *<u>4 projects</u>*

Acronym-Project full title	ID	Starting date	End date	Total project budget (€) (funding)	Coordinator	Country
3DPRISM-3DPRinting Skills for Manufacturing		2014	2018	337.350	University of Sheffield	UK
METALS-MachinE Tool ALliance for Skills		2015	2018	858.080	CECIMO	BE
ADMIRE-Knowlede Alliance for Additive Manufacturing between industry and universities		01/01/2017	31/12/2019	998.035,00	CRANFIELD UNIVERSITY	UK
CLAIMM-Creating knowLedge and skilLs in AddItive Manufacturing		01/01/2018	31/12/2020	997.488 (997.448)	CESOL	ES

INTERREG: *4 projects*

Acronym-Project full title	ID	Starting date	End date	Total project budget (€) (funding)	Coordinator	Country
SAMT-SUDOE- Spread of AM and advanced materials technologies for the promotion of KET industrial Technologies in plastic processors and mould industries within sudoe space		27/09/2016	30/06/2019	994.827	AIJU	SPAIN
ADDISPACE- Selection of aerospace components for improving Metal Additive Manufacturing technologies		01/07/2016	30/06/2019	1.774.450,69	ESTIA	FRANCE
TRANSFRONT 3D		01/06/2016	01/06/2019	1.649.649 (1.025.525)	TECNALIA	SPAIN
COMPETITIV'eko					Nouvelle Aquitanio Comerce Chamber	FRANCE

ANNEX B: List of Regional AM Related Projects

N.B. Project highlighted in yellow are actually labs/centres/facilities built thanks to national/regional fundings.

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
1	Austria		AM 4 Industry	Quality assurance and cost models supporting the wide spread use of additive manufacturing		01/11/2016	ECO plus								x	x
2	Austria		HiPA²l	High Performance Additive Manufacturing of Aluminium alloys	National agencies	01/06/2017	LKR Leichtmetallkompetenzzentrum Ranshofen GmbH (Austria)								x	x
3	Austria		NextGen3D	Next Generation 3D-Printing: Material and process development for the industry-strength application	FFG	01/04/2015	Profactor								x	
4	Belgium		FATAM	Fatigue of Additive Manufactured components – Relating AM process conditions to long-term dynamic performance of metallic AM parts	SIM & VLAIO	01/05/2017	Siemens Industry Software NV								x	
5	Belgium		HyLa Form	Hybrid laser-based additive & subtractive research platform		2017	VUB	x	x			x	x	x		
6	Belgium	Wallonie	IAWATHA	InnovAtion en Wallonie par les TecHnologies Additives	FEDER and Wallonie and Operateurs publics	2016	Sirris	x	x	x		x	x	x		

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
7	Belgium		STREAM	STRuctural Engineering materials through Additive Manufacturing: 3D printing of structural materials by increasing the knowledge base about additive manufacturing of polymers and metals, with emphasis on the material properties.	SIM & VLAIO	01/12/2013	Materialise								x	
8	Czech Republic		3D Concept	V rámci projektu se otevírá specializované multifunkční centrum zaměřené na inovace v oblasti designu výrobků, vývoje nových produktů, výrobních postupů a dekorativního umění pomocí technologie 3D tisku.	OPERAČNÍ PROGRAM PRAHA – KONKURENCESCHOPNOST	01/04/2014	NAVIGA 4, sro								x	
9	Czech Republic		3D Concept – nový rozměr	V rámci projektu budou pořízeny nové technologie pro prezentaci modelů technologií "rozšířené reality" a tisk modelů s hladkým povrchem a vysokou mírou detailu.	OPERAČNÍ PROGRAM PRAHA – KONKURENCESCHOPNOST	01/06/2015	NAVIGA 4, sro								x	
10	Czech Republic		Ortho3D			01/07/2015	ProSpon, spol. s r.o.						x			
11	Czech Republic		Adaptivní parametrický CAD model ortézy horní		ERDF (European Regional Development Fund)	17/10/2016	Ortopedická protetika Frýdek-Místek, s.r.o.						x			

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
			končetiny zhotovené 3D tiskem													
12	Czech Republic		Implementace 3D tisku kovů a jeho využití u kovovýroby pro automotive		ERDF (European Regional Development Fund)	2017	LAKUM - AP, a.s.		x							
13	Denmark		3DIMS	3D Printing Integrated Manufacturing System	Innovation Fund Denmark	2016	AddiFab ApS			x			x	x		
14	Denmark		CartigenPro	3D printede implantater med nanoteknologi skal genskabe ødelagte led	Innovation Fund Denmark	2013	DAVINCI Development A / S						x			
15	Denmark		3D-print i nyt plastmateriale med grafen		Innovation Fund Denmark	2015	Aarhus University			x		x				
16	Denmark		3P	Personalised food Products for Patients	Innovation Fund Denmark	2018	The Danish Technological Institute						x			x
17	Finland		3D Boost and 3D Invest	The objective of the project is to form a remarkable hub of expertise in 3D printing techniques in Tampere Region.			Tampere University of Technology (TUT), Tampere University of Applied Sciences (TAMK) and Sastamala Municipal Education and Training Consortium (SASKY)								x	
18	Finland		HYBRAM	Industrialization of Hybrid and Additive Manufacturing – Implementation to Finnish industry		01-06-2016	Tampere University of Technology							x		x
19	Finland		Project Juniper	Large Scale Wood Printing	Business Finland	01/09/2017	3D Step				x					

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
20	Finland		Välkky	Vaativa digitaalinen valmistus ekosysteemin lisäarvon tuottajana	Pirkanmaan liitto	2016	VTT & Tampere University of Technology							x		x
21	France		3D Hybrid	Machine HYBRIDE d'impression 3D métal couplant fonctions additive (SLM) et soustractive (laser ultracourt)	Fonds Uniques Interministerial (FUI)		Manutech USD	x	x			x	x			
22	France		3DRX-online	Cathodes CNTs forts courants pour le contrôle RX 3D en ligne	ANR	01/10/2015	Thales Research & Technology							x		
23	France		3D-SLS	3D-numerical Simulation of the Laser Sintering processing of thermoplastic powders for the prediction of microstructural features and part warpage	ANR	01/10/2015	Institut National des Sciences Appliquées de Lyon - Laboratoire d'Ingénierie des Matériaux Polymères /National Institute of Applied Sciences of Lyon - Laboratoire d'Ingénierie							x		x
24	France		ACAPULCO	Développement d'outillages d'injection polymère avec la technologie DLP	Fonds unique interministériel (FUI)	10/01/2016	SMP							x		
25	France		ALMARIS	Architecturation Laser de MAtéRIaux Superélastiques	ANR	2016	ONERA PALAISEAU	x								
26	France	Rhône-Alpes	Almée	Aluminium Additive Layer Manufacturing pour Equipements Electroniques	Fonds Uniques Interministerial (FUI)		THALES	x		x						

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
27	France		ATOMIQ	Advanced Technologies fOr Millimeterwave Integrated filters in Q and V bands	ANR	01/01/2014	THALES ALENIA SPACE FRANCE	x								x
28	France		Bone printing	Laser-Assisted Bioprinting for bone tissue engineering	ANR	01/11/2010	INSTITUT NATIONAL DE LA SANTE ET DE LA RECHERCHE MEDICALE - DELEGATION DE BORDEAUX						x			x
29	France		CAPIT4L	Réalisation de caloducs en fabrication additive polymère avec développement de polymères conducteurs thermiques	Institute Carnot	01/01/2018	IPC	x		x						
30	France		CNRS3D/SATTSE between Nancy and Marseille	2 Photons 3D printing	SATT-SE and CNRS	2015	L. Gallais								x	x
31	France		CNRS4D between Nancy and Paris	Matière stimulable par fabrication additive	CNRS	2017	B. Roman								x	x
32	France		CNRS-I3DI between Marseille and Nancy	Impression 3D Instantanée	CNRS	2017	M. Zerrad								x	x
33	France	Rhône-Alpes	Dry to Fly	Eco-Fabrication 3D imbricative intelligente de pièces de grandes dimensions	INVESTISSEMENT D'AVENIR PSPC	01/01/2015	MECACHROME	x	x		x	x		x		
34	France		ELASTICITE	Titanium alloys elaboration with superelastic properties for cladding tests implants	ANR	01/03/2013	INSA de Strasbourg, LGeCO						x			x

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
35	France		FA2SCINAE	Additive Manufacturing and Fatigue of cellular structures integrated in aerospace	ANR	01/10/2015	SIMAP	x								x
36	France		FADIPLAST 2													
37	France		FAIR	(Fabrication additive pour intensification de réacteurs	(CGI) + BPI		Air Liquide & Poly-Shape								x	
38	France		FastPrinting	New Photosensitive Resins for Fast Printing	ANR	01/10/2015	Institut de Science des Matériaux de Mulhouse /Institute of Materials Science of Mulhouse							x		x
39	France		FollowKnee	Improve Follow-up of Knee surgery	ANR	02/2018	INSERM DR Grand-Ouest						x			
40	France	Rhône-Alpes	GPP MULTIMAT	Grand Projet Poudre Multimatériaux	Fonds Uniques Interministerial (FUI)	01/01/2007	CETIM	x	x				x			x
41	France		Grand Est Region 4D between Mulhouse, Nancy, Reims, Strasbourg	4D Printing	Instituts Carnot	2018	A Spangenberg and C. Frochot								x	x
42	France		GRMH2TANK	High-performance and lightweight Graphene-CFRP compressed Hydrogen storage tank for aerospace applications	ANR	01/12/2015	University of Kiel, Faculty of engineering, Institute for Material Science - Functional Nanomaterials	x								x
43	France		ILTO	Laser printing of organic thin film transistors	ANR	01/01/2012	CNRS DR Provence et Corse			x						

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
44	France	Rhône-Alpes	Itech Mould	Intégration de technologies innovantes pour le développement de moules optimisés thermiquement pour l'injection thermoplastique, la mise en forme des composites et la fonderie sous-pression	Fonds Uniques Interministeriel (FUI)	01/01/2014	ARRK Shapers							x		
45	France		LEMCI	Laboratory of research and modeling for Printed Circuit Boards	ANR	01/03/2015	Laboratoire d'etude des microstructures et de mécanique des matériaux / Laboratory for the study of microstructures and materials mechanics			x						x
46	France		LIGNOPROG	Modelling progression of enzymes in lignocellulosic assemblies and plant cell walls	ANR	01/10/2014	UMR Fractionnement des Agroressources et Environnement				x					x
47	France		MACOY3D	Dielectric composite materials, with optimized microwave properties and prepared by 3D additive manufacturing	ANR	01/10/2015	Institut de Chimie de la Matière Condensée de Bordeaux /Institute of Chemistry of Condensed Matter of Bordeaux	x		x						x

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
48	France		MATERIAL	Micro-geometry Approach of Texture Reproduction for Artistic Legacy	ANR	01/10/2015	Institut National de Recherche en Informatique et en Automatique /National Institute for Research in Computer Science and Control			x						
49	France		MELTED	Amélioration de la tenue en fatigue d'empreintes de moule réalisées en fabrication additive métal	Institute Carnot	01/01/2017	LaMCoS							x		
50	France		MMLED	Modélisation multi échelle et étude expérimentale de l'endommagement dans les matériaux composites architectures obtenus par fabrication additive	ANR	2017	MSME Laboratoire Modélisation et Simulation Multi Echelle								x	
51	France		MONARCHIES	Molds and cores architectured by sand 3D printing	ANR	01/12/2015	Laboratoire d'Ingénierie et Sciences des matériaux - URCA /Laboratory of Engineering and Materials Science							x		x
52	France		MOSART	Processing of architectured structures for transpiration cooling	ANR	01/10/2014	Office National des Etudes et de Recherches Aérospatiales	x								x
53	France	Rhône-Alpes	Mouilinnov	Développement de MOULes INNOVants à hautes performances pour l'injection de matières plastiques	Fonds Uniques Interministerial (FUI)	01/01/2013	SCHNEIDER Electric							x		

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
54	France		NextBone	Bone of Tomorrow	ANR	01/10/2015	Groupe d'Etudes sur le Remodelage Osseux et les bioMatériaux / Study Group on Bone Remodeling and BioMaterials						x			x
55	France		OrthoFLase	Manufacturing of tricalcium phosphate bone tissue engineered orthopedic implants by selective laser sintering	ANR	01/01/2012	OSSEOMATRIX						x			x
56	France		PAM-PROD		PIA3	04/2018	APERAM							x		
57	France		SISCob	Safety Intelligent Sensor for Cobot	ANR	01/10/2014	PPRIME - Université de Poitiers /Poitiers university							x		x
58	France		SOFIA	"Solutions pour la Fabrication Industrielle Additive métallique"	Auvergne-Rhône-Alpes region	2016	Fives Michelin Additive Solutions								x	x
59	Germany		3DHartstoffdruck	Generative Fertigung hochbeanspruchter, dünnwandiger, komplexer Strukturelemente mittels Kurzlichtbogenverfahren und Fülldraht	BMBF-Förderung	01/05/2016	GEFERTEC GmbH				x			x		
60	Germany		ASM	Additive Sandwich Manufacturing: Innovative Prozesskette zur Herstellung faserverstärkter Funktionsbauteile auf	BMBF-Förderung	01/10/2106	EEW-PROTEC GmbH					x		x		

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
				Basis von Sandwichstrukturen mittels additiver Fertigung												
61	Germany		3dsupply	3Dprint-Supply Services	BMBF-Förderung	01/09/2017	FIR e. V. an der RWTH Aachen								x	x
62	Germany		3DMetalWire	Entwicklung einer Produktionstechnologie zum drahtbasierten 3D-Drucken von Metallbauteilen	BMBF-Förderung	01/06/2017			x					x		
63	Germany		AMPECS	Entwicklung eines neuen additiven Herstellungsverfahrens für 3D gedruckte Elektronik auf keramischen Substraten	BMBF-Förderung	01/06/2017	Neotech AMT GmbH			x						x
64	Germany		COMMANDD	Rechnerunterstützte Entwicklung und Fertigung dentaler Produkte	BMBF-Förderung	01/03/2012	Datron AG - Technology Center						x			
65	Germany		ConPAM	Entwicklung eines flexiblen und skalierbaren Systems zur Aufbereitung metallischer Pulver für additive Fertigungsprozesse	BMBF-Förderung	01/07/2017	Technische Universität Chemnitz								x	

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
66	Germany		HiPerLS	Ressourceneffizientes und reproduzierbares Hochleistungs-Laser-Sintern zur Herstellung von Kunststoffbauteilen	BMBF-Förderung	01/08/2014	EOS GmbH Electro Optical Systems	x	x				x	x		
67	Germany		PROGEN	Hochproduktive generative Produktherstellung durch laserbasiertes hybrides Fertigungskonzept	BMBF-Förderung	01/08/2014	robot-machining GmbH	x				x	x			
68	Germany		AGENT 3D	Additiv-Generative Fertigung - Die 3D-Revolution zur Produktherstellung im Digitalzeitalter (*14 more projects running under the program "Agent3-D will be added in the final roadmap)	BMBF-Förderung		Fraunhofer-Institut								x	
69	Germany		AGENT-3D elF	Additive Manufacturing Technologies for Integration of Electronic Functionalities	BMBF-Förderung		Fraunhofer-Institut	x	x	x		x	x	x		
70	Germany		SmartStream	Intelligente Bearbeitung durch die Verwendung schaltbarer Fluide	BMBF-Förderung	01/08/2014	Fraunhofer-Institut	x	x					x		
71	Germany		HyAdd3D	Hybrides Verfahren für die additive Multimaterialbearbeitung von individualisierten	BMBF-Förderung	01/02/2017	Uwe Brick BURMS - Rapid Manufacturing Solutions	x	x	x		x	x	x		

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				Produkten mit hoher Auflösung												
72	Germany		HybriDentCT	Hochgenaue 3D-Digitalisierung und Qualitätsprüfung im Dentalbereich zur Produktion von komplexem Zahnersatz	BMBF-Förderung	01/04/2014	Hugo Rost & Co. GmbH						x			
73	Germany		InSensa	In-Prozess Sensorik und adaptive Regelungssysteme für die additive Fertigung	BMBF-Förderung	01/05/2017	Materialise GmbH								x	
74	Germany		MultiMat3D	Additive Fertigung von Multimaterial-Hybridbauteilen	BMBF-Förderung	01/10/2016	VIA electronic GmbH								x	
75	Germany		AM-OPTICS	Additive Fertigung optischer Hochleistungskomponenten	BMBF-Förderung	01/02/2017	ARGES GmbH	x						x		
76	Germany		OptiAMix	Mehrzieloptimierte und durchgängig automatisierte Bauteilentwicklung für additive Fertigungsverfahren im Produktentstehungsprozess	BMBF-Förderung	01/01/2017	Krause DiMaTec GmbH							x		
77	Germany		BadgeB	Betriebsfestigkeit additiv gefertigter Bauteile	BMBF-Förderung	01/04/2017	Fraunhofer-Institut	x	x		x	x				

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78	Germany		KitkAdd	Kombination und Integration etablierter Technologien mit additiven Fertigungsverfahren in einer Prozesskette	BMBF-Förderung	01/01/2017	Siemens AG	x				x				x
79	Germany		MYTHOS	Multimateriale hybride Technologie für die addtive Herstellung in dentalen Prozessketten	BMBF-Förderung	01/01/2017	imes-icore GmbH						x			
80	Germany		IndiPro	Bauteilindividuelle Prozesssteuerung und -überwachung zur anforderungsgerechten additiven Massenfertigung	BMBF-Förderung	01/11/2016	EOS GmbH Electro Optical Systems	x	x	x				x		
81	Germany		ProLMD	Prozess- und Systemtechnik zur HybridFertigung großer Bauteile mit dem Laser Metal Deposition (LMD) Verfahren	BMBF-Förderung	01/01/2017	KUKA Industries GmbH & Co. KG	x	x					x		
82	Germany		StaVari	Additive Fertigungsprozesse für komplexe Produkte in variantenreicher und hochfunktionaler Stahlbauweis	BMBF-Förderung	01/10/2016	EDAG Engineering GmbH	x	x		x	x		x		

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83	Germany		CustoMat 3D	Maßgeschneiderte LAM-Aluminiumwerkstoffe für hochfunktionale, variantenreiche Strukturbauteile in der Automobilindustrie	BMBF-Förderung	01/02/2017	EDAG Engineering GmbH		x							
84	Germany		FLATISA	Flammgeschützte, temperaturbeständige Thermoplaste für den industriellen Serieneinsatz von Additiven Fertigungsverfahren	BMBF-Förderung	08/05/2017	Airbus Operations GmbH	x				x				
85	Germany		HY2PRINT	Generative Herstellung von Implantaten mit Hybridstrukturen für den Schädelbereich	BMBF-Förderung	01/04/2017	Stryker Leibinger GmbH & Co. KG						x			
86	Germany		LextrA	Laserbasierte additive Fertigung von Bauteilen für extreme Anforderungen aus innovativen intermetallischen Werkstoffen	BMBF-Förderung	01/02/2017	Siemens AG	x				x				
87	Germany		MuSiK	Multimaterialdruck von C/Si/SiC-Keramiken	BMBF-Förderung	01/05/2017	Schunk Kohlenstofftechnik GmbH	x						x		
88	Germany		NextTiAl	Maßgeschneiderte TiAl-Legierungen für die additive Fertigung mittels Elektronenstrahlschmelzen	BMBF-Förderung	01/02/2017	MTU Aero Engines AG	x								

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89	Germany		3DCRIMP	Additive Fertigungsprozesse für Crimpwerkzeuge	BMBF-Förderung	01/12/2016	WEZAG Gesellschaft mit beschränkter Haftung Werkzeugfabrik							x		
90	Ireland			Creating a 3D Manufacturing facility in the southeast that will provide: Advanced manufacturing training to industry employees, AM exposure to undergraduate students, develop standards for additive manufacturing, and provide product development support.	Regional Enterprise Development Fund		Three-D (Design Develop Disseminate) DAC								x	x
91	Italy		ULTRAHIGH TEMPERATURE CERAMIC MATRIX COMPOSITES BY ADDITIVE MANUFACTURING USING POLYMER PRECURSORS		Ministry of Abroad Affair "La Farnesina"	01/01/2016	ISTEC	x				x				
92	Italy		HIGH PERFORMANCE MANUFACTURING		MIUR (Italian Ministry of University and Research)		MCM SpA, Vigolzone (PC) / Politecnico di Milano							x		
93	Italy		MADE4LO	Metal AdditivE for LOmbardy	Lombardy Region	01/06/2017	Tenova								x	
94	Italy	Lazio	MANUSPACE	Special components for aerospace applications by additive manufacturing and INVESTMENT CASTING	Lazio Region	01/09/2015	Consorzio Matris (La Sapienza, Roma 3, Università Tor vercata, Centro Sviluppo Materiale)	x								

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95	Italy	Trentino	PRO-M Facility (AM Prototyping)		FESR and Trentino Region	2017	Trentino Region		x	x				x		
96	Italy		SICO	Control System for Aeronautical and aero-derived engines	European Funds for Regional Development	01/05/2016	Avio Aero	x								
97	Italy	Liguria	Smart Manufacturing 2020		MIUR (Italian Ministry of University and Research)		Siemens SpA, Genova Politecnico di Milano		x	x				x		
98	Italy	Piemonte	STAMP	Sviluppo Tecnologico dell'Additive Manufacturing in Piemonte	POR Piemonte	01/10/2016	Prima Industrie							x		
99	Netherlands		3D Lab Radboudumc	3D imaging and Printing for MedTech		2017	Oost NL						x			
100	Netherlands		3D Metal printing Biz2		TechForFuture	01/04/2018	Saxion								x	x
101	Netherlands		3D&FPP	INTEGRATING 3D PRINTING AND FLEXIBLE POST-PROCESSING	European Regional Development Fund	01/07/2016	Rotterdam University of Applied Sciences								x	
102	Netherlands		3DComp - Toepassen van thermoplastische composieten	Toepassen van thermoplastische composieten - naar aanleiding van het SIA RAAK MKB project 3DComp: 3D print technologie voor continu-vezelversterking in kunststof producten project		01/08/2016	Saxion Hogeschool, College van Bestuur	x	x					x		
103	Netherlands		Brainport Industries Campus		NL-gov	01/01/2018	TNO	x					x	x		x
104	Netherlands		CRANIOSAFE	Optimized and innovative materials and customized	NWO	09/01/2017	Universiteit van Amsterdam						x			x

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				treatment strategies for cranioplasty												
105	Netherlands		Field lab 3D MM - Multi-Material Additive Manufacturing		European Fund for Regional Development (EFRO)	2017	TNO			x			x	x		
106	Netherlands		Fun-WAAM	Fundamentals of stress and temperature profiles during wire arc additive manufacturing	NWO	06/03/2017	Technische Universiteit Delft	x								
107	Netherlands		K3D - 3D metalprinting for Industry			2017	Oost NL		x		x			x		
108	Netherlands		Next UPPS	Integrated design methodology for Ultra Personalised Products and Services		01/01/2017	Technische Universiteit Delft Faculteit Industrieel Ontwerpen Design Engineering			x						
109	Netherlands		OLL - Open Learning Labs		Regional	2016	Fontys								x	x
110	Netherlands		ProTOcool	Control of porosity and surface roughness in topology optimized SLM conformal cooling systems	NWO	16/08/2017	Rijksuniversiteit Groningen	x	x			x		x		
111	Netherlands		SINTAS	Sustainability Impact of New Technology on After sales Service supply chains	NWO	01/11/2014	Universiteit Twente								x	x

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112	Netherlands		SMART PRODUCTION	Develop novel processes, machines and materials for low volume productions	ERDF (European Regional Development Fund), the Ministry for Economic Affairs and Energy of the State North Rhine-Westphalia (MWEIMH NRW), the Dutch Ministry of Economic Affairs, and the provinces Gelderland and Overijssel	01/01/2017	Netzwerk Oberfläche NRW e.V.								x	
113	Netherlands		TPC Future		RAAK-MKB subsidy, financed by Regieorgaan SIA, part of the Netherlands Organization for Scientific Research (NWO)	01/03/2017	Saxion Hogeschool, College van Bestuur	x	x					x		
114	Netherlands			Functionally Graded Materials Through Wire Arc Additive Manufacturing	NWO	01/06/2017	Technische Universiteit Delft								x	
115	Netherlands			Accelerating Mass Personalization in Orthopedics facilitated by Machine Learning and Bone MRI-based Digital Fabrication.	NWO	15/05/2017	Universiteit Utrecht						x			x

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116	Netherlands			Design voor 3D printing in de utiliteitssector	NWO	15/01/2018	Hogeschool van Amsterdam			x	x	x		x		
117	Netherlands			Developing innovative materials for Additive Manufacturing and 4D printing	Netherlands Organisation for Scientific Research		Brightlands Materials Center								x	
118	Norway		3D-CAPS	Three Dimensional Printed Capture Materialsfor Productivity Step-Change	ERA-NET ACT program	01/08/2017	ECN								x	
119	Norway		AddForm	Additiv tilvirkning av forminnsatser for sprøytestøping av funksjonelle prototyper og små produktserier	Research council of Norway	01/10/2015	SINTEF AS							x		
120	Norway		AM Super Duplex	Laser-PBF of Super Duplex		01/08/2017									x	
121	Norway		HighEFF	National Research Centre for an Energy Efficient and Competitive Industry	Research Council of Norway	01/08/2016	SINTEF Energi								x	
122	Norway		IPN ESSpK	Extra big injection moulded components	Research council of Norway	01/03/2016									x	
123	Norway		IPN NewMan	New manufacturing route for Multi Port Extrusion dies	Reserach council of Norway	01/08/2016									x	
124	Norway		LAMINA	Leading Additive Manufacturing technology Into New Application	Basic funding to SINTEF	01/01/2017	SINTEF								x	
125	Norway		MKRAM	Material knowledge for robust additive manufacturing	Research council of Norway	01/01/2016	SINTEF AS								x	x

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126	Norway		NESSIE	New structured substrates for downstream processing of complex biopharmaceuticals	M-era.Net and National funding agencies.	01/04/2017	SINTEF AS						x			
127	Norway		SFI Manufacturing	SFI Manufacturing: Sustainable Innovations for Automated Manufacturing of Multi-Material Products	Research council of Norway	01/08/2015	SINTEF Raufoss Manufacturing								x	
128	Norway		SIAM 3D	SINTEF's Initiative on Additive Manufacturing and 3D technology	Reserach council of Norway	01/06/2017	SINTEF	x	x	x	x	x		x		
129	Poland		AMgAvio	Magnesium-based alloys processed with SLM technology for aeronautical applications	Polish National Centre for research and Development (PNC R&D)	2017	PWr (Wroclaw University of Science and Technology)	x								
130	Poland		AMpHOra	Additive Manufacturing Processees and Hybrid Operations Research for Innovative Aircraft Technology Development	NCBiR	41609	PWr (Wroclaw University of Science and Technology)	x								
131	Poland		InnsLOT	Development of innovative additive manufacturing method for the production of complex thin-walled, nickel-based aircraft engine components	Polish National Centre for research and Development (PNC R&D)	2018	PWr (Wroclaw University of Science and Technology)	x								

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132	Poland		ReCover	Layers and coatings with rhenium, its compounds and alloys properties, areas and methods of application	Polish National Centre for research and Development (PNC R&D)	2015	Nicolaus Copernicus University								x	
133	Poland		TiSPHERO	Manufacturing of spherical powders from scraps for special applications	KIC RawMaterials	01/10/2016	IMN								x	
134	Portugal		add.AM	Add Additive Manufacturing to Portuguese Industry	POCI FEDER	01/07/2017	ADIRA - METAL FORMING SOLUTIONS, S.A.	x	x		x			x		x
135	Portugal		ADDing	Multi-scale Modelling of ADDitive Manufacturing by Direct Energy Deposition of Metallic Powders.	POCI | FEDER + FCT	26/07/2018	INEGI - INSTITUTO DE CIÊNCIA E INOVAÇÃO EM ENGENHARIA MECÂNICA E ENGENHARIA INDUSTRIAL (RTO)							x		x
136	Portugal		AddStrength	Enhanced mechanical proprieties in additive manufactured components.	POCI | FEDER + FCT	27/07/2018	INEGI - INSTITUTO DE CIÊNCIA E INOVAÇÃO EM ENGENHARIA MECÂNICA E ENGENHARIA INDUSTRIAL (RTO)							x		x
137	Portugal		ADIMAQ	Fabrico ADItivo por extrusão e MAQuinagem para produção híbrida de modelos, moldes e moldações de grandes dimensões.	POCI FEDER	01/10/2015	CEI Zipor (SME)							x		x
138	Portugal		BIGPROTO	FABRICO AVANÇADO DE PROTÓTIPOS TÉCNICOS E GRANDE DIMENSÃO	xx	2010	CENTIMFE		x					x		x

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139	Portugal		FIBR3D	Additive manufacturing based hybrid processes for long or continuous fiber reinforced polimeric matrix composites	POCI FEDER	01/09/2016	INEGI - INSTITUTO DE CIÊNCIA E INOVAÇÃO EM ENGENHARIA MECÂNICA E ENGENHARIA INDUSTRIAL (RTO)							x		
140	Portugal		FRF	FABRICO RÁPIDO DE FERRAMENTAS	xx	2002	CENTIMFE	x	x				x	x		x
141	Portugal		HIBRIDMOULDE	Desenvolvimento de Metodologias Alternativas de Projeto e Fabrico de Moldes Rápidos para Injeção de Termoplásticos de Engenharia	POCTI	2003	CENTIMFE		x					x		x
142	Portugal		HIBRIDMOULDE 21	Desenvolvimento de uma solução de engenharia para peças plásticas de grandes dimensões em pequenas séries.	xx	2010	CENTIMFE		x					x		x
143	Portugal		MAMTool	Machinability of Additive Manufactured Parts for Tooling Industry	POCI | FEDER + FCT	02/08/2018	INEGI - INSTITUTO DE CIÊNCIA E INOVAÇÃO EM ENGENHARIA MECÂNICA E ENGENHARIA INDUSTRIAL (RTO)							x		
144	Portugal		NEXT.parts	Next-Generation of Advanced Hybrid Parts	POCI FEDER	01/07/2016	3DTECH - PRODUÇÃO, OPTIMIZAÇÃO E REENGENHARIA LDA. (SME)						x	x		x
145	Portugal		PRODUTECH SIF	PRODUTECH SIF - Soluções para a Indústria de Futuro	POCI FEDER	01/05/2017	TEGOPI, S.A.	x	x	x				x		x

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146	Portugal		RNPR	REDE NACIONAL DE PROTOTIPAGEM RÁPIDA	xx	1997	CENTIMFE	x	x				x	x		x
147	Portugal		ROBMOLDE	Development of Robotic Cell for Surface Regeneration System using Intelligent Reverse Engineering	ANI	01/10/2002	ISQ - Instituto de Soldadura e Qualidade (Portugal)							x		x
148	Portugal		SIRBLADE	Automated Repair of Turbine Blade for Aero Turbine Engine	ANI	01/06/2003	TAP - Transportes Aéreos Portugueses (Portugal)	x								
149	Portugal		SLMXL	Sistemas de fabricação aditiva de peças metálicas de grande dimensão	POCI FEDER	01/10/2015	ADIRA - METAL FORMING SOLUTIONS, S.A.							x		x
150	Portugal		TOOLING4G	Advanced Tools for Smart Manufacturing	POCI FEDER	01/07/2017	ANÍBAL H. ABRANTES - INDÚSTRIAS DE MOLDES E PLÁSTICOS S.A.							x		x
151	Serbia		3D Plus	Improving Value-chain of plastic product by AM	Serbian Development Agency	01/05/2017	University of Kragujevac - Faculty of Mechanical Engineering -Kraljevo							x		
152	Serbia		Digital Technologies for product development		GIZ	29/05/2018	University of Kragujevac - Faculty of Mechanical Engineering -Kraljevo							x		x
153	Serbia		IMPuls	Innovation Management for new Products	RSEDP2	09/03/2011	University of Kragujevac - Faculty of Mechanical Engineering -Kraljevo							x		

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154	Spain		3DCONS	Novel 3D printing technologies in the construction industry	CDTI (Spanish Centre for the Development of Industrial Technology)	01/11/2014	VIAS Y CONSTRUCCIONES				x					
155	Spain	Basque Region	ADDITIVE	New alloys and industrial components through additive manufacturing for strategic sectors	Gobierno Vasco	01/01/2016	LORTEK S. COOP	x	x				x			
156	Spain		ADVANSEAT	Development of a new concept of advanced, removable and electrified seat for motor vehicles, from new manufacturing processes more flexible, improving its safety performance and comfort	CDTI (Spanish Centre for the Development of Industrial Technology)	01/10/2015	GRUPO ANTOLIN		x							x
157	Spain	Aragon	AM INNOVA	ADDITIVE MANUFACTURING TECHNOLOGIES APPLYED TO PRODUCTS, MOULDS AND TOOLS IN AERONAUTICAL SECTOR	REGIONAL-Aragon	01/07/2015	CLUSTER AERONÁUTICO DE ARAGÓN - AERA	x								x
158	Spain	Asturias	AMFOOD	Research on new textures and formulations in order to develop new food types through additive manufacturing techniques	IDEPA (Institute for Economic Development of Principado de Asturias)	01/12/2015	CASA GERARDO						x			x

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159	Spain	Asturias	AM-MEDICO	Research on biomedical adaptive design, topological optimization and development of new materials and processes for additive manufacturing, in order to generate high added-value custom-made solutions in the medical field.	FICYT (Foundation for promotion of applied research and technology in Asturias)	01/01/2016	Fundación PRODINTEC						x			x
160	Spain		BIO AM	Improvement of the biofunctionality of polymeric scaffolds made by additive manufacturing	MINECO	01/03/2018	Universidad de Las Palmas de Gran Canaria - ULPGC						x			
161	Spain		BUIL3D-PRINT	DEVELOPMENT OF An INTEGRAL PRODUCTIVE PROCESS FOR THE CONSTRUCTION INDUSTRY BASED ON AM TECHNOLOGIES	CDTI (Spanish Centre for the Development of Industrial Technology)	01/06/2015	CEMENTOS TUDELA VEGUIN				x			x		x
162	Spain		CON3D	Development of an automatized structure manufacturing process using 3D printing technologies for the construction sector	CDTI (Spanish Centre for the Development of Industrial Technology)	01/08/2013	COPROSA				x			x		x
163	Spain		ECLIPSE	Structures in composites and lightweight materials for simple assembly processes	CDTI (Spanish Centre for the Development of Industrial Technology)		EADS CASA								x	

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164	Spain	Basque Region	FAMOLD	Additive manufacture of molds and inserts with new functionalities for processes of transformation of plastic and aluminum	Gobierno Vasco	03/05/2015	LORTEK S. COOP		x							
165	Spain		FRACTAL	Development of Spanish-Technology-Based Advanced Manufacturing and Prototyping Systems for Strategic Components via Laser Assisted Powder Sintering	CDTI (Spanish Centre for the Development of Industrial Technology)	06/02/2015	ETXE-TAR							x		
166	Spain		FUTURALVE	Materials and advanced manufacturing technologies for the new generation of high speed turbines	CDTI (Spanish Centre for the Development of Industrial Technology)	01/05/2015	ITP	x								x
167	Spain		JAMES BONE	Juncture replacement through Additive Manufacturing & electro-spun scaffolds for human bones	MANUNET-IDEPA (Institute for Economic Development of Principado de Asturias)	01/12/2014	Cirugía Oral y Maxilofacial Dr. Llorente						x			x
168	Spain		KERAMIC	NOVEL PRODUCTS AND TECHNOLOGIES FOR ADVANCE PROCESSES OF ADDITIVE MANUFACTURING BASED ON CERAMIC COMPOSITIONS	NATIONAL	01/10/2015	TORRECID			x				x		x

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169	Spain	Asturias	RECLAMA	Research on laser cladding solutions for turbine blades manufacturing processes	FICYT (Foundation for promotion of applied research and technology in Asturias)	01/01/2014	TALLERES ZITRON S.A.			x						x
170	Spain		SELENA	More electrical, safe and reconfigurable systems oriented to a more efficient airplane reducing the pilot load	CDTI (Spanish Centre for the Development of Industrial Technology)	01/09/2015	CESA	x								x
171	Spain		SILENCIO		CDTI (Spanish Centre for the Development of Industrial Technology)		EADS CASA	x								
172	Spain	Asturias	SLSAero	Research on SLS-based manufacturing processes to be applied in the aeronautics sector	IDEPA (Institute for Economic Development of Principado de Asturias)	01/11/2015	ACITURRI ADDITIVE MANUFACTURING	x								x
173	Spain	Asturias	SOLADI3D	Research on joining steel parts based on 3D printing and additive manufacturing technologies	IDEPA (Institute for Economic Development of Principado de Asturias)	05/05/2014	ArcelorMittal España, S.A.			x						x
174	Spain		SUPPORT	Improvement of osseointegration of Titanium porous structures by design optimization and surface modification with polymeric coatings	MINECO	01/01/2016	Universidad de Las Palmas de Gran Canaria - ULPGC						x			

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175	Spain			Implementation of wear-reduction micro textures through additive manufacturing technology over joint prosthesis featuring metal/plastic contact.	IDEPA (Institute for Economic Development of Principado de Asturias)	01/11/2017	MBA INCORPORADO; INGENIACITY	x								
176	Spain			Adaptation of DMLS 3D printing technology for knee prosthesis components	IDEPA (Institute for Economic Development of Principado de Asturias)	01/11/2016	SOCINSER 21 S.A.	x								
177	Sweden		3DTC	Characterization Of Additive Manufacturing Metal – Carbon-Fibre Composite Bond By Dual-Energy Computed Tomography	EURF	Jan 2016	Alfred Nobel Science Park (ANSP)							x		x
178	Sweden		AT-LAB	Regional additive manufacturing laboratory at Karlstad University	EURF	Jan 18 tbc	KARLSTAD UNIVERSITY								x	
179	Sweden		CAM2	Centre for Additive Manufacture - Metal	VINNOVA - Swedish Innovation Agency	2017	Chalmers University								x	
180	Sweden		DiLAM	Additive manufacturing of large components Etablering av en fysisk och virtuell test- och demonstrationsanläggning för additiv tillverkning av storskaliga komponenter.	Vinnova		SWEREA							x		x

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
181	Sweden		DiSAM	Digitalization of Supply Chain in Swedish Additive Manufacturing	Vinnova	2017-11-06	SWEREA							x		x
182	Sweden		LIGHTCAM	Light Weight Solutions for High-Performance Components by Additive Manufacturing	Vinnova	2015-12-01	SWEREA	x								x
183	Sweden		Miljo:FIA	Demonstration environment for flexible and innovative automation (Demonstrationsmiljö för flexibel och innovativ automation, Miljo:FIA)	EU, Region Vaestra Gotaland, Swedish Agency for Economic and Regional Growth	01/02/2017	University West							x		
184	Sweden		RAMp-UP	Swedish Roadmap for Industrialization of Metal Additive Manufacturing	VINNOVA - Swedish Innovation Agency	01/10/2016	SWEREA								x	x
185	Sweden		RecAM	Recycling study of AM metal powder	Vinnova	2016-08-31	SWEREA							x		x
186	Sweden		REPLAB	Reparation och återanvändning av metallprodukter genom additiv tillverkning	EU&VGR	2018-01-01	University West								x	
187	Sweden		SAMw	Synergy for Additive Manufacturing using laser beam heat source and wire	The Knowledge Foundation	01/11/2017	University West	x						x		x
188	Sweden		SUMAN	Sustainable MANufacturing	The Knowledge Foundation	01/03/2011	University West	x	x			x	x	x		x
189	Sweden		SUMANnext	Sustainable MANufacturing through Next-	The Knowledge Foundation	01/01/2017	University West	x	x			x	x	x		x

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
				generation additive processes												
190	Sweden		Tolls for AM - SENAI	Tools and methods for certification of AM fabricated parts for aerospace applications	Vinnova/SENAI	2018-11-01	SWEREA	x								x
191	Sweden		VR rölam	Region Värmland - Region Örebro - AM initiative		10/07/1905	ANSP	x	x					x		x
192	UK		3D Fashion: Closures and trims		Innovate UK		Biov8tion Ltd			x						
193	UK		3D Screen Printing		Innovate UK	01/07/2017	Cadscan Limited							x		
194	UK	North West	ALF	Additive Layer Flexomer Manufacturing	Innovate UK	01/02/2017	Nottingham Trent University							x		
195	UK	South East	AMSURFIN	Additive Manufacturing SURface FINishing - An automated intelligent solution for polymer parts	Innovate UK	01/01/2017	Additive Manufacturing Technologies Ltd							x		
196	UK	London	CAM	Carbon Additive Manufacture	Innovate UK	01/10/2017	London Forest Products Limited						x			
197	UK	East of England	CAMBER	Concrete Additive Manufacturing for the Built Environment using Robotics	Innovate UK	01/03/2017	Skanska Technology Limited				x					
198	UK	South East	CHARM	Additive Manufacturing for Cooled High-Temperature Automotive Radial Machinery	Innovate UK	01/04/2016	Hieta Technologies Ltd		x							

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
199	UK		DIGI-TOOL		Innovate UK	01/03/2018	Toolroom Technology Limited							x		
200	UK		DRAMA	Digital Reconfigurable Additive Manufacturing facilities for Aerospace	Aerospace Technology Institute (ATI)	November 2017	Manufacturing Technology Centre (MTC)	x								
201	UK		FLEXIFINISH	FLEXIBLE AND AUTOMATED FINISHING AND POST-PROCESSING CELL FOR HIGH VALUE AM COMPONENTS	Innovate UK	01/06/2016	Toolroom Technology Limited								x	
202	UK		Gravity Sketch - Intuitive 3D Creation		Innovate UK	01/08/2015	Gravity Sketch Limited							x		
203	UK		HERMiT	High Efficiency Recuperator for stationary power Micro-Turbine	Innovate UK	01/05/2016	Hieta Technologies Ltd					x				
204	UK		IMPULSE	Improving Additive Manufactured Metal Parts Using Laser Surface Finishing and Electrochemical Machining	Innovate UK	01/10/2013	Ecm Developments Limited								x	
205	UK		MEGCAP	More Electric Generation, Controls & Aircraft Power	Innovate UK	01/06/2017	Safran Power UK Ltd.	x								
206	UK		Newcastle University and DePuy International Limited	To develop design rules and quality assessment procedures for solid and porous titanium alloy medical implants made using additive manufacture techniques	Innovate UK	01/12/2016	Newcastle University						x			

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
207	UK		PlasMan	High integrity manufacture	Innovate UK	01/07/2017	Aquasium Technology Limited		x					x		
208	UK		PowderCleanse	Automated powder recycling and quality assurance for enhanced additive manufacturing material reuse	Innovate UK	01/04/2017	L.P.W. Technology Limited							x		
209	UK		ProAMP	Production Capable Additive Manufacturing of Polymers	Innovate UK	01/10/2017	Euriscus Limited			x						
210	UK	London	PROMENADE	Plasma Removal of Methane from Natural Gas Dual-Fuel Engines	Innovate UK	01/09/2016	Johnson Matthey Plc		x							
211	UK	North West	RAD-AMP	Rapid Development of Additive Manufacturing Powder	Innovate UK	01/12/2017	L.P.W. Technology Limited								x	
212	UK	Yorkshire and the Humber	RAMP-UP	Reliable Additive Manufacturing technology offering higher ProdUctvity and Performance	Innovate UK	01/05/2016	Reliance Precision Limited	x								
213	UK		RoboWAAM	Robotic Wire + Arc Additive Manufacture cell	Innovate UK	01/04/2018	Kuka Robotics UK Ltd							x		x
214	UK	North West	SEAM	Surface Engineering of Additive Manufactured Components	Innovate UK	01/10/2016	Wallwork Heat Treatment Limited	x	x				x	x		
215	UK	South East	SEAMLESS	Digitally-Enabled, Automated Post-Processing for AM	Innovate UK	01/05/2017	Toolroom Technology Limited							x		
216	UK	South East	SHAPE	Self-Healing Alloys for Precsion Engineering	Innovate UK	01/09/2015	Ilika Technologies Ltd								x	

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
217	UK	South West	START	Subtractive Technologies for Additively Realised Test-parts Manufactured Parts	Innovate UK	01/06/2017	Scorpion Tooling UK Limited	x					x	x		
218	UK	South East	TACDAM	Tailorable and Adaptive Connected Digital Additive Manufacturing	Innovate UK	01/01/2017	Hieta Technologies Ltd		x							
219	UK		The University of Sheffield and LPW Technology Limited	To devise a methodology for efficient development of high performance bespoke alloys to serve the rapidly growing metallic Additive Manufacturing market and understand effects of alloy compositional manipulation on AM processability.	Innovate UK	01/04/2016	University of Sheffield								x	
220	UK		University of Sheffield and Tripal Ltd	To identify and implement optimal processes and material for use in the manufacture of footwear using Additive Manufacturing technology	Innovate UK	01/10/2017	University of Sheffield			x						x
221	UK	South West	WINDY	WIng DesigN methodologY validation	Innovate UK	01/05/2016	Airbus Operations Limited	x								x

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
222	UK	Wales		Development Improvements in atomising nickel, cobalt & iron based alloys for use in AM	Innovate UK	01/07/2017	LSN Diffusion Limited	x	x				x			
223	UK	North West		Metal AM Process Informatics for Improved Surface Finish of Complex Parts	Innovate UK	01/08/2017	Croft Additive Manufacturing Ltd							x		
224	UK	West Midlands		Development and commercialization of 3D-printed ceramic/refractory carbonized items.	Innovate UK	01/05/2017	Shakespeare Foundry Limited	x		x		x		x		
225	UK	East of England		Unravelling &addressing orthopaedics & prosthetics problems by human-centred design	Innovate UK	01/08/2017	Innovative Technology and Science Limited						x			
226	UK	East of England		Wire Arc Additive manufacturing of near net shapes for Spacecraft propellant tanks	Innovate UK	01/10/2015	Airbus Defence And Space Limited	x		x						
227	UK	North West		High temperature, affordable polymer composites for AM aerospace applications	Innovate UK	01/02/2016	Victrex Manufacturing Limited	x								
228	UK	South East		Advanced Inverted Brayton Cycle exhaust heat recovery with Steam Generation	Innovate UK	01/02/2016	Hieta Technologies Ltd	x				x				
229	UK	London		A 3D printing solution to solve parents pain with orthotics services	Innovate UK	01/04/2016	Project Andiamo Ltd						x			

N	Country	Region (If available)	Project Acronym	Project full title	Funding entity	Starting date (DD/MM/YYYY)	Coordinator	Aerospace	Automotive	Consumers &	Construction	Energy	Health	Industrial Eq. &	All	Non-tech
230	UK			Prototype Development of a Hybrid Gas and Ultrasonic Powder Delivery System	Innovate UK	01/01/2016	Advanced Laser Technology Limited							x		

ANNEX D: List of Enablers

Legend:

Sectors: H=health; AE=aerospace; AU=automotive, CG=consumer goods; E=electronics, EN=energy; E&T= Industrial equipment &tooling; C= construction; O=other

VC segments: M&S=modelling and simulation; D=design; M=materials; P=process; PP=post-processing; Pr=product; EL=end of life

Process: PBF=Powder Bed Fusion; VP=Vat Photopolymerization; MJ=Material Jetting; ME=Material Extrusion; SL=Sheet Lamination; DED=Direct Energy Deposition; BJ=Binder Jetting; O=Other

Non technology activities: STD=standardisation; L=legislation; EDU=education/training; IE=business, commercialisation, industrial exploitation; IPR=intellectual property rights; TT=technology transfer

NAME	SUPPLY CHAIN	WEBSITE	COUNTRY/ Region	Sectors	VC segments	AM processes	AM Materials	Non Tech.
RTOs								
Aalto University Digital Design laboratory	R&D, design, end user	www.aalto.fi	FINLAND/Helsinki-Uusimaa-Etelä-Suomi	ALL	ALL	ALL	ALL	STD; L, EDU; IE; IPRS, TT
ACAM	R&D; Materials; Design	http://acam.rwth-campus.com/	GERMANY/ Aachen	ALL	ALL	-	Metal, polymer	STD, L, EDU, IE, IPR, TT
AIDIMME	R&D, design,	www.aidimme.es	SPAIN/ Comunidad Valenciana	ALL	ALL	PBF, VP, MJ, ME	Metal, Polymer, O: wood, natural materials	STD; EDU; IE; IPRS, TT
AIMPLAS	R&D; service Bureau; design	www.aimplas.net	SPAIN/ Comunidad Valenciana	ALL	M; P; PP; Pr, EL	ME	Polymer, food, bio-materials	STD; L; EDU; TT
AITIIP	R&D; service Bureau; Materials provider; design	www.aitiip.com	SPAIN/ Aragon	ALL	ALL	PBF; VP; ME;	Metal, Polymer, Ceramic y Bio-materials	STD;EDU;IE; IPRS; TT
AMSyst-HTSC-TU/e	R&D	https://www.tue.nl/en/	NETHERLANDS/Noord-Brabant	ALL	ALL	ALL	ALL	EDU, IE, TT
ANDALTEC	R&D, design, Prototyping	www.andaltec.org/en/	SPAIN/ Andalucía	AE, AU,CG, E, Food Packaging	M&S, D, M, Pr, EL	VP, MJ, ME, BJ	Polymer, Bio-Materials	EDU, TT
BMC	R&D, OEM, Materials provider	www.brightlandsmaterialscenter.com	NETHERLANDS/Limburg	ALL	ALL	PBF, VP, MJ, ME	Polymer, Bio-materials	TT
Brunel	R&D, design	www.brunel.ac.uk	UNITED KINGDOM/ Outer London - West and North West	ALL	M&S, D, M, P, PP, Pr	PBF; VP; ME;	Metal, Polymer, Composites	STD;EDU;IE; IPRS; TT
CEA	R&D	www-liten.cea.fr	FRANCE / Rhône-Alpes	ALL	M, P, EL	PBF, VP, MJ, DED	Metal, polymer, ceramic	TT
CEIT-IK4	R&D, Materials provider; design	www.ceit.es	SPAIN/ Basque Country	ALL	M&S; D;M; P; PP	PBF, MJ	Metal, polymer, ceramic	EDU; TT

CEITEC-BUT	R&D, Materials provider	www.ceitec.eu	CZECH REPUBLIC/ Jihovychod	H, AE, AU	M, P, PP	ME	Metal, Polymer, ceramic, Bio-Materials,	EDU, TT
CENTIMFE	R&D; service Bureau; ; design	www.centimfe.com	PORTUGAL/ Centro	ALL, packaging	M&S, D, M, P, PP, Pr	PBF, VP, MJ, ME, DED	Metal, Polymer	EDU, IE, IPRS, TT
CETIM	R&D	www.cetim.fr/fr	FRANCE/ Rhône-Alpes	ALL	ALL	ALL, 3D printing metal	Metal, Polymer, Bio-Materials	STD, EDU, IE,TT
CIDETEC	R&D, Service Bureau	www.cidetc.es	SPAIN/ Pais Vasco	H, AE, AU, EN	PP	-	Metal, Bio-materials	EDU, IE, IPRs, TT
CNES	R&D end user	cnes.fr	FRANCE/ Midi-Pyrénées	AE	ALL	ALL	Metal, Polymer, ceramic,	STD, TT
COVENTRY University	R&D, Design	www.coventry.ac.uk	UNITED KINGDOM/ West Midlands	ALL	ALL	PBD, DED	Metal, Polymer	STD, EDU, IE, TT
CSM	R&D	www.c-s-m.it	ITALY/ Lazio	AE, AU	M, PP, Pr	PBD, VP	Metal, ceramic	EDU, TT
CTTC	R&D, Materials provider	www.cttc.fr	FRANCE/ Limousin	H, AE, CG, E, EN	M, P, PP, Pr	VP, MJ, ME, SL, DED, BJ	Ceramic	EDU, TT
CU	R&D	www.cranfield.ac.uk/	UNITED KINGDOM/Bedfordshire and Hertfordshire	AE, AU, E, EN, E&T, C	M&S, M, P, Pr	PBF, DED	Metal	STD, EDU, IE, TT
DEMI, FCT NOVA	R&D	https://www.fct.unl.pt/	PORTUGAL/ Área Metropolitana de Lisboa	H, AE, AU, EN, E&T, Non Destructive Testing (NDT)	M&S, D, M, P, PP, Pr	MJ, ME, DED	Metal, Polymer	EDU, TT
DMRC	R&D, Design	www.dmrc.de	GERMANY/Detmold	ALL	ALL	PBF, MJ, ME, Arburg Plastic Freeforming	Metal, polymer	STD, EDU, IE, TT
DTI	R&D, Service Bureau, OEM, design, end user	www.dti.dk	DENMARK/ Hovedstaden	ALL	ALL	PBF, VP, MJ, ME, BJ	Metal, polymer, food, bio-materials	STD, L; EDU, IE, TT
ECN	R&D	www.ecn.nl/expertise/engineering-materials/	NETHERLANDS/ Noord-Brabant	ALL	M, P, PP, Pr	PBF, VP, DED	Metal, ceramic, catalysts	IE, TT
ENGIN	R&D, Design, end user, Education	http://www.cardiff.ac.uk/engineering	UNITED KINGDOM/ East Wales	H, AE, AU, CG, EN, E&T	ALL	PBF, VP, ME	Metal, Polymer	EDU, IE, TT
EURECAT	R&D, Pilot and testing, Training	www.eurecat.org	SPAIN/ Cataluña	H, AU, CG E&T	M&S, M; P; Pr	PBF, ME, SL	Metal, polymer, food	EDU, IE, IPRs, TT
Flanders Make	R&D	www.flandersmake.be	BELGIUM/ Vlaams-Brabant	AE, AU, CG,	P,PP	PBF, DEP	Metal, Polymer	TT
Fontys CoE HTSM	R&D, Design	https://fontys.edu/	NETHERLANDS/ Noord-Brabant	ALL	M&S,D,M,P,PP, Pr	PBF, VP, MJ, ME	Metal, Polymer	EDU, IE, TT
Fraunhofer IFAM Bremen	R&D, Materials provider, Design	www.ifam.fraunhofer.de/en/Profile/Locations/Bremen	GERMANY/ Bremen	H, AE, E, EN; E&T, C	M&S, D, M, P, PP	PBF, VP, ME; BJ	Metal, Polymer, Ceramic	STD; EDU, IE, IPRs, TT
Fraunhofer IFAM Dresden	R&D, Materials provider, Design	www.ifam.fraunhofer.de/en/Profile/Locations/Dresden.html	GERMANY/ Dresden	H, AE, AU, E, EN, E&T, C	M&S, D, M, P, PP	PBF, ME, BJ, 3D screen printing	Metal, Ceramic	STD, EDU, IE, IPRs, TT

Fraunhofer ILT Aachen	R&D, Materials provider, Design	https://www.ilt.fraunhofer.de/en.html	GERMANY/ Aachen	H, AE, AU, EN, E&T, C	M&S, D, M, P, PP, Pr	PBF, SL; DED; O	Metal, Ceramic	STD, EDU, IE, IPRs, TT
Fraunhofer iGCV Augsburg	R&D, Materials provider, Design	https://www.igcv.fraunhofer.de/en.html	GERMANY/ Augsburg	H, AE, AU, EN, E&T, C	M&S, D, M, P, PP, Pr	PBF, SL; MJ; O	Metal, Ceramic	STD, EDU, IE, IPRs, TT
Frederick University	R&D	www.frederick.ac.cy	CYPRUS/ Kýpros	H,AU, E&T, C	M&S, D	BJ	Metal, Polymer, bio-materials	STD, EDU ,TT
Friuli Innovazione	R&D, Service Bureau	www.friulinnovazione.it	ITALY/ Friuli-Venezia Giulia	ALL	ALL	-	-	STD, L, EDU, IE, IPRs, TT
IK4-LORTEK	R&D, Design	www.lortek.es	SPAIN/ Pais Vasco	AE, AU, CG, E&T	M&S,D,M,P,PP, Pr	PBF, DED	Metal	EDU, TT
IK4-TEKNIKER	R&D	www.tekniker.es	SPAIN/ Pais Vasco	AE,AU, E; EN, E&T, C	M&S, D, P, PP	DED	Metal	TT
IMDEA	R&D; Materials provider	www.materials.imdea.org/groups/pm	SPAIN/ Madrid	ALL	M&S, D, M, PP	ME, SL	Metal, polymer, bio-materials	EDU, TT
IMR	R&D, Design	www.imr.ie	IRELAND/ Southern and Eastern	ALL	ALL	ALL	ALL	STD, L, EDU, IE, TT
INEGI	R&D, Design	http://www.inegi.pt/inicial.asp?k=z&LN=EN	PORTUGAL/Norte	H, AE, AU, E&T	ALL	VP, MJ, ME, DED, BJ, Composite materials AM	Metal, Polymer, Ceramic, Composite materials	TT
INSPIRE AG	R&D, Design	-	SWITZERLAND	ALL	M&D, D, M, P, PP, Pr	PBF, DED	Metal, polymer, ceramic	STD, EDU, IE, TT,
IOR	R&D, Software Provider, Design, End User	www.ior.it	ITALY/ EmiliaRomagna	H, Biomedical research	M&S, D, M, P, PP, Pr	PBF, VP, ME	Metal, polymer, bio-materials	STD, EDU, TT, Orthopaedic treatments and their validation
ITAINNOVA	R&D, Service Bureau, Design, End user	www.itainnova.es	SPAIN/ Aragon	AE, AU, CG, E, EN, E&T, C	M&S, D, M; P	PBF, MJ	Polymer	TT
IPC	R&D, Service Bureau, Design	http://ct-ipc.com/	FRANCE/ Rhône-Alpes	ALL	M&S, D; M; P; PP; Pr	PBF, VP, ME	Metal, polymer	EDU, IE, TT
IQS. Ramon Llull University	R&D	www.iqs.edu	SPAIN/ Cataluña	own R&D	M&S, D, M, P	VP, ME	Polymer, ceramic, bio-materials	EDU, TT
ISQ	R&D	www.isq-group.com	PORTUGAL/Area Metropolitana de Lisboa	ALL	M, P, EL	DED	Metal	STD, EDU, TT
ITC	R&D, Service Bureau, End user	http://www.itc.uji.es	Spain/Comunidad Valenciana	CG, EN, C, Ceramic	ALL	ME, BJ	Ceramic	STD, EDU, IE, TT
KIMAB	R&D	www.swerea.se/kimab	SWEDEN/ Stockholm	ALL	M&S, M, P	PBF	Metal	EDU, TT
KMWE	R&D, Service Bureau, OEMs, Design	www.kmwe.com/Capabilities/Additive-Manufacturing.htm	NETHERLANDS/ Noord-Brabant	H, AE, Semiconductors, Industrial Automation	ALL	PBF, DED, EBAM	Metal	IE, TT
LEITAT	R&D, Design	www.leitat.org	SPAIN/Catalonia	H, AE, AU, CG, EN	ALL	PBF	Metal, Polymer,	IE, IPRs, TT

							bio-materials	
LMS	R&D, Design, Modelling and simulation, experimentation	http://lms.mech.upatras.gr/	GREECE/ Δυτική Ελλάδα	AE, AU,CG	ALL	PBF, VP, ME, SL, DED	Metal, polymer	STD, EDU, TT
LBORO	R&D, Design	www.lboro.ac.uk/	UNITED KINGDOM /Leicestershire, Rutland and Northamptonshire	C	D, M, P, PP, Pr	ME	Concrete	STD, EDU, IE, IPRs, TT
Lurederra	R&D, Materials provider	www.lurederra.es	SPAIN/ Navarra	ALL	M, Pr	materials technology, nanotechnology	Metal, polymer, ceramic, nanomaterials	STD, IPRs, TT
M2i	R&D, Services Bureau	www.m2i.nl	NETHERLANDS/ Zuid-Holland	AE, AU, O (maritime and offshore)	M&S, M	PBF, DED	Metal	IPRs, TT
NLR	R&D, Design	www.nlr.nl	NETHERLANDS/ Flevoland	ALL	M&S, D, M, P, PP, Pr	PBF	Metal	EDU, TT
POLIMI-Departmenrt of Mechanical Engineering	R&D	www.polimi.it	ITALY/ Lombardia	ALL	ALL	PBF, ME, SL, DED	Metal, polymer, ceramic, bio-materials	STD, EDU, IE, IPRs, TT
PRODINTEC	R&D, Services Bureau, Design	www.prodintec.com	SPAIN/ Asturias	ALL	M&S, D, P, PP, Pr	PBF, VP, MJ, ME, SL;BJ O: direct light processing	ALL	STD, EDU, IE, IPRs, TT
PROFACTOR	R&D	www.profactor.at	AUSTRIA/ Oberösterreich	ALL	M&S, M, P; PP	VP, MJ, ME	Polymer	EDU, IPRs, TT
PSI	R&D, End User	www.psi.ch	SWITZERLAND/ Aargau	H, AE, AU, E, EN, C	M&S, M, PP, Pr	PBF	Metal, Polymer, Ceramic, Bio-materials	-
SIRRIS	R&D, Services Bureau	www.sirris.be	BELGIUM/ Prov. Liège	ALL	D, M, P, PP, Pr	ALL	Metal, Polymer, Ceramic	STD, L, IPRs, TT
TECNALIA	R&D	www.tecnalia.com	SPAIN/ País Vasco	ALL	ALL	DED	Metal	L, IE, IPRs
TNO	R&D, Design	www.tno.nl	NETHERLANDS/Noord-Brabant	ALL	ALL	PBF, VP, MJ, ME, BJ, continuous SLS or material jetting	Metal, polymer, ceramic, food	STD, EDU, IE, IPRs, TT
TUD	R&D, Design	http://www.hyperbody.nl/research/projects/robotic-building/	NETHERLANDS /Zuid-Holland	AE, AU, E, EN, E&T, C	M&S, D, M	ME	Polymer, Ceramic	EDU
TU Delf	R&D, Design, End user	http://designinformatics.bk.tudelft.nl/	NETHERLANDS /Zuid-Holland	C	M&S, D, P	PBF, VP ME	Polymer	EDU, TT
TUKE	End user	www.sjf.tuke.sk/kppt/	SLOVAKIA/ Východné Slovensko	ALL	M, P, PP	ME	Polymer	EDU, TT
TWI	R&D	www.twi.co.uk	UNITED KINGDOM/ South Yorkshire	ALL	ALL	PBF, DED	Metal	STD, EDU, TT

University of Extremadura	R&D	http://materiales.unex.es	SPAIN/ Extremadura	ALL	M&S, M, P	ME	Polymer, ceramic, biomaterails	EDU, TT
VIVES	Educational Establishment, R&D, design	www.vives.be/onderzoek-ontwerp-productietechnologie	BELGIUM	CG, O (mechanics)	M, D, PP, Pr	PBF, ME,	Metal, Polymer	EDU, TT
VTT	R&D, Material Provider, Design	www.vtt.fi/powder	FINLAND	ALL	ALL	PBF, ME, DED, Powder production	Metal, Ceramic	L, EDU, IE, IPRs, TT

Industry

NAME	SUPPLY CHAIN	WEBSITE	COUNTRY/ Region	Sectors	VC segments	AM processes	AM Materials	Non Tech.
3DStep	R&D, Service Bureau, Design, AM training, Innovation services	www.3dstep.fi	FINLAND/Tampere	AE, EN, E&T, C, Food	ALL	PBF, ME	Metal, Polymer, Bio-materials, Composite materials, Chocolate	EDU, IE, TT, Community development
3DCeram Sinto	Service Bureau, OEMs, Materials Provider	www.3Dceram.com	FRANCE/Limousin	H, AE,AU,E,EN	M,P,PP,Pr	VP	Ceramic	IE, TT
+90	R&D, Service Bureau, OEMs, Design, End User	www.arti90.com	TURKEY	ALL	D, M, P, PP, Pr	PBF, MJ, ME	Polymer	STD
ADMATEC	R&D, Service Bureau, OEM	www.admateceurope.com	NETHERLANDS/Noord-Brabant	H, AE, AU, E, ALL	M, P, PP, Pr	VP	Metal, Polymer, Ceramic, Bio-materials	-
AIM Sweden	R&D, Services Bureau, OEMs, Design	www.aimsweden.com	SWEDEN/ Mellersta Norrland	H, AE, AU, O (industrial)	M&S, D, M, P ,PP, Pr	PBF, EBM	Metal	EDU, IE, TT
AIRBUS	R&D, Design, End user	www.airbus.com	SPAIN	AE	M&S, D, M; PP; Pr	PBF, MJ; DED	Metal, Polymer	STD, LE, EDU, IE, IPRS, TT
ALTRAN Deutschland SAS & Co. KG	R&D, OEM, Software provider, design	www.altran.com	GERMANY/ Hamburg	ALL	ALL	PBF, ME	Metal, Polymer, Biomaterials	STD, EDU, IE, IPRS, TT
ATLAS COPCO	OEM	www.atlascopco.com	BELGIUM/ Antwerpen	O (industrial applications)	M&S, D, P, PP, Pr	PBF, ME, BJ	Metal, polymer	L, EDU
ATOS SE	R&D, OEMs, Materials & Software provider, design, End user		FRANCE/ Ile de France	ALL	M&S, D, P, Pr	-	-	STD, EDU; IE, IPRs, TT
CAM	R&D, Services Bureau, OEMs, Design, End user	www.croftam.co.uk	UK/Cheshire	AE, AU, CG ,E, EN,E&T, C	D, PP, Pr	PBF	Metal	EDU, IE
CRIT	R&D	www.crit-research.it	ITALY/ Emilia-Romagna	AE, AU, E	D, M, P	PBF	Metal, polymer	EDU, IE, TT
Digital Metal	Services Bureau, Equipment supplier	www.digitalmetal.tech	SWEDEN/ Sydsverige	H, AE, AU, CG, EN, E&T	D, M, P, PP, Pr	BJ	Metal	STD, IE, IPRs

EOS	R&D, OEM, Materials & Software provider, End user	www.eos.info	GERMANY/Oberbayern	ALL	ALL	PBF	Metal, polymer	STD, IE, IPRs
ESI Group	R&D, Software provider, Design	www.esi-group.com	FRANCE/ Île de France	ALL	M&S; D	PBF, DED	Metal	STD; EDU; TT; IPRs; IE
FADDTORY	R&D, Service Bureau design, end user	www.faddtory.com	BELGIUM/ Namur	H, AE, AU, CG, E, EN, E&T	ALL	PBE, VP, ME, DED, BJ	Metal, Polymer, Ceramic	EDU, IE, TT
GFMS	OEM, pre- and postprocessing equipment	www.gfms.com	SWITZERLAND/Geneva	ALL	D, P, PP	PBF, DED	Metal	IE
GOCERAM AB	Materials provider	www.goceram.com	SWEDEN/ Västsverige	ALL	M	ME, Feedstock provider	ALL	TT
Granta	R&D, Software provider	www.grantadesign.com	UNITED KINGDOM/ East Anglia	ALL	ALL	ALL	ALL	STD, EDU, IE, TT
Granutools	R&D, OEMs, Materials provider, End user	www.granutools.com	BELGIUM/ Liège	ALL	P	PBF	Metal, polymer, ceramic	STD, EDU, IE, TT
HAMUEL	Machine tool builder	www.hamuel.de	GERMANY/Oberfranken	E&T	P	Laser Metal Deposition (LMD)	Metal	EDU, TT
HILTI	End User	www.hilti.group	LIECHTENSTEIN	E&T, C	M&S, M, Pr	PBF, MJ, BJ	Metal, Ceramic, Hardmetals (cemented carbide composites)	IE
Höganäs	R&D, Materials provider	www.hoganas.com	SWEDEN/ Sydsverige	ALL	M	PBF, DED, BJ	Metal	STD, EDU, IE, IPRs
IMA	R&D, Design, End User	www.ima.it	ITALY/ Emilia-Romagna	Industrial machines for packaging	D. Pr	PBF	Polymer	IE, TT
IMR	Materials provider	www.imr-group.com	AUSTRIA/ Kärnten	AE, AU, CG, EN, E&T	M	PBF, MJ, BJ	Metal	IE
InnoSyn B.V.	End User	www.innosyn.com	NETHERLANDS/ Limburg	E, (Chemical)	P	PBF	Metal	IE
LCV	R&D, Services Bureau, Design	www.lcv.be	BELGIUM/ Antwerpen	ALL	D, M, P, Pr	DED	Metal	STD, TT
LINDE France	Materials provider, Process gases for AM + powder production + post-treatment	www.linde-gas.fr	FRANCE/ Rhône-Alpes	ALL	M, P, PP, Pr	PBF, MJ, SL, DED, BJ, Cladding, deposition	Metal	-
Lithoz	R&D, Materials provider, design, technology provider	www.lithoz.com/en/	AUSTRIA/Wien	ALL	D; M; P; PP	VP	ceramic, biomaterials	EDU; IE, IPRs, TT
MATERIALISE NV	R&D, Service Bureau, software provider, design, end user	www.materialise.com	BELGIUM/ Prov. Vlaams-Brabant	H, AE, AU, CG	M, D; M; P; PP; Pr	PBF; VP; MJ; ME	Metal, polymer, ceramic, biomaterials	STD; L; IE; IPRS; TT
MBN	R&D, Materials provider	www.mbn.it	ITALY/Veneto	H, O (cutting tools)	M	PBF, DED, O	Metal, polymer,	-

							composite, intermetallic	
MCI	Service Burerau, Communication and Dissemination partner	www.mci-group.com	BELGIUM/ Région de Bruxelles-Capitale	ALL	ALL	ALL	ALL	STD; L; EDU, IE; IPRS; TT
MIMETE	Materials provider	www.mimete.com	ITALY/Lombardia	ALL	M	Gas atomization of metal powders for AM	Metal	-
Melotte	Service Bureau, design	www.melotte.be	BELGIUM/ Prov. Limburg	ALL	M&S, D; PP; Pr	Selective Laser Melting	Metal	EDU, IE
N-ABLE	Service Bureau	www.n-able.io	FRANCE/ Rhône-Alpes	ALL	ALL	ALL	ALL	STD, L, EDU, IE, TT, R&D/Demonstration and market policy
OCE	R&D, OEMs, Design	http://oce.com/	NETHERLANDS/ Limburg	ALL	M&D, D, M, P, PP, Pr	MJ	Metal, polymer, ceramic	IE
Oceanz B.V.	R&D, Service Bureau, OEM, Materials provider, Design, End user	http://oceanz.eu/	NETHERLANDS/ Gelderland	ALL	M, P, PP, Pr	SLS	Polymer, Food	EDU, IE
PRIMA	OEM	www.primaindustrie.com	ITALY/Piedmont	E, EN, E&T, C	P	PBF, DED	Metal	STD, IE
PwC	R&D Business Consultancy	www.pwc.nl	NETHERLANDS/ Noord-Holland	ALL	ALL	ALL	ALL	L, EDU, IE, IPRs, TT
RINA Consulting S.p.A.	R&D, D, Engineering consultancy operation and maintenance	www.rina.org	ITALY/Genova	ALL	ALL	ALL	Metal, polymer	STD, EDU, IE, IPRs, TT, roadmapping, safety
RINA Consulting - Centro Sviluppo Materiali S.p.A.	R&D, D, Engineering consultancy; Materials, processes	www.rina.org	ITALY/ Lazio	ALL	ALL	ALL	Metal, polymer	STD, EDU, IE, IPRs, TT, roadmapping, safety
Rosswag	R&D, Services bureau, Materials provider, Design	www.rosswag-engineering.de	GERMANY/Karlsruhe	EN, E&T, C	ALL	PBF	Metal	STD, EDU, TT
SAFRAN	R&D, OEMs, End user	www.safran-group.com	FRANCE/Île de France	AE	All	PBF, DED	Metal, polymer, ceramic	IE
SCHUNK	R&D, Design	www.schunk.com	GERMANY/Stuttgart	O (mechanical, engineering, automation)	M, D, Pr	PBF, O (laser sintering plastics)	Polymer	IE, IPR
SIEMENS	R&D, Software provider, Design, End user	www.siemens.com	GERMANY/Berlin	H, E	All	PBF, VP, ME, DED	Metal, polymer, ceramic	STD, L, EDU, IE, IPR, TT
Sintertech	OEM	-	FRANCE/Rhône-Alpes	AE, AU, CG, EN	Pr	PBF, BJ	Metal	-

SWEREA KIWAB	R&D	www.swerea.se/kimab	SWEDEN/ Stockholm	ALL	M&S, M, P	BPF	Metal	EDU, TT
TRIDITIVE	R&D, Services bureau, Design	www.dynamics.triditive.com	SPAIN/Asturias	All	M&S, D, P, PP, PR	VP, ME	Polymer	EDU, IE, TT
TRUMPF	R&D OEM, Materials provider,Software provider	www.trumpf.com	GERMANY/ Baden-Württemberg	AE, AU, CG, EN, E&T	M&S, D, M, P, PP, PR	PBF, DED	Metal	EDU, IE

Other

NAME	SUPPLY CHAIN	WEBSITE	COUNTRY/ Region	Sectors	VC segments	AM processes	AM Materials	Non Tech.
AD GLOBAL	Human Resources	www.alexanderdanielsglobal.com	SPAIN AND UK/Barcelona and Birmingham	ALL	ALL	ALL	ALL	EDU, Hiring AM talent
BERENSCHOT	Consulting company	www.berenschot.com	NETHERLANDS/Utrecht	ALL	ALL	ALL	ALL	STD,EDI, IE, IPRs, TT
IDEA CONSULT	Consulting company	www.ideaconsult.be	BELGIUM/ Bruxelles-Capitale	ALL	ALL	ALL	ALL	L, IE, TT
ISONORM	Consultancy on standardisation	-	ITALY/ Piemonte	ALL	ALL	O	ALL	STD

Clusters/networks/associations

NAME	SUPPLY CHAIN	WEBSITE	COUNTRY/ Region	Sectors	VC segments	AM processes	AM Materials	Non Tech.
3C ACADEMY	R&D; Service Bureau; design provider	-	BULGARIA/ Sofia-grad	H, AU; CG, E, EN; E&T, C	M&S, D, P, PP, Pr	PBF, VP, MJ; ME; DED, BJ	Metal, polymer, ceramic	STD, EDU, IE, IPRs
3DPA	Service Bureau	www.the3dprintingassociation.com	NETHERLANDS/ Zuid-Holland	ALL	ALL	ALL	ALL	STD, L; EDU, IPRs
AM Platform	ALL	www.am-platform.eu	EUROPE	ALL	ALL	ALL	ALL	All
ADDIMAT	ALL	www.addimat.es	SPAIN/ Pais Vasco	ALL	ALL	ALL	ALL	-
CECIMO	R&D; Materials & software provider	www.cecimo.eu	BELGIUM/ Bruxelles-Capitale	O (machine tool)	D, M, P, PP; Pr	PBF	Metal	STD, L; EDU; IE
EPMA	All Metal AM supply Chain	www.epma.com	BELGIUM/ Bruxelles-Capitale	O (powder metallurgy)	ALL	PBF	Metal	EDU, TT, Networking; Synergy
ERRIN	Network regional Innovation and of Smart Specialisation Strategies.	www.errin.eu	BELGIUM/ Bruxelles-Capitale	O (AM and nanotechnology)	-	-	-	EDU, TT, Networking
EWF	Education & Training, Standardization	www.ewf.be	BELGIUM/ Bruxelles-Capitale	AE, AU, CG, E, Manufacturing	M, P	PBD, DED	Metal, polymer	STD, EDU, IE, IPRs, TT
FLAM3D	cluster, network, association	www.flam3d.be	BELGIUM/ Flanders	ALL	ALL	-	ALL	ALL
IAM 3D Hub	R&D OEM, Design, Business development	-	SPAIN/ Catalonia	ALL	ALL	PBF, VP, ME	Metal, Polymer	STD, EDU, IE, IPRs, TT
MATIKEM	R&D; service Bureau;	en.matikem.com	FRANCE/ Nord - Pas-de-Calais	H, AU, CG	D, M, P, Pr, EL	VP, ME	Polymer, ceramic,	STD, EDU, IE, IPRs, TT

	Materials provider; design; end user						food, bio materials, o	
PRODUTECH - Production Technologies Cluster	ALL	www.produtech.org	PORTUGAL/ Norte	ALL	ALL	ALL	ALL	STD, L, EDU, IE, IPRs, TT

ANNEX E: AM-MOTION Gaps and actions details

TECHNICAL CROSS CUTTING

Action name	**Moving from production shape optimization based on simulations to 3D models for AM up to "automatic" model-aided printing process**		
Action n.	1	**Sector**	Technical Cross-Cutting
Description of the challenge (current gap)			
Development of accurate modelling and simulation tools is an important fundamental building block. Alignment is needed among mathematical representations in CAD, FEM, simulations and project planning. Fast, economic modelling is required. Some good examples of such activity has been performed (e.g. FIOH in Finland, INRS France) but further efforts are required. One of key aspects is interoperability and continuity.			
Proposed activities			
● Complete realisation from design to part. Holistic modelling approaches using multi-physics, multiscale simulation and going from process parameters and simulation to product mechanical properties, via thermal mapping/history of the workpiece. ● Integrate software tools with lean management, considering the overall life cycle assessment ●Integrate software tools with increased automation of AM processes (including robotics for manufacturing and packaging) ●Stochastic/empirical modelling techniques utilizing a large volume of data (knowledge repository) ●Development of material databases (material, properties and relation to surface condition) ●Integration of modelling in the general process. Digital twin approaches ●Develop software tools that enable parametric modelling of lattice structures for design of light-weight products. ●Exploitation of FP7/H2020 projects' outcomes in this field (in alignment with the European Material Modelling Council).			
Ongoing & recent projects already (partially) addressing the gaps	CAxMan, ENCOMPASS, ADDAM, Kraken, Bionic Aircraft, DIMAP, SYMBIONICA, SMARTIC, BAMOS		
Value chain segments	[x] Modelling [x] Design [x] Material [x] Process	[x] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Reduced time to market *Environment & Social* Material resource saving Increased number of jobs Jobs reshoring in EU		

Action name	Advanced and novel technologies for multi-voxel printing and digital materials		
Action n.	2	**Sector**	Technical Cross-Cutting
Description of the challenge (current gap)			
Multi-material printing is the combination of materials is on the Macro Level. Digital material is a seemingly one material where the combination of materials is on the Voxel level (microstructure), achieving completely new macroscopic properties.Voxel (volumetric pixel) is a volume element representing a value on a regular grid in three dimensional space. Most AM technologies (e.g. SLA, SLS, FDM) are working on a layer level. Working at voxel level will increase 3D printing opportunities enhancing the quality and functionalities of products (e.g. by achieving full color 3D printing, continuous transitions of properties, building new materials etc.). Further research is needed to develop novel incremental technologies able to control both layers and voxels (e.g. based on polyjet) or to work without layers achieving full digital printing.			
Proposed activities			
● Develop new materials and technologies for multi-voxel printing resulting in 3D printed digital materials ● Demonstrate the technologies in relevant environment and sectors.			
Ongoing & recent projects already (partially) addressing the gaps			
Value chain segments	☐ Modelling ☒ Design ☒ Material ☒ Process	☐ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL		**Target TRL**	
Type of Action			
High expected impact on:	*Economic & Industrial* Potential for EU leadership Increased production capacity Reduced time to market *Environment & Social* Material resource saving Jobs reshoring in EU Increased number of jobs		

Action name	**Design guidelines: need for AM process-/ material-/ application-specific guidelines**		
Action n.	3	**Sector**	Technical Cross-Cutting
Description of the challenge (current gap)			
Despite the solid progress in standardisation (there are ISO guidelines developed by ISAP TC 261 (still under development) ISO/ASTM DIS 52910-2 (general); ISO/ASTM 52911-1 (powder bed metals); ISO/ASTM DIS 52911-2 (Powder bed plastics) and ISO/NP TR 52912 (functionally graded AM parts)), there is need for process; material; application specific guidelines as well as Design standards for AM: -Automotive industry -For electronic devices -For light weight structures -For low vibration.			
Proposed activities			
●Establishment of a set of generic AM design rules with guidelines integrated with design modelling tools ●Design guidelines should not be limited to just the AM process but also include the entire manufacturing aspects of AM in combination with both preparations, pre- and post-processing ●Development of topology optimization methodologies in the design phase to move from feature-based to function-based design with the aim to support the ongoing work of ISO TC/261 jointly with ASTM F42 on the subject ●Creation of a central European data bank as base reference ● Application-Specific Design Guidelines: as industry fields mature in particular AM applications, best practices should be recorded.			
Ongoing & recent projects already (partially) addressing the gaps	FAST, ENCOMPASS, LASIMM, PARADDISE, IMRAM, LASIMM, TIFAN; MERLIN; AlForAMA, Kraken, Bionic Aircraft, BOREALIS; SYMBIONICA; 4DHYBRID, SMARTIC		
Value chain segments	[x] Modelling [x] Design [ ] Material [ ] Process	[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	5-6	**Target TRL**	7
Type of Action	IA/CSA		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased business generated Increased production capacity *Environment & Social* Material resource saving Jobs reshoring in EU Increased number of jobs		

Action name	**Need for advanced in process monitoring and control and generation of process validation data (through for eg. Artificial Vision, prediction models of microstructure control of parts during fabrication and supply chain control)**		
Action n.	4	**Sector**	Technical Cross-Cutting

Description of the challenge (current gap)
Process monitoring is important for quality and production throughput. Improvement of control technologies are needed to enable effective in process measurement as current ones are not robust enough. Need for in-process monitoring and control to minimize defects and increase reproducibility and process reliability. There is also need for Traceability of AM products.
Proposed activities
● Use of a "knowledge repository" to improve process reliability ●"Prevention of defects" module during the design process .To be linked/incorporated with product build preparation (build direction, nesting, maintenance etc.) ● Investigate the consequence of defects/porosity/surface condition under service load conditions (fatigue loads), and identify the critical defect shape /size that could lead to premature failure. ● Explore effective post-processing methods (e.g. heat treatment, HIPing (Hot Isostatic Pressing), laser peening) to reduce defect size. ● Identify the best manufacturing route for a product ● Definition of the parameters to be controlled ● Development of real-time in-process faster/cheaper measurement techniques to enable total control. Bring inspection techniques more developed in subtractive manufacturing to the world of AM. Integration of artificial vision in in-line monitoring system. ● In-situ process monitoring and of materials processing and allow for product defect detection ● In-line non-destructive testing and/or in-situ analysis on the AM product ● Inspection of welding for thermoplastic materials joining, and section inspections need in production lines through ultrasonic welding vibration during the welding process , infrared inspection, artificial vision inspection. ● Implementation of existing AM manufacturing platforms to be fully integrated with the process ● Automated conformity assessments, and its cross validation with existing standards; for example dynamic certification based on similar parts, processes, designs and material combinations, including big data, data safety and security ● Use design guidelines to support business decisions ● Address the generation of process validation data more than real time control

Ongoing & recent projects already (partially) addressing the gaps	FAST, ENCOMPASS, LASIMM, PARADDISE, Kraken, Open Hybrid, Bionic Aircraft, BOREALIS; SYMBIONICA, 4DHYBRID, SMARTIC, MAESTRO
Value chain segments	[x] Modelling [x] Design [ ] Material [x] Process [x] Post Process [ ] Product [ ] End of Life [ ] Complete VC

Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
High expected impact on:	*Economic & Industrial*		

	Increased product quality and performances Increased IPR protection Increased production capacity *Environment & Social* Jobs reshoring in EU Increased number of jobs Material resource saving

Action name	Simulation / prediction of thermal / residual stress for AM		
Action n.	5	**Sector**	Technical Cross-Cutting
Description of the challenge (current gap)			
The selection of optimum process parameters for reducing structural distortion and residual stresses by simulation (e.g. in laser direct manufacturing (LDM))			
Proposed activities			
● Investigation of thermal distortion of thin walls and substrates to optimize tool paths and deposition strategies to either control or minimize distortion. ● Thermal field mapping (from machine sensors) in order to determine residual stresses and distortion. ● Investigating how the process parameters affect thermal field, microstructure and mechanical properties to enable prediction of material properties. ● study in-process and post-process methods for reduction of residual stresses			
Ongoing & recent projects already (partially) addressing the gaps	Borealis, FAST, CAxMan, ENCOMPASS, LASIMM, Distraction, Kraken, Open Hybrid, DIMAP		
Value chain segments	[x] Modelling [x] Design [ ] Material [ ] Process	[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	4-5	**Target TRL**	6-7
Type of Action	IA		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Reduced time to market *Environment & Social* Material resource saving Jobs reshoring in EU Increased number of jobs		

Action name	Innovative strategies to reduce post processing steps/activities		
Action n.	6	Sector	Technical Cross-Cutting
Description of the challenge (current gap)			
Post-processing involves removal of the part from the platform and/or finishing the part. This segment of the manufacturing VC should be minimised, automated and integrated in the overall process as much as possible. Moreover, post-processing quality and reliability should be improved. There is need for breaktrhough innovations which address such challenges.			
Proposed activities			
● Development of innovative AM technologies and processes which minimise the need of post-processing. ● Strategies for increased automation of post processing and minimisation of manual operations ● Further investigation and evaluation of the effect of different post-processing operations (for example different heat treatments, Hot isostatic pressing (HIP) etc.) ● Integration of the AM process in a single process/hybrid machine to reduce the need of post-processing activities ● In-line process control and development of intelligent fix and handling systems ● Identifying a cost effective and adequate surface finishing method ● Understanding how the removal of material from the surface impacts the oversize of the design ● Investigate how post-processing can be supported via modelling providing a complete digital track of all steps ● Design approaches in am: make functional use of layers/lines in design for function			
Ongoing & recent projects already (partially) addressing the gaps	HyProCell, Interreg2seas, FAST, CAxMan, ENCOMPASS, LASIMM, IMRAM, TIFAN; Kraken, PALMS, 4DHYBRID, IG2		
Value chain segments	☐ Modelling ☐ Design ☐ Material ☒ Process	☒ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Reduced manufacturing cost Increased production capacity *Environment & Social* Material resource saving Jobs reshoring in EU Increased number of jobs		

Action name	Develop procedures and methods for qualification and promoting certification of AM products		
Action n.	7	**Sector**	Technical Cross-Cutting
Description of the challenge (current gap)			
A quick and cost-effective certification should be developed. There is a need for qualification and certification methods that will increase the number of certified quality AM parts. The ability to certify and qualify parts to existing specifications (e.g. aerospace) is also important. There is need to boost equivalence-Based & model-based qualification routes			
Proposed activities			
● Adaptive and flexible qualification for products ● Experimental: development of a matrix of required mechanical tests and acceptance criteria (e.g. tension, bending, fatigue endurance, fatigue crack growth rate, fracture toughness) that comply with certification rules ● Modelling and design: Predictive models that develop and demonstrate the capability of prediction (of strength and fatigue life) to satisfy the certification requirements. These should take account of specific AM material characteristics, such as graded microstructures, residual stresses due to thermal load distribution and anisotropic properties of the final parts ● Classification and categorization of defects in AM components and creation of an Atlas of defects. Defects nomenclature standardization ● Development of a European wide system to certify companies that carry out AM (for example ISO3834). This is crucial to ensure the quality of the products that are produced ● Ensure that existing knowledge and rules are transmitted to AM players			
Ongoing & recent projects already (partially) addressing the gaps	IMRAM, LASIMM , ADDISPACE, Kraken, ENCOMPASS; Open Hybrid, Bionic Aircraft, BOREALIS; SYMBIONICA, 4DHYBRID, BAMOS		
Value chain segments	[x] Modelling [x] Design [ ] Material [x] Process	[x] Post Process [x] Product [ ] End of Life [ ] Complete VC	
Current TRL	6	**Target TRL**	7
Type of Action	CSA		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased business generated Increased production capacity *Environment & Social* Material resource saving Jobs reshoring in EU Increased number of jobs		

<table>
<tr><td>Action name</td><td colspan="3">Role of AM in circular economy/circularity for material resources: need for recycling parts made with AM and for using recycled materials to produce AM components/products</td></tr>
<tr><td>Action n.</td><td>8</td><td>Sector</td><td>Technical Cross-Cutting</td></tr>
<tr><td colspan="4">Description of the challenge (current gap)</td></tr>
<tr><td colspan="4">From one hand, there is a shortage of material recycling services and means for reusing AM materials. From the other hand it is needed to promote reusing feedstock for parts production.</td></tr>
<tr><td colspan="4">Proposed activities</td></tr>
<tr><td colspan="4">● Effective Life Cycle Analyses (LCA), Life Cycle Cost Analysis and Social LCA, enabling the application of LC methodologies for accurate analysis of the environmental impact of AM processes, incorporating an environmental perspective into decision-making processes for transitioning to AM.
● Development of Environmental Impact Module/Evaluator acquiring real-time process data from measurement systems
● Definition and quantification of environmental KPIs such as energy consumption, waste streams, heat emission and gaseous emissions
● Development of effective feedstock recycling processes
● Development of regulatory requirements for recycling metal powders and production of functional parts
● Need for standard validation procedure for material properties in parts produced with feedstock that has been subjected tore-use or recycling, as well as guidelines for acceptable material properties and actions that restore the material properties to the original target values</td></tr>
<tr><td>Ongoing & recent projects already (partially) addressing the gaps</td><td colspan="3">PARADDISE, MERLIN, BARBARA, CIRCPACK; Bionic Aircraft</td></tr>
<tr><td>Value chain segments</td><td colspan="3">☐ Modelling ☐ Post Process
☐ Design ☐ Product
☐ Material ☐ End of Life
☐ Process ☒ Complete VC</td></tr>
<tr><td>Current TRL</td><td>4-6</td><td>Target TRL</td><td>7</td></tr>
<tr><td>Type of Action</td><td colspan="3">IA</td></tr>
<tr><td>High expected impact on:</td><td colspan="3"><u>Economic & Industrial</u>
Potential for EU leadership
Increased product quality and performances
Increased production capacity
<u>Environment & Social</u>
Material resource saving
Increased recycling
Better environment</td></tr>
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<table>
<tr><td>Action name</td><td colspan="3">Building a knowledge repository of materials and process parameters</td></tr>
<tr><td>Action n.</td><td>9</td><td>Sector</td><td>Technical Cross-Cutting</td></tr>
<tr><td colspan="4">Description of the challenge (current gap)</td></tr>
<tr><td colspan="4">Databases of process parameters and material properties need to be developed to enable determination of product design and establishment of material design allowances for specific processes. There is need to achieve sustainability of preferred/chosen knowledge repository</td></tr>
<tr><td colspan="4">Proposed activities</td></tr>
<tr><td colspan="4">● Knowledge generation for the effect of AM parameters (including waste streams), to the energy consumption and environmental footprint (activity connected with life cycle analysis approaches).
● Generation and availability of data regarding mechanical properties, dimensional accuracy, surface roughness etc. coupled with the respective machine characteristics and process parameters.
● AM material information database to enable the correct choice of AM materials
● Investigations on effect of several protective gases / mixtures on material characteristics
● Library of industry cases (successful and failed)
● Open innovation on consortia (e.g. Cambridge pharma) collaborating at pre-competitive stage</td></tr>
<tr><td>Ongoing & recent projects already (partially) addressing the gaps</td><td colspan="3">AM Database (@AM-Platform), FAST , SAMT SUDOE, ENCOMPASS, PARADDISE, IMRAM, AMable, Kraken, LASIMM, ibus</td></tr>
<tr><td>Value chain segments</td><td colspan="3">[x] Modelling
[x] Design
[x] Material
[x] Process
[x] Post Process
[x] Product
[ ] End of Life
[ ] Complete VC</td></tr>
<tr><td>Current TRL</td><td>4-6</td><td>Target TRL</td><td>7</td></tr>
<tr><td>Type of Action</td><td colspan="3">IA/CSA</td></tr>
<tr><td>High expected impact on:</td><td colspan="3"><u>Economic & Industrial</u>
Increased product quality and performances
Reduced time to market
Potential for EU leadership
<u>Environment & Social</u>
Material resource saving
Jobs reshoring in EU
Increased number of jobs</td></tr>
</table>

Action name	Increased industry engagement on standards development and decrease fragmentation of Am Standardization initiatives		
Action n.	10	**Sector**	Technical Cross-Cutting

Description of the challenge (current gap)

To accelerate AM market take up, industry should be further engage in CEN, ASTM, and ISO standards development (e.g. in process certification:
-Simulation software for NDF & variation certificaton
-Application specific requirements).
Possible barriers concerning time and money to follow this activity should be minimized. Involvement of customers in AM is important. There is also need for Open data warehouse on certified designs (with production requirements)

Proposed activities

- Lower the barrier to engaging stakeholders by centralization of standardisation activities in specific key meetings/events etc.
- Promote the ongoing activities on standardization at a wider level. Continuous interaction with local, national, EU and international standards development bodies/activities should be pursued. Cooperation between the different Standardization bodies
- Support further engagement via H2020 projects or other relevant projects with central focus on AM to evaluate possible use of results for standards elaboration. When suitable a Work Package dedicated to dealing/engaging with standardization should be mandatory. Another alternative could be having a continuous standarisation project that interacts and coordinates with existing projects
- Explore feasibility to evaluate which standards already approved and existing in non-AM sectors can be extended to AM
- Ensure availability of information on existing AM standards and HWIP (Health Workforce Information Programme)

Ongoing & recent projects already (partially) addressing the gaps	SASAM (update needed), CAxMan, PARADDISE, LASIMM 0, AMable, Kraken, Open Hybrid, 4DHYBRID, BOREALIS; SYMBIONICA, BAMOS		
Value chain segments	☐ Modelling ☐ Design ☐ Material ☐ Process	☐ Post Process ☐ Product ☐ End of Life ☒ Complete VC	
Current TRL	NA	**Target TRL**	NA
Type of Action	CSA		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Potential for EU leadership *Environment & Social* Material resource saving Jobs reshoring in EU Increased number of jobs		

<table>
<tr><td>Action name</td><td colspan="3">Availability of high quality and cost-effective materials</td></tr>
<tr><td>Action n.</td><td>11</td><td>Sector</td><td>Technical Cross-Cutting</td></tr>
<tr><td colspan="4">Description of the challenge (current gap)</td></tr>
<tr><td colspan="4">AM community relies on a limited selection of conventional feedstock material. The availability of quality, economically feasible raw materials or feedstocks should be fostered. The range of available materials needs to be expanded (e.g. there is need for high-class powders (Titanium); polymer compounds with tailor made properties (with active funcionalities such as antimicrobic, electrical or thermal conductive…)). It is important to understand to transport these materials (safety issues) to achieve distributed manufacturing; Strategic support is needed for European powder/material for AM supply chain and growth</td></tr>
<tr><td colspan="4">Proposed activities</td></tr>
<tr><td colspan="4">● Developing new polymers (and charge, where relevant) through interdisciplinary actions linking together chemistry, material research, new manufacturing process and user needs.
● Realization of innovative feedstock for FDM 3d printer based on polymer compound with tailor made properties (with active functionalities such as antimicrobial, electrical or thermal conductive…)
● Ultra-high temperature materials (refractory, composite, others). New alloys with high temperature capability
● Research into materials suitable for printing of multifunctional components/ Multi-material for multi-functional parts towards smart system.
● Use of Hybrid AM machine with tools able to improve joining between dissimilar materials (for example atmospheric plasma jet)
● Research on materials compatibility with current and novel AM processing technologies
● Novel materials resulting in fewer undesirable by-products and less waste
● Reinforce collaboration between designers, material producers and AM machine manufacturers
● Increase awareness on existing powder metallurgy solutions</td></tr>
<tr><td>Ongoing & recent projects already (partially) addressing the gaps</td><td colspan="3">FAST, LASIMM, AlForAMA, Kraken, Bionic Aircraft, DIMAP, SMARTIC , BAMOS, EAST</td></tr>
<tr><td>Value chain segments</td><td colspan="3">[x] Modelling
[x] Design
[x] Material
[ ] Process
[ ] Post Process
[ ] Product
[ ] End of Life
[ ] Complete VC</td></tr>
<tr><td>Current TRL</td><td>4-6</td><td>Target TRL</td><td>7</td></tr>
<tr><td>Type of Action</td><td colspan="3">IA</td></tr>
<tr><td>High expected impact on:</td><td colspan="3"><u>Economic & Industrial</u>
Increased product quality and performances
Potential for EU leadership
Increased IPR protection
<u>Environment & Social</u>
Jobs reshoring in EU
Increased number of jobs
Material resource saving</td></tr>
</table>

Action name	**Quality management systems: need for definition of key quality affecting parameters for various AM systems& applications**		
Action n.	12	**Sector**	Technical Cross-Cutting
Description of the challenge (current gap)			
Quality management system covering the whole AM-process chain from powder to the final product, as a basis for part qualification, and AM-process chain surveillance. This includes data gained from pre-process analysis (powder), process monitoring solutions as well as machine data etc. Producing parts with standard properties requires development of standard procedures			
Proposed activities			
● Development of AM-process chain monitoring solutions, protocols and data systems, which give indication about the conformance of the AM-process chain with existing standards and rules ● Development of statistically based knowledge about the influence of AM-processing-chain parameters on the final part quality ● Development of specific “AM-quality management” standards. Definition of quality on several levels: microstructure, mechanical properties and discontinuities ● Setup of a qualification label for AM service providers ● Experimentally-validated databases containing standard sets of process parameters per process/machine/material ● Standard materials database ● Standard post-processing (especially heat treatment) temperature profiles			
Ongoing & recent projects already (partially) addressing the gaps	HyProCell, ENCOMPASS, IMRAM, LASIMM , Combilaser, Kraken		
Value chain segments	☐ Modelling ☐ Design ☐ Material ☐ Process	☐ Post Process ☐ Product ☐ End of Life ☒ Complete VC	
Current TRL	4-6	**Target TRL**	7
Type of Action	IA		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Reduced time to market *Environment & Social* Increased number of jobs Jobs reshoring in EU Material resource saving		

<table>
<tr><td>Action name</td><td colspan="3">Integrating AM technologies into existing industrial processes/chains</td></tr>
<tr><td>Action n.</td><td>13</td><td>Sector</td><td>Technical Cross-Cutting</td></tr>
<tr><td colspan="4">Description of the challenge (current gap)</td></tr>
<tr><td colspan="4">Integration in the shop floor requires attention as AM machines do not stand alone in factories. Combination with other machinery (subtractive, metallization, inspection, assembly) allows complex process chains and highly functional products, thus higher value and possible sale prices. Connect pre-, in- and post-processing for AM parts both physically (automation) and digitally (continuous digital thread)</td></tr>
<tr><td colspan="4">Proposed activities</td></tr>
<tr><td colspan="4">● Integration of entire process chains
● Interfaces development
● Evaluate/reconfigure CAD/CAM systems. CAD-CAM Platforms to support the integration of AM processes and equipment. Extension of existing file formats (i.e. STEP-NC) to include AM as well as pre- and post-processing steps in different "blocks"
● Fully automated AM processes connected via ERP and with the other machines in the production lines, to produce single parts in continuous production flow
● Creation of framework for multiple hardware equipment communication and collaboration</td></tr>
<tr><td>Ongoing & recent projects already (partially) addressing the gaps</td><td colspan="3">NL project PV2020, KitkAdd project, SAMT SUDOE, CAxMan, ENCOMPASS, PARADDISE, IMRAM; ADDAM, LASIMM, HyProCell, Kraken, ENCOMPASS; Open Hybrid; PALMS, 4DHYBRID, IG2, SMARTIC, BAMOS</td></tr>
<tr><td>Value chain segments</td><td colspan="3">☐ Modelling
☐ Design
☒ Material
☒ Process
☒ Post Process
☐ Product
☐ End of Life
☐ Complete VC</td></tr>
<tr><td>Current TRL</td><td>4-6</td><td>Target TRL</td><td>7</td></tr>
<tr><td>Type of Action</td><td colspan="3">IA</td></tr>
<tr><td>High expected impact on:</td><td colspan="3"><u>Economic & Industrial</u>
Increased product quality and performances
Increased production capacity
Reduced time to market
<u>Environment & Social</u>
Decrease of inequalities
Material resource saving
Better environment</td></tr>
</table>

Action name	Standard protocols for round robin testing		
Action n.	14	**Sector**	Technical Cross-Cutting
Description of the challenge (current gap)			
Leverage a rich knowledge base in AM to gain competitive advantage in Europe by accelerate the adoption of these technologies			
Proposed activities			
● To boost truly collaborative environments and networks among the regions and Member States following their capabilities (RIS3 strategy) / needs along the value chains segments ● To analyse the need of the creation of an “EU Makes portal / platform” similar to USA model ● To coordinate policy actions and incentives at the local/regional/ national or EU level ● AM marking / branding / labelling. “Made by AM” ● Development of practical solutions for the production and distribution of the products ● Cooperation & coordination between AM standardization bodies			
Ongoing & recent projects already (partially) addressing the gaps	MANSYS, BOREALIS		
Value chain segments	☐ Modelling ☐ Design ☒ Material ☒ Process	☒ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	NA	**Target TRL**	NA
Type of Action	CSA		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Potential for EU leadership Reduced manufacturing cost *Environment & Social* Increased number of jobs Material resource saving Jobs reshoring in EU		

Action name	Research and demonstration of 4D Printing technologies fueled by smart materials and multi-material/digital printing		
Action n.	15	Sector	Technical Cross-Cutting
Description of the challenge (current gap)			
4D printing is a combination of 3D printing and the fourth dimension, which is time and/or the change of functionalities. This technique allows a printed object to be programmed to carry out shape change while adapting to its surroundings. This allows for masterized self-assembly, multi-functionality, and self-repair. While 4D printing looks promising for many applications such as the packaging, medical, actuation, construction, and automotive fields, it is still a very raw and new technology with many challenges that require resolution. Significant issues include the development of that possess reversibility (e.g shape memory materials; informed matter); material printability and repeatability of 4D printed objects. Moreover mechanical constraints, time response linked with the desired application, design of structured printing (i.e. smart foam) and mathematical modeling are required for the design of the distribution of multiple materials in the structure.			
Proposed activities			
● Develop and/or optimise new 4 Printing technologies and solutions with smart stimulus-responsive materials (shape/functionality change materials or shape memory materials) able to respond to stimuli such as water, heat, electromagnetic field or light or their combinations. ●Development and application of 4D printing and smart multi-material/digital structures in several sectors (medical, bio-printing, construction, packaging and drug distribution, consumer electronics and automotive).			
Ongoing & recent projects already (partially) addressing the gaps			
Value chain segments	[ ] Modelling [ ] Design [X] Material [X] Process	[x] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	2-3	**Target TRL**	4-5
Type of Action	RIA		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased business generated New types of ventures started *Environment & Social* Material resource saving Better environment Reduction of CO2 emission		

Action name	**Convergence among Artificial Intelligence, Robotics, Sensing Technologies and 3D Printing**		
Action n.	16	**Sector**	Technical Cross-Cutting
Description of the challenge (current gap)			
AI can make 3D printing more productive by for example enabling more people to be designers (translating their needs directly into CAM files) and improving co-creation opportunities in different environments (e.g.health, consumer markets etc.). Robots and disruptive software may enhance 3D printing speed and properties including quality by introducing artificial intelligence algorithms such as computer vision algorithms for in line quality control. Development of new AM technologies that can move away from classical cartesian coordinates and print in more complex spaces is also important. For example in the health sector it is important to create more complex structures that better mimick the architecture of our body parts. Further research is needed in such areas.			
Proposed activities			
● Development of novel AM technologies, integrating mechatronics, robotics and software development ● Integrate artificial intelligence in 3D printing design process, promoting co-creation and enhancing design opportunities by involving users and different stakeholders (e.g. patients, surgeons etc.) in health and consumer markets. ● Increase automation, manufacturing speed and in line quality control in 3D printing through robotics and artificial intelligence.			
Ongoing & recent projects already (partially) addressing the gaps			
Value chain segments	[x] Modelling [x] Design [x] Material [x] Process	[x] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	2-3	**Target TRL**	4-5
Type of Action	RIA		
High expected impact on:	***Economic & Industrial*** Increased product quality and performances Increased production capacity Reduced time to market ***Environment & Social*** Jobs reshoring in EU Increased number of jobs Material resource saving		

Action name	Development of improved heat or light sources for AM manufacturing equipment		
Action n.	17	Sector	Technical Cross-Cutting
Description of the challenge (current gap)			
The heat or light source (in most) AM equipment is a bottle neck for improved production quantity and accuracy (resolution). This is a very important issue in terms of industries linked to glass manufacturing (not only jewel-lery, but e.g. also optics).			
Proposed activities			
● Development of improved heat transfer/control/distribution/strategy/new lasers/energy sources etc.			
Ongoing & recent projects already (partially) addressing the gaps	Laserdioded based sources (Addfactor, PV2020), ENCOMPASS, Bionic Aircraft, MAESTRO		
Value chain segments	☐ Modelling ☐ Design ☐ Material ☒ Process	☒ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	1-3	**Target TRL**	4-5
Type of Action	RIA		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Potential for EU leadership *Environment & Social* Material resource saving Better environment Reduction of CO2 emission		

Action name	Convergence between Virtual Reality and AM		
Action n.	18	Sector	Technical Cross-Cutting
Description of the challenge (current gap)			
Availability of effective technologies for virtual reality to be useful for AM			
Proposed activities			
● Develop AM smart objects which can be on-site inspected on-site with a cell phone and smart glasses			
Ongoing & recent projects already (partially) addressing the gaps			
Value chain segments	☐ Modelling ☐ Design ☐ Material ☐ Process	☐ Post Process ☐ Product ☐ End of Life ☒ Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
High expected impact on:	*Economic & Industrial* New types of ventures started Increased product quality and performances Reduced time to market *Environment & Social* Increased number of jobs Better quality of life Material resource saving		

NON-TECHNICAL CROSS CUTTING

<table>
<tr><th>Action name</th><th colspan="5">Promoting effective communication of AM technologies for high applications and impact</th></tr>
<tr><td>Action n.</td><td>1</td><td colspan="2">Sector</td><td colspan="2">Non-Technical Cross-Cutting</td></tr>
<tr><td colspan="6">Description of the challenge (current gap)</td></tr>
<tr><td colspan="6">In some cases, the AM technology/term has been over-characterised and described by excessive media hype and expectations. This has brought serious damage to the credibility and development of the AM industry. To ensure rapid and effective guides, real benefits and impact need be communicated to industry as well as basic and practical AM knolewdge should be disseminated. At the same time, it will be useful to discuss on the effect of the short lifetime of new machines which are for too short time used, linking the discussion with new business strategies and models.</td></tr>
<tr><td colspan="6">Proposed activities</td></tr>
<tr><td colspan="6">● Use of existing communication networks of reference (e.g. Platforms, industrial associations, standardisation committees…) to inform the different communities and foster dialogue between them. Moreover, to reach the general public and policy maker, sector magazines, newspapers and 2.0 tools (Twitter, You Tube) should be further exploited.
● Emphasis on design for AM and special considerations (overhangs/ supports/solid structures or latticed/post-processing requirements required for AM)
● Coordination with local industrial chambers and organisation, including umbrella organizations, of training days/seminars including practical workshops
● Screening of existing/ organisation of events, conferences to present the novelties, bringing examples of good collaborations, success stories in industrial implementation, and societal impact. This includes bringing together different stakeholders (policy makers, industry, end-users etc.) and adopting a ‘correct’ communication channel for each of them
● Attention to the development of “use” cases where businesses in application sectors can have access to technology facilities and use AM equipment, thereby improving their practical understanding of this technology. This would tackle the problem related to overall conservative attitude towards AM in industry
● Learning-by-doing support action for industry (including deep-learning and artificial intelligent elements)</td></tr>
<tr><td colspan="3">Ongoing & recent projects already (partially) addressing the gaps</td><td colspan="3">SAMT SUDOE, CAxMan, ENCOMPASS, all IMR activities, LASIMM, ADDISPACE, Kraken, BOREALIS, SMARTIC, BAMOS</td></tr>
<tr><td>Current TRL</td><td colspan="2">NA</td><td colspan="2">Target TRL</td><td>NA</td></tr>
<tr><td colspan="2">Type of Action</td><td colspan="4">CSA</td></tr>
<tr><td colspan="2">High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Increased product quality and performances
Increased production capacity
Reduced time to market
<u>Environment & Social</u>
Jobs reshoring in EU
Increased number of jobs
Material resource saving</td></tr>
</table>

Action name	Develop AM specific educational and training modules both through linking with "regular" high education curricula (engineering, business schools) and training on the job approaches		
Action n.	2	Sector	Non-Technical Cross-Cutting

Description of the challenge (current gap)

New jobs around AM will be created. Finding the workforce with the right competences is a challenge. Thus, knowledge gaps and educational needs for the AM workforce need to be identified and addressed. Training and education establishments need to preserve and develop the employability of workers. Industry and other employers (e.g. Standardisation bodies, IPR entities etc.) should be also engaged in the process in order to align their needs with regard to skills with the educational contents. AM education and training requires an integrated and interdisciplinary approach to prepare the current and future workforce to boost AM's real potential. It is important to define new jobs and skill sets, while addressing the current uncertainty about their education domain (engineering, design, processes etc.). Finally, there is lack of engineering & design specialists in Europe. The complexity of interdisciplinary processes has to be mastered…which is quite difficult as reported in previous works.

Proposed activities

● Map existing Educational programs and actors in Academic and Industry
● Promote collaboration of educational bodies with industry and governments at regional, national and EU levels towards the inclusion of AM aspects on the educational curricula in an effective way
● Map existing Educational programs and actors in Academic and Industry
● Promote collaboration of educational bodies with industry and governments at regional, national and EU levels towards the inclusion of AM aspects on the educational curricula in an effective way
● Emphasise design for AM and special considerations (overhangs/ supports/solid structures or latticed/post-processing requirements required for AM)
● Ensure that AM curricula addresses employer's needs, address multidisciplinarity and includes both technical (AM and traditional manufacturing processes, materials, design for AM, safety, etc.) and business related aspects. They should target different levels: management, engineers, shop floor, etc. - from University level to the operator level, focusing not only in preparing a new workforce but also in re-skilling the existing one to work and implement AM
● Introduce new means of teaching: For example practical modules held at industrial or specialized R&D centres.
● Provide AM training programs to gain AM knowledge and experience for workers seeking alternative employment pathways
● Use of standards as a base for all training materials and courses (certification by professional bodies) from industry training to higher education
● Offer support for collaborative and community-oriented maker spaces/events that, as informal learning environments, promote awareness of AM among society
● Introduce AM to curricula of Elementary and High schools in all EU
●CSA for promotion of AM technologies to wide public
-Support Fablab initiative
● AM promotion through the organization of competition for AM design (free form design) for young people (high school pupils, students) and public promotion of their design
● These activities should be supported by popular lectures and workshops

Action name	**Develop AM specific educational and training modules both through linking with "regular" high education curricula (engineering, business schools) and training on the job approaches**		
Ongoing & recent projects already (partially) addressing the gaps	SAMT SUDOE, LASIMM, Kraken, Skillman , ADMIRE; CLLAIM, 3DPRISM; METALS		
Current TRL	NA	**Target TRL**	NA
Type of Action	CSA/ERANET		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Potential for EU leadership Increased production capacity *Environment & Social* Increased number of jobs Jobs reshoring in EU Material resource saving		

<table>
<tr><th>Action name</th><th colspan="3">Innovative AM sustainable business models</th></tr>
<tr><td>Action n.</td><td>3</td><td>Sector</td><td>Non-Technical Cross-Cutting</td></tr>
<tr><td colspan="4">Description of the challenge (current gap)</td></tr>
<tr><td colspan="4">Business cases and models are still needed to show decision makers what is possible with AM and how it could impact their business (for parts, for prototyping, for production processes). Accessibility to AM technology for newcomers should be easier and cost effective. There is need to understand the effect of new supply chains on companies ‘business models?
We should not confuse that AM is often not the need, but rather the means.
It is important to learn how to incorporate presumption and (autonomous) co-creation in business models as well as find sustainable business models for direct manufacturing and distributed manufacturing. The general idea of redesign of part is probably a good route for promoting AM.</td></tr>
<tr><td colspan="4">Proposed activities</td></tr>
<tr><td colspan="4">● Evaluation of AM capabilities for new products and structures. Identification of appropriate use cases, right applications and markets, and development of practical solutions for the production and distribution of the products.
● Success models for business collaboration, realising current bottlenecks and best practices for transferability of novel technologies
● Explore existing AM manufacturing platforms and materials to evaluate suitability as an alternative manufacturing solution
● Business and economic model analysis using also a life cycle cost analysis approach. Ability to calculate the total increase in manufacturing cost vs. the benefits arising from its use during the lifecycle.
● Consideration of 3D parts models access and IPRs possible issues
● Assessment of value creation by AM in industrial applications
● AM as service: -Business model based on uptime; -Flexible attitude towards temporary parts.
● Consideration of maintenance/replacement of AM parts, especially in the case of function-integrated structures
● Creation of a decision-support tool able to quantify benefits of introduction of AM during the lifecycle of a product</td></tr>
<tr><td colspan="2">Ongoing & recent projects already (partially) addressing the gaps</td><td colspan="2">HyProCell, ManSYS; AMable, CAxMan, PARADDISE, IMRAM, AMable, BOREALIS, SYMBIONICA, 4DHYBRID, SMARTIC, BOREALIS, BAMOS</td></tr>
<tr><td>Current TRL</td><td>NA</td><td>Target TRL</td><td>NA</td></tr>
<tr><td>Type of Action</td><td colspan="3">CSA/IA</td></tr>
<tr><td>High expected impact on:</td><td colspan="3"><u>Economic & Industrial</u>
Increased product quality and performances
Increased production capacity
Reduced time to market
<u>Environment & Social</u>
Jobs reshoring in EU
Material resource saving
Increased number of jobs</td></tr>
</table>

<table>
<tr><td>Action name</td><td colspan="4">Safety issues on AM (with focus on metal AM): need for safety assessment, safety management and guidelines and education on EHS challenges</td></tr>
<tr><td>Action n.</td><td>4</td><td>Sector</td><td colspan="2">Non-Technical Cross-Cutting</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">Need for Rules/Guidelines/ Education on EHS challanges with AM. In relation with protection of Machine Operators: there is a need for standards to address EHS in the AM process. Typical hazards to be addressed include: guarding from moving parts that are not protected from contact; chemical handling (liquids, powders, wires); air emissions (dusts, vapors, fumes); noise (cleaning apparatus); electrical (water wash systems, electro-static systems); flammable/combustible cleaning materials; solid waste; laser use (sintering processes); and UV light (may require eye and skin protection based on design)</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">●Recommend creating a standard addressing EHS issues relative to additive machines (power, laser, safe handling, air quality, etc.). Physical measurement of operator exposure to AM materials is one of the most critical needs and can be leveraged from existing industry standards and guidelines.
●In case of use of nanomaterials during the AM process safe by design approach is relevant in respect of European Nanosafety Cluster
● Understanding the potential of the operation to generate fine powders, the exposure and the effect of volatile powders on the individual and surrounding environment during the life cycle.
● Develop sufficient protective equipment around AM (ventilation, powder handling stations, etc.)
● Development of technical solutions to minimize contact between operator and material (e.g. Solvent Damp Powders - There should be sufficient solvent that the powder cannot form a dust cloud; Large Particle Size Materials and Blends - Concentration of fine powder within the bulk of the material)
● Exploring the potential for charging powders into Flammable Atmospheres
● Promote education and training activities related to EHS challenges in AM with focus on powder handling</td></tr>
<tr><td colspan="2">Ongoing & recent projects already (partially) addressing the gaps</td><td colspan="3">FAST, DIMAP, BOREALIS, 4DHYBRID, BOREALIS</td></tr>
<tr><td>Current TRL</td><td colspan="2">4-5</td><td>Target TRL</td><td>6-7</td></tr>
<tr><td colspan="2">Type of Action</td><td colspan="3">IA</td></tr>
<tr><td colspan="2">High expected impact on:</td><td colspan="3"><u>Economic & Industrial</u>
Increased product quality and performances
Increased business generated
Increased number of private companies involved
<u>Environment & Social</u>
Better personal health
Jobs reshoring in EU
Material resource saving</td></tr>
</table>

<table>
<tr><th>Action name</th><th colspan="4">Promoting crowdsourcing solutions for design and manufacturing</th></tr>
<tr><td>Action n.</td><td>5</td><td colspan="2">Sector</td><td>Non-Technical Cross-Cutting</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">There is need for self-sustainable co-creation platform with easy to use softwares</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">● Connect data and available tools and platforms, integrating existing applications, systems and enterprise processes.
● Involvement of software companies/ computational services providers.</td></tr>
<tr><td colspan="2">Ongoing & recent projects already (partially) addressing the gaps</td><td colspan="3">Kraken</td></tr>
<tr><td>Current TRL</td><td>NA</td><td>Target TRL</td><td colspan="2">NA</td></tr>
<tr><td colspan="2">Type of Action</td><td colspan="3">CSA</td></tr>
<tr><td colspan="2">High expected impact on:</td><td colspan="3"><u>Economic & Industrial</u>
Reduced time to market
Increased number of private companies involved
Increased business generated
<u>Environment & Social</u>
Jobs reshoring in EU
Increased number of jobs
Better quality of life</td></tr>
</table>

<table>
<tr><td>Action name</td><td colspan="3">Development of a European network system for AM education and training</td></tr>
<tr><td>Action n.</td><td>6</td><td>Sector</td><td>Non-Technical Cross-Cutting</td></tr>
<tr><td colspan="4">Description of the challenge (current gap)</td></tr>
<tr><td colspan="4">AM is a fast developing technology constantly changing, and educational contents and training guidelines need to be updated at the same speed and in a sustainable way to ensure the system tackles immediate and future needs. Moreover, new educational partnerships are needed to deliver broad education covering innovative and interdisciplinnary aspects. Specific focus should be given on 21st century skills:
- Deep learning, use of AI in education;
- Communication & collaboration;
- Industry 4.0, big Data, -AI/Robotization and IoT.</td></tr>
<tr><td colspan="4">Proposed activities</td></tr>
<tr><td colspan="4">● Creation of a European network for AM education as a central reference hub for training and educational purposes, covering VET, HE etc.
● Development of harmonized qualification and certification system for AM, covering all European Qualifications Framework (EQF) levels. The system would address the needs for training and qualification (and re-qualification) of personnel at all levels. Consideration also of different training needs of the different end-users sectors industrial, educational and consumers in order to generate suitable support material
● Quality assurance system to guarantee the quality of the training provided along with standard best practices
● Resource and facilities sharing, good quality course materials and other contents provided to create and sustain AM education across Europe
● Promote students/workers/teachers exchange among educational establishments and practices in companies/R&D centres
● Coordination with local industrial chambers and organisation of training days/seminars and practical workshops.
● Dialogue with applied science HEI Networks to develop new curricula
● Involvement on MAJOR HE interest organizations
● Focus ALSO on vocational training in AM</td></tr>
<tr><td colspan="2">Ongoing & recent projects already (partially) addressing the gaps</td><td colspan="2">SAMT SUDOE,
LASIMM , Skillman, ADMIRE; CLLAIM; AMable, 3DPRISM; METALS</td></tr>
<tr><td>Current TRL</td><td>NA</td><td>Target TRL</td><td>NA</td></tr>
<tr><td>Type of Action</td><td colspan="3">CSA/ERANET</td></tr>
<tr><td>High expected impact on:</td><td colspan="3"><u>Economic & Industrial</u>
Potential for EU leadership
Reduced time to market
Increased product quality and performances
<u>Environment & Social</u>
Jobs reshoring in EU
Increased number of jobs
Material resource saving</td></tr>
</table>

<table>
<tr><td>Action name</td><td colspan="3">Developing and promoting effective intellectual properties strategies in AM and better awareness of IP issues</td></tr>
<tr><td>Action n.</td><td>7</td><td>Sector</td><td>Non-Technical Cross-Cutting</td></tr>
<tr><td colspan="4">Description of the challenge (current gap)</td></tr>
<tr><td colspan="4">Intellectual property implications of AM should be reviewed to avoid that it hinders. Implications of AM on the intellectual property system should be mapped and monitored to avoid that IPRs hinder innovation. Short term key IPR issues relate to AM designs and copyrights. Designs could be stolen and thus, reproduced. Open innovation strategies should be further exploited. There should be greater awareness in the IP law community on how AM is impacting client´s business models
Among current challenges there are also:
-need for digitalization of patent law (Not only copyright) + Digitalization of design rights and trademarks
-Territoriality of IPRs vs. Global nature of digitalization
- Protection of information included in CAD file via exclusive rights such as IPRs
- Legal Nature of CAD file (Software? Work of art? Database? something else?
- IPR protection of new materials like for Bioprinting
- Limits to apply patent law due to possible ethical issues involved
- Enforcement issues of IPRs related to digitalization
- Use of technical protection measures (e.g. blockchain) to increase efficiency of enforcement of IPRs</td></tr>
<tr><td colspan="4">Proposed activities</td></tr>
<tr><td colspan="4">● Development of a strategy to identify possible IP rights and issues that may arise taking into account the interests of all stakeholders
● New forms of protection mechanisms; clearer guidance on defining whether a CAD file could have IPR protection
● Involvement IPR related entities as EPO (European Patent Office)
● Learn lessons from the past; look at past digitisation waves and avoid doing the same mistakes
● Joint tech/non-tech actions aiming at raising awareness
● Solving IP issues by implementing new business models</td></tr>
<tr><td colspan="2">Ongoing & recent projects already (partially) addressing the gaps</td><td colspan="2"></td></tr>
<tr><td>Current TRL</td><td>NA</td><td>Target TRL</td><td></td></tr>
<tr><td>Type of Action</td><td colspan="3">CSA</td></tr>
<tr><td>High expected impact on:</td><td colspan="3"><u>Economic & Industrial</u>
Increased product quality and performances
Potential for EU leadership
Increased IPR protection
<u>Environment & Social</u>
Material resource saving
Jobs reshoring in EU
Increased number of jobs</td></tr>
</table>

<table>
<tr><th>Action name</th><th colspan="3">Promoting the creation of a suitable IP framework</th></tr>
<tr><td>Action n.</td><td>8</td><td>Sector</td><td>Non-Technical Cross-Cutting</td></tr>
<tr><td colspan="4">Description of the challenge (current gap)</td></tr>
<tr><td colspan="4">Currently there is no case law about AM/ 3D-Printing in Europe. Knowing the real implications of AM will take some time and it will most likely happen that legislation comes after the act. On the one hand, it is important to understand how the existing IP framework can be used in a suitable manner. On the other hand, the IP system might need to shape itself to be able to meet the needs of AM technology.</td></tr>
<tr><td colspan="4">Proposed activities</td></tr>
<tr><td colspan="4">● To explore aspects that might be further regulated or regulated differently, and liability aspects
● To explore the need of regulating AM specifically and separately
● To assess applicability and efficiency of current protection tools : copyright, Patents, Design Rights, Utility Models, Trade Secrets
● Research needed to address challenges and understand:
-What field of IPRs (Status Quo) can currently apply to CAD Files + need for new ad hoc types of tools
-What legal nature should we "assign" to CAD files
● IPR Helpdesk workshops focusing on iP challenges related to AM</td></tr>
<tr><td colspan="2">Ongoing & recent projects already (partially) addressing the gaps</td><td colspan="2">CAxMan, LASIMM</td></tr>
<tr><td>Current TRL</td><td>NA</td><td>Target TRL</td><td></td></tr>
<tr><td>Type of Action</td><td colspan="3">CSA</td></tr>
<tr><td>High expected impact on:</td><td colspan="3"><u>Economic & Industrial</u>
Potential for EU leadership
Increased IPR protection
Increased number of private companies involved
<u>Environment & Social</u>
Material resource saving
Increased number of jobs
Jobs reshoring in EU</td></tr>
</table>

HEALTH

<table>
<tr><td>Action name</td><td colspan="3">Modelling methods for interaction between materials and living tissue and design software for AM product customization and data management</td></tr>
<tr><td>Action n.</td><td>1</td><td>Sector</td><td>Health</td></tr>
<tr><td colspan="4">Description of the challenge (current gap)</td></tr>
<tr><td colspan="4">Modelling can be an effective tool to test advanced, breakthrough research solutions. As an example, fine mesh structures of AM promote osteointegration in implants . Therefore, analysis and simulation of cell responses and cell tissue growth behavior is required</td></tr>
<tr><td colspan="4">Proposed activities</td></tr>
<tr><td colspan="4">● Increase research and knowledge of bio-AM in cell response and tissue growth behaviour.
●Data management of modelling methodologies for AM product customisation
● Investigate the robustness of models including repeatability
● Converging biotechnology, engineering and medical expertise
● Material models for controlled drug release</td></tr>
<tr><td>Value chain segments</td><td colspan="3">[x] Modelling
[x] Design
[ ] Material
[ ] Process
[ ] Post Process
[ ] Product
[ ] End of Life
[ ] Complete VC</td></tr>
<tr><td>Current TRL</td><td>3-4</td><td>Target TRL</td><td>5-6</td></tr>
<tr><td>Type of Action</td><td colspan="3">RIA</td></tr>
<tr><td>Target Products</td><td colspan="3">✓ Medical Implants
✓ Living Tissues & Organs</td></tr>
<tr><td>High expected impact on:</td><td colspan="3"><u>Economic & Industrial</u>
Increased product quality and performances
Increased business generated
Increased number of private companies involved
<u>Environment & Social</u>
Better personal health
Better quality of life
Material resource saving</td></tr>
</table>

Action name	Novel biomaterials suitable for AM with focus on material variety and large production at lower costs		
Action n.	2	**Sector**	Health
Description of the challenge (current gap)			
Novel bio-functional materials capable of supporting the use of printing in current and novel human and diagnostic applications are needed. Materials for medical applications (e.g. implants, dental elements, chirurgical instruments) must meet high demands on biocompatibility and reliability. It is important to look for lowest cost according to the goal (cost-benefit analysis). Interdisciplinary aspects and convergence of disciplines should be addressed.			
Proposed activities			
● New or adapted processes for bio-functional powder production. ● Adapted equipment for bio-functional powder use ● Development of new machine concepts e.g. for graded material properties and multi material combinations ● Development of new composites based on polymer/ ceramic and ceramics reinforced metal (metal matrix composites, i.e. MMCs) ● New materials: e.g. magnesium, copper, biodegradable polymers, etc. ● Focus on biocompatibility and required performance properties ● Mechanical characterisation comparison with traditional materials			
Value chain segments	☐ Modelling ☒ Design ☒ Material ☒ Process	☐ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	4-5	**Target TRL**	6-7
Type of Action	IA		
Target Products	✓ Medical Implants ✓ Living Tissues & Organs ✓ Surgical Guides, Tools & Models ✓ Other Customized Products ✓ Other Dental Products		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased business generated Increased number of private companies involved *Environment & Social* Material resource saving Better personal health Better quality of life		

Action name	Validation of mechanical and thermal properties of existing materials		
Action n.	3	**Sector**	Health
Description of the challenge (current gap)			
Material quality control and high reliability materials are key issues for medical applications that require validation. As basic requirement is fundamental to develop material targeting to at least replicate the mechanical and biocompatible characteristics of traditional implantable parts.			
Proposed activities			
● Significant experimental effort needed and population of corresponding databases ● Establish the effect of build orientation on mechanical properties ● Improve process stability. Brittle fracture is a key property to be assessed, i.e. fracture toughness and effect of small defect on the fracture property ● Implement methods to improve quality across batches of used and raw material ● Develop best-practice for machine and feed-stock handling, round-robin testing and mapping of process parameters vs. material properties ● Research the effects of heat treatment and post processing operations			
Value chain segments	☐ Modelling ☐ Design ☒ Material ☐ Process	☐ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	5-6	**Target TRL**	7-8
Type of Action	IA		
Target Products	✓ Medical Implants ✓ Living Tissues & Organs ✓ Assistive & Prosthetic Devices ✓ Surgical Guides, Tools & Models ✓ Other Dental Products		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Potential for EU leadership Reduced time to market *Environment & Social* Material resource saving Increased number of jobs Better environment		

Action name	Vascularization and innervation of tissues through biofabrication		
Action n.	4	Sector	Health
Description of the challenge (current gap)			
In biofabrication, a lot of effort is placed to create vascularized tissue constructs. Innervation is often forgotten, despite being also a very important network to maintain tissue functionality.			
Proposed activities			
● Exploration of materials and biological factors to create conditions similar to human physiology ● Converging biotechnology, engineering and medical expertise			
Value chain segments	[x] Modelling [x] Design [x] Material [x] Process	[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	1-2	Target TRL	3-4
Type of Action	RIA		
Target Products	✓ Living Tissues & Organs ✓ Pharmaceutical Products		
High expected impact on:	*Economic & Industrial* Potential for EU leadership Increased number of private companies involved Increased business generated *Environment & Social* Better personal health Better quality of life Increased number of jobs		

Action name	Viable processes for fabrication of 'smart scaffolds' and for construction of 3D biological and tissue models		
Action n.	5	**Sector**	Health
Description of the challenge (current gap)			
One of the key issue is the knowledge of biological processes (epistemiology) before taking actions. Then, the production of parts for medical applications requires special processes and equipment			
Proposed activities			
● Development to enable industrial fabrication and implementation for medical applications ● Encourage synthesis of multi-material porous structure for impregnation ● Novel equipment supporting printing of biocompatible fabrication including multi-material and printing of living cells.			
Value chain segments	[x] Modelling [x] Design [x] Material [x] Process	[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	2-3	**Target TRL**	4-5
Type of Action	IA		
Target Products	✓ Living Tissues & Organs ✓ Pharmaceutical Products		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Potential for EU leadership Increased number of private companies involved *Environment & Social* Better personal health Better quality of life Jobs reshoring in EU		

<table>
<tr><td>Action name</td><td colspan="4">Modelling methods and digital twin technologies for customised implants and medical devices and prediction of long-term clinical performance</td></tr>
<tr><td>Action n.</td><td>6</td><td></td><td>Sector</td><td>Health</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">Advanced modelling tools combining various medical imaging methods with modelling and design to support AM production are needed for efficient use of AM. Knowledge of long term clinical performance of AM implants will help to optimise their efficacy.</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">● Compilation of specifications and identification of current capability gaps in available software
● Development of scanning and surgical methods; for example the development of multi-physics, multiscale modelling tools to ensure functionality and safety of parts and increase the understanding of how it will perform after surgery (from grain size or molecule to component level)
● Development of file compatibility between imaging and AM modelling software
● Development of modelling tools that recognise how implants will perform after surgery (from the tissue to the material and implant)
● Experimental testing of implants for corrosion, fatigue and wear
● Long term clinical observations that aim to understand the health related performance. This should use a case approach in which the full financial impact on the value chain is detailed. To include participation of all stakeholders (medical, organisational, financial, insurance, patients supply etc.)
● Apply digital twin technologies to constantly improve performance and monitor behaviour
● Transfer information to meta-models</td></tr>
<tr><td>Value chain segments</td><td colspan="4">[x] Modelling
[x] Design
[ ] Material
[x] Process
[ ] Post Process
[ ] Product
[ ] End of Life
[ ] Complete VC</td></tr>
<tr><td>Current TRL</td><td>3-4</td><td></td><td>Target TRL</td><td>5-6</td></tr>
<tr><td>Type of Action</td><td colspan="4">RIA</td></tr>
<tr><td>Target Products</td><td colspan="4">✓ Medical Implants
✓ Living Tissues & Organs
✓ Surgical Guides, Tools & Models
✓ Pharmaceutical Products</td></tr>
<tr><td>High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Increased product quality and performances
Increased production capacity
Reduced time to market
<u>Environment & Social</u>
Better personal health
Better quality of life</td></tr>
</table>

<table>
<tr><td>Action name</td><td colspan="4">Smart and multi-material products with improved functionalities focusing on assistive and prosthetic devices</td></tr>
<tr><td>Action n.</td><td>7</td><td colspan="2">Sector</td><td>Health</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">Materials for introducing new functionalities and/or producing inte-grated electronics to broaden the application of AM</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">● Development of “smart” parts by embedding sensors and/or effectors
● Use of nanomaterials and nanotechnologies to improve material properties;</td></tr>
<tr><td>Value chain segments</td><td colspan="4">[ ] Modelling
[ ] Design
[x] Material
[x] Process
[x] Post Process
[x] Product
[ ] End of Life
[ ] Complete VC</td></tr>
<tr><td>Current TRL</td><td>2-3</td><td>Target TRL</td><td colspan="2">4-5</td></tr>
<tr><td>Type of Action</td><td colspan="4">RIA</td></tr>
<tr><td>Target Products</td><td colspan="4">✓ Medical Implants
✓ Living Tissues & Organs
✓ Assistive & Prosthetic Devices
✓ Surgical Guides, Tools & Models
✓ Other Dental Products</td></tr>
<tr><td>High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Increased product quality and performances
Potential for EU leadership
Increased business generated
<u>Environment & Social</u>
Jobs reshoring in EU
Increased number of jobs
Material resource saving</td></tr>
</table>

Action name	Integration of life cycle approach in the health sector: AM pilots operating with closed loop recycling, reuse of precious materials, use of sustainable materials (including bio-based ones).		
Action n.	8	**Sector**	Health
Description of the challenge (current gap)			
Recovery and reuse of expensive AM materials without compromising reliability and safety of produced critical parts. Use of sustainable materials (including bio-based ones) whenever appropriate.Linked with cross-cutting gaps.			
Proposed activities			
● Demonstration of pilot line operating with closed loop recycling and reuse of precious materials ● Set up of exemplary processes through demonstration projects (including re-use of materials, use of bio-based materials, development of recyclable materials) ● Development of automated conformity assessment protocols/systems to secure entry status and in-process validation of the quality, safety and security of the designs, (recycled) material, differentiated for use categories in the Medical arena ● Integrating life cycle analysis and life-cycle cost analysis, use a case approach to estimate the full financial and environmental impact on the value chain when making use of recycled materials, including risk assessments and financial impact of those risks			
Value chain segments	[ ] Modelling [ ] Design [ ] Material [x] Process	[x] Post Process [x] Product [x] End of Life [ ] Complete VC	
Current TRL	2-3	**Target TRL**	4-5
Type of Action	RIA		
Target Products	✓ Medical Implants ✓ Assistive & Prosthetic Devices ✓ Surgical Guides, Tools & Models ✓ Other Dental Products		
High expected impact on:	*Economic & Industrial* Potential for EU leadership Increased number of private companies involved New types of ventures started *Environment & Social* Material resource saving Reduction of CO2 emission Better environment		

Action name	Biological structures development for drug testing		
Action n.	9	Sector	Health
Description of the challenge (current gap)			
Biological structures that can mimic key biological functions can help improving drug's development and replacing animal testing			
Proposed activities			
● Exploration of materials and biological factors to create conditions similar to human physiology ● Converging biotechnology, engineering and medical expertise ● Upscaling of biofabrication technologies to reach human scale dimensions			
Value chain segments	[x] Modelling [x] Design [x] Material [x] Process	[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	2-3	**Target TRL**	4-5
Type of Action	RIA		
Target Products	✓ Living Tissues & Organs ✓ Pharmaceutical Products		
High expected impact on:	*Economic & Industrial* Potential for EU leadership Increased number of private companies involved New types of ventures started *Environment & Social* Material resource saving Better environment Increased recycling		

Action name	Novel exoskeletons developed by additive manufacturing		
Action n.	10	Sector	Health
Description of the challenge (current gap)			
Personalised prototypes for disabled patients (focusing on children) for example to help carrying heavy weights.			
Proposed activities			
● Optimisation of materials and technologies and demonstration in working prototypes. ● Integration of robotics, sensoring and artificial intelligence aspects.			
Value chain segments	[ ] Modelling [ ] Design [x] Material [x] Process	[x] Post Process [x] Product [ ] End of Life [ ] Complete VC	
Current TRL	2-3	Target TRL	4-5
Type of Action	RIA		
Target Products	✓ Assistive & Prosthetic Devices		
High expected impact on:	*Economic & Industrial* Potential for EU leadership Increased IPR protection Increased product quality and performances *Environment & Social* Better personal health Better quality of life Jobs reshoring in EU		

Action name	**Organ Bioprinting**				
Action n.	11		**Sector**		Health
Description of the challenge (current gap)					
Bioprinting hold the promise to be a game changer for the fabrication of organ replacements. Yet, up to today only very simple and rudimentary small models have been developed. To explore the full potential of organ bioprinting, functional full organ or (as minimum) organ patches should be developed					
Proposed activities					
● Exploration of materials and biological factors to create conditions similar to human physiology ● Converging biotechnology, engineering and medical expertise ● Upscaling of biofabrication technologies to reach human scale dimensions					
Value chain segments	[x] Modelling [x] Design [x] Material [x] Process		[x] Post Process [x] Product [ ] End of Life [ ] Complete VC		
Current TRL	2-3		**Target TRL**		4-5
Type of Action	RIA				
Target Products	✓ Living Tissues & Organs				
High expected impact on:	*Economic & Industrial* Increased number of private companies involved Increased production capacity Increased business generated *Environment & Social* Material resource saving Better personal health Better quality of life				

Action name	Studying and modelling the whole body and its evolution over time, supported by 3D imaging and 3D prototyping, for optimized prostheses		
Action n.	12	**Sector**	Health
Description of the challenge (current gap)			
Current imagining methodologies (computed-tomography, magnetic resonance etc.) coupled with 3D prototyping may lead to virtual and physical reconstruction of human body and its evolution over time from youth to old age. Coupling such systems with modelling and advanced parametric design has the potential to develop optimised prostheses.			
Proposed activities			
● Perform long-term studies /have access to medical data with the evolution of the human body over time and develop parametric design and modelling; ● Demonstrate the potential of the tool in critical prostheses (e.g. Cardiovascular or orthopaedic devices).			
Value chain segments	[x] Modelling [x] Design [ ] Material [ ] Process	[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	1-3	**Target TRL**	2-4
Type of Action	RIA		
Target Products	✓ Medical Implants ✓ Living Tissues & Organs ✓ Pharmaceutical Products		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased business generated Increased number of private companies involved *Environment & Social* Better personal health Better quality of life Material resource saving		

AEROSPACE

Action name	**Develop or optimize modelling tools for process, material and topology optimization.**		
Action n.	1	**Sector**	Aerospace
Description of the challenge (current gap)			
Design optimization in combination with process reliability: there is need for: - full integration of AM process modelling in state of the art software systems for efficient and optimized modelling. - evaluation of correlation between process parameteres and part properties, understanding how defects form and why (advanced melt pool modelling and simulation is necessary).			
Proposed activities			
● Address simulation of the thermal conditions in the aerospace part in combination with topological optimization of the support structure and fixtures ● Conduct a state-of-art literature survey of existing models and models that are currently being developed. Integration of state of the art tools emerging from FP7 and H2020 programs ● Encourage modelling using machine parameters as entry parameters and build orientation, and establish links with mechanical properties ● Funding of HPC resources ● Publish Public Material properties database relevant in AM ● Knowledge transfer from Academia to Industry ● Web-based platform of reference test models including experimental results. A rating of the models should be possible.			
Value chain segments	[x] Modelling [x] Design [ ] Material [ ] Process	[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	5-6	**Target TRL**	7
Type of Action	RIA/CSA		
Target Products	✓ Turbine Parts / Engine ✓ Small aircraft wings and fuselage and their components ✓ Other complex parts ✓ Components of large aircraft wings and fuselage ✓ Spare parts & repair ✓ Concept modelling, prototyping and advanced moulds ✓ Niche, low volume parts ✓ Embedded Electronics		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Reduced time to market *Environment & Social* Material resource saving Reduction of CO2 emission Better environment		

Action name	Demonstration of simplified assembly of complex parts through optimzed AM design		
Action n.	2	**Sector**	Aerospace
Description of the challenge (current gap)			
Advanced design tools to help utilize the advantages of AM			
Proposed activities			
● Introduce topology optimization methodologies in the design phase to move from feature-based to function-based design ● Integrate AM Design constraints (overhangs, etc..)and rules into topology optimization to minimize supports ● Demonstrate topology optimization approaches leading to CAD files for complex products			
Value chain segments	☐ Modelling ☒ Design ☐ Material ☐ Process	☐ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	6	**Target TRL**	7
Type of Action	IA		
Target Products	✓ Turbine Parts / Engine ✓ Other complex parts ✓ Components of large aircraft wings and fuselage ✓ Spare parts & repair ✓ Concept modelling, prototyping and advanced moulds ✓ Niche, low volume parts ✓ Embedded Electronics		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Reduced time to market *Environment & Social* Material resource saving Reduction of CO2 emission Increased number of jobs		

Action name	Quality and consistency of powder production		
Action n.	3	**Sector**	Aerospace
Description of the challenge (current gap)			
Identification of powder properties that are critical to obtain a "good" part during processing in AM machine (e.g. Shape, chemical composition, porosity, etc..). Moreover, having the right requirement for powder batch acceptance is required for certification compliance. Understanding of the limits of recycling powders. Connected with automotive action n. 2			
Proposed activities			
● Work on material quality, shape for powder and size in order to have a well-controlled material for the 3D process, including feedstock management and handling including recycling of powders. ● Quality and consistency of powder production. Improve processes for powder production with better distribution size control ● Define powder testing and validation criteria which can depend on each machine (feeding, laser source, etc.)			
Value chain segments	☐ Modelling ☐ Design ☒ Material ☒ Process	☐ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	6	**Target TRL**	7
Type of Action	IA		
Target Products	✓ Turbine Parts / Engine ✓ Small aircraft wings and fuselage and their components ✓ Other complex parts ✓ Components of large aircraft wings and fuselage ✓ Spare parts & repair ✓ Concept modelling, prototyping and advanced moulds ✓ Niche, low volume parts ✓ Embedded Electronics		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Reduced time to market *Environment & Social* Material resource saving Better environment Jobs reshoring in EU		

Action name	New materials and processes and related characterisation in the field of multi-functional materials, multi-materials and materials with highly improved functionality for aerospace applications		
Action n.	4	**Sector**	Aerospace

Description of the challenge (current gap)
Reliability of AM produced parts during their life time is essential for aerospace applications. Reliable high performance materials (light weight, strong, high temperature, reliable) and special materials (ceramic/metal) or materials that include multifuncional capabilities on the materials (e.g. sensorng conductivity), Another challenge is enabling the use of multi materials and graded materials. This may be achieved also through reliable modeling tools and optimized processes.
Proposed activities
● Development of shape memory alloys (thermal and magnetic), piezoelectric actuators and electro active polymers ● Lightweight materials (e.g. titanium alloys) ● Extreme operating temperatures superalloys for turbine components ● Improved dynamic (fatigue) materials properties: development of new alloys with improved dynamic properties and the development of advanced composites including high mechanical resistance ceramic particles in metal matrix ● Development of materials with improved creep and oxidation resistance ● Development of new routes for powder production to enable cheaper powders ● Development of wire feedstock value chain with chemistry tailored for AM applications ● Welding filler metal supplier ● Development of "smart" parts by embedding sensors and/or effectors ● Development of new machine concepts e.g. for graded material properties and multi material combinations and the development of modelling tools to support this activity ● Fatigue and fracture toughness properties; effect of defects ● Residual stress in materials, caused by AM process and miss-match of different material properties (i.e. elastic modulus and coefficient of thermal expansion)

Value chain segments				
	[ ]	Modelling	[ ]	Post Process
	[ ]	Design	[ ]	Product
	x	Material	[ ]	End of Life
	x	Process	[ ]	Complete VC

Current TRL	4-6	**Target TRL**	7
Type of Action	IA		
Target Products	✓ Turbine Parts / Engine ✓ Small aircraft wings and fuselage and their components ✓ Cabin & Cockpit parts ✓ Other complex parts ✓ Components of large aircraft wings and fuselage ✓ Spare parts & repair ✓ Niche, low volume parts ✓ Embedded Electronics		

Action name	New materials and processes and related characterisation in the field of multi-functional materials, multi-materials and materials with highly improved functionality for aerospace applications
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Potential for EU leadership *Environment & Social* Increased number of jobs Material resource saving Jobs reshoring in EU

Action name	Develop processes and tools to manage graded materials, overcoming the need of joining/welding		
Action n.	5	**Sector**	Aerospace
Description of the challenge (current gap)			
Machining and welding of super alloys produced by AM (Ni and Ti based) can be very difficult. Develop processes to manage graded materials to overcome the need of joining/welding parts manufactured with different methods. Necessary to have a fast and accurate measuring method to adapt new geometry to the already existing.			
Proposed activities			
● Establish methodology with machine parameters through defined design of experiments ● New optimized cutting tools (in terms of materials and geometry) for AM parts ● Use of ceramics ● Development of appropriate modelling tools to support this activity ● 3D optical in-process measuring and data tranfer			
Value chain segments	[ ] Modelling [x] Design [x] Material [x] Process	[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	2-3	**Target TRL**	5
Type of Action	RIA		
Target Products	✓ Turbine Parts / Engine ✓ Small aircraft wings and fuselage and their components ✓ Other complex parts ✓ Components of large aircraft wings and fuselage ✓ Spare parts & repair ✓ Niche, low volume parts ✓ Embedded Electronics		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased IPR protection Increased business generated *Environment & Social* Reduction of CO_2 emission Material resource saving Better personal health		

Action name	Improved process with control mechanisms for improved repeatability, reproducibility and performance of AM processes		
Action n.	6	**Sector**	Aerospace

Description of the challenge (current gap)

Current building processes often perform the printing without recognizing errors during the fabrication. It is required to demonstrate that the key process parameters are under control for certification in this sector. Repeatability, reproducibility and performance of AM processes can be improved using knowledge and tools, in order to get predictable outcome of the process. Lack of availability of suitable monitoring systems for AM; Incorporation into existing machines to control quality during building process. Control mechanisms for yield optimised processes. This is necessary for processing and equipment right performance, and the ability to qualify and certify parts and processes.

Proposed activities

- Implement real thermal field mapping (from machine sensors) to determine residual stresses.
- Data regarding mechanical properties, dimensional accuracy, surface roughness etc. coupled with the respective machine characteristics and process parameters
- Efficient modelling tools to provide intelligent feedback control
- Make use of established know-how in polymer fused deposition modelling (FDM), injection moulding and powder injection molding (PIM)
- Interaction with the “design” and “modelling” VC segments, i.e. design and process iterations
- Structural integrity analysis: design against fatigue and design for damage (defect) tolerance
- Develop in-situ multiscale analysis methods by vision systems and image processing
- Create in line control systems with feedback capabilities

Value chain segments		
	[x] Modelling	[ ] Post Process
	[x] Design	[ ] Product
	[x] Material	[ ] End of Life
	[x] Process	[ ] Complete VC

Current TRL	4-6	**Target TRL**	7

Type of Action	IA
Target Products	✓ Turbine Parts / Engine ✓ Small aircraft wings and fuselage and their components ✓ Cabin & Cockpit parts ✓ Other complex parts ✓ Components of large aircraft wings and fuselage ✓ Spare parts & repair ✓ Concept modelling, prototyping and advanced moulds ✓ Niche, low volume parts ✓ Embedded Electronics
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Reduced time to market

Action name	Improved process with control mechanisms for improved repeatability, reproducibility and performance of AM processes
	Environment & Social Material resource saving Jobs reshoring in EU Reduction of CO2 emission

Action name	**Research on material characterization focusing on dynamic properties and residual stresses**		
Action n.	7	**Sector**	Aerospace
Description of the challenge (current gap)			
Study dynamic properties of metal materials, for different materials and AM technologies; Study residual stresses in AM parts			
Proposed activities			
● perform fatigue tests in order to determine fatigue limit and construct S-N curves for various materials and AM technologies ● derive distinction between the influences of properties of the material, the technology and layered structure to the observed dynamic behaviour ● perform studies of influence of technological supports to residual stresses ● study influence of technology process parameters to residual stresses ● study in-process and post-process methods for reduction of residual stresses			
Value chain segments	☐ Modelling ☐ Design ☒ Material ☒ Process	☒ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
Target Products	✓ Turbine Parts / Engine ✓ Small aircraft wings and fuselage and their components ✓ Cabin & Cockpit parts ✓ Other complex parts ✓ Components of large aircraft wings and fuselage ✓ Concept modelling, prototyping and advanced moulds		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Reduced time to market Increased IPR protection *Environment & Social* Material resource saving Jobs reshoring in EU Better environment		

Action name	Design strategies for the development of complex shaped structures (e.g. Lattice structures)			
Action n.	8		**Sector**	Aerospace
Description of the challenge (current gap)				
The ability of AM to produce optimised complex shapes can only be utilised if these shapes can be designed.				
Proposed activities				
● Develop algorithms to automatically generate stress optimized lattice structures (Preliminary design) ● Develop automated plausibility checks for structures under constraints (Preliminary design).Integrate CAD packages with AM process (Conceptual design) ● Integration of simulation into the design phase (both in the Preliminary and Detail design) ● Include material properties taking into account process defects in design loop ● Extension of topology optimization tools (including dynamic loads, cyclic loads, vibrations, shock absorption, optimal weight) ● Structural Integrity & Durability assessment (Detail design)				
Value chain segments	[x] Modelling [x] Design [ ] Material [ ] Process		[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	5-6		**Target TRL**	7
Type of Action	IA			
Target Products	✓ Turbine Parts / Engine ✓ Small aircraft wings and fuselage and their components ✓ Other complex parts ✓ Components of large aircraft wings and fuselage ✓ Concept modelling, prototyping and advanced moulds			
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased business generated Potential for EU leadership *Environment & Social* Material resource saving Reduction of CO2 emission Jobs reshoring in EU			

Action name	Increased automation of repair processes through integration of AM and robotics		
Action n.	9	Sector	Aerospace
Description of the challenge (current gap)			
Process integration, CAM for automated repairing -> CNC (computer numerical control) robots. Repair of expensive parts (eg turbine blades) by adding new material at worn regions.			
Proposed activities			
● Develop and adapt the process chain for repair approach in order to have an easy process and a final product with the best properties ● Develop fully automated repairing processes through CAM (computer-aided manufacturing), robotics and AM: NDT defect detection / Gouging machining / AM / Final inspection. ● More advanced repair operations through selective re-application of advanced alloy materials (e.g. IN718). Possibly in combination with some hybrid manufacturing solutions, this should be a part of industrial process development, evaluation and demonstration projects. ●Support such automation strategies with development of appropriated standards			
Value chain segments	☐ Modelling ☐ Design ☐ Material ☒ Process	☐ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	5-6	**Target TRL**	7
Type of Action	IA		
Target Products	✓ Other complex parts ✓ Spare parts & repair ✓ Niche, low volume parts ✓ Embedded Electronics		
High expected impact on:	*Economic & Industrial* Increased production capacity Reduced time to market Increased business generated *Environment & Social* Material resource saving Reduction of CO2 emission Better environment		

Action name	Improved process control and reproducibility of nozzle-based AM techniques		
Action n.	10	**Sector**	Aerospace
Description of the challenge (current gap)			
It is required to demonstrate that the key process parameters are under control for certification in this sector. Repeatability, reproducibility and performance of AM processes can be improved using knowledge and tools, in order to get predictable outcome of the process. Lack of availability of suitable monitoring systems for AM; Incorporation into existing machines to control quality during building process.			
Proposed activities			
● Create advantage by combining small complex and functional AM parts with large volume parts with only stability as a function ● Development of combined AM/subtracting with very good control of final product geometry and properties ● Hybrid solutions should not necessarily be implemented within the same machine: develop techniques for AM integration in the industrial production system and/or Hybrid fabrication processes using multiple AM and other processes ● Joining technologies, e.g. by welding, to join AM with AM or conventional materials to form a larger or complex geometry part			
Value chain segments	☐ Modelling ☒ Design ☒ Material ☒ Process	☐ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
Target Products	✓ Turbine Parts / Engine ✓ Small aircraft wings and fuselage and their components ✓ Cabin & Cockpit parts ✓ Other complex parts ✓ Components of large aircraft wings and fuselage ✓ Spare parts & repair ✓ Niche, low volume parts ✓ Embedded Electronics		
High expected impact on:	*Economic & Industrial* Potential for EU leadership Reduced manufacturing cost Increased production capacity *Environment & Social* Better environment Material resource saving Reduction of CO2 emission		

<table>
<tr><td>Action name</td><td colspan="4">Develop materials and surface finishing processes for improved surface quality of AM products</td></tr>
<tr><td>Action n.</td><td>11</td><td></td><td>Sector</td><td>Aerospace</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">Complex lattice structures are difficult to reach for post process surface treatments. Surface finishing can improve the fatigue properties of a workpiece as cracks can start at the surface of the part.</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">● Research into the effect of post processing operations and automation of post processing.
● Development of materials (cermet/metcer)
● Develop new cost-effective surface finishing processes for example combination of AM and subtractive manufacturing
● Reduce and control particles size of powder
● Optimisation of post-processing, e.g. on balance of cost (time, money) vs. material quality (residual stress, defect size, strength)</td></tr>
<tr><td>Value chain segments</td><td colspan="4">[ ] Modelling
[x] Design
[x] Material
[x] Process
[x] Post Process
[ ] Product
[ ] End of Life
[ ] Complete VC</td></tr>
<tr><td>Current TRL</td><td>6</td><td>Target TRL</td><td colspan="2">7</td></tr>
<tr><td>Type of Action</td><td colspan="4">IA</td></tr>
<tr><td>Target Products</td><td colspan="4">✓ Turbine Parts / Engine
✓ Small aircraft wings and fuselage and their components
✓ Cabin & Cockpit parts
✓ Other complex parts
✓ Components of large aircraft wings and fuselage
✓ Spare parts & repair
✓ Niche, low volume parts
✓ Embedded Electronics</td></tr>
<tr><td>High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Increased production capacity
Reduced time to market
Increased product quality and performances
<u>Environment & Social</u>
Material resource saving
Jobs reshoring in EU
Increased number of jobs</td></tr>
</table>

<table>
<tr><td colspan="2">Action name</td><td colspan="4">Develop NDT and inspection criteria (for Aerospace applications) and procedures for AM</td></tr>
<tr><td>Action n.</td><td>12</td><td colspan="2">Sector</td><td colspan="2">Aerospace</td></tr>
<tr><td colspan="6">Description of the challenge (current gap)</td></tr>
<tr><td colspan="6">Are the "classic" NDT methods applied in the aerospace valid and sufficient also for AM?</td></tr>
<tr><td colspan="6">Proposed activities</td></tr>
<tr><td colspan="6">● Networking, coordination and research activities in the following aspects:
– Defect classification
– Analysis of influence on static and fatigue performance
– Analysis and measurement of residual stresses
– Defect detection techniques (CT, UT)
– Acceptance criteria</td></tr>
<tr><td colspan="2">Value chain segments</td><td colspan="4">☐ Modelling
☐ Design
☐ Material
☐ Process
☒ Post Process
☐ Product
☐ End of Life
☐ Complete VC</td></tr>
<tr><td>Current TRL</td><td colspan="2">6</td><td colspan="2">Target TRL</td><td>7</td></tr>
<tr><td colspan="2">Type of Action</td><td colspan="4">CSA/IA</td></tr>
<tr><td colspan="2">Target Products</td><td colspan="4">✓ Turbine Parts / Engine
✓ Small aircraft wings and fuselage and their components
✓ Cabin & Cockpit parts
✓ Other complex parts
✓ Components of large aircraft wings and fuselage
✓ Spare parts & repair
✓ Embedded Electronics</td></tr>
<tr><td colspan="2">High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Increased product quality and performances
Reduced manufacturing cost
Potential for EU leadership
<u>Environment & Social</u>
Material resource saving
Reduction of CO2 emission
Better environment</td></tr>
</table>

Action name	Production of larger airframe structures through AM technologies		
Action n.	13	**Sector**	Aerospace
Description of the challenge (current gap)			
Increasing the size of envelopes mean increases the productivity of the "printers" including DED (directed energy deposition) processes with wire, at a reasonable cost with the same quality. Also, methods to perform quality control/NDT on large AM parts are to be furthermore investigated.			
Proposed activities			
● Development of new machines with larger build envelopes, high deposition rate for higher productivity, and integrated post-processing ● Assembly operations to be reduced towards the end of the production line ● Address critical issues such as reliability of the process both over a large area, and over long building times. For example detection and elimination of faults with 100% certainty, achieve consistency of properties and minimize tension over a large build area and volume. ● Secure good printing conditions like heating in the whole printing area ● High deposition rate keeping good quality			
Value chain segments	☐ Modelling ☒ Design ☒ Material ☒ Process	☒ Post Process ☒ Product ☐ End of Life ☐ Complete VC	
Current TRL	3-4	**Target TRL**	6
Type of Action	RIA		
Target Products	✓ Components of large aircraft wings and fuselage ✓ Concept modelling, prototyping and advanced moulds		
High expected impact on:	*Economic & Industrial* Reduced time to market Increased production capacity Potential for EU leadership *Environment & Social* Material resource saving Better environment Increased recycling		

AUTOMOTIVE

Action name	**Improved modelling tools for materials processing**		
Action n.	1	**Sector**	Automotive
Description of the challenge (current gap)			
Need for modelling and simulations prior to production to enable first time right and minimal lightweight design (structural computational modelling, thermal history, porosity modelling, multiphysics, topology optimization, AM material properties table).			
Proposed activities			
● Increase understanding of the microstructure-material properties relationships. Foster the academic structure in the simulation of material microstructure (coarse grained, Monte Carlo, random walk) ● Develop multiphysics, multiscale modelling, from grain size or molecule towards components ● Holistic modelling approaches using multiphysics simulation going from process parameters and simulation to product mechanical properties, via thermal mapping/history of the workpiece ● Stochastic/empirical modelling techniques utilizing a large volume of data (knowledge repository)			
Value chain segments	[x] Modelling [x] Design [ ] Material [ ] Process	[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
Target Products	✓ Engine Components ✓ Auxiliary means of production and supports ✓ Embedded electronics ✓ Concept modelling, prototyping and design ✓ Niche, low volume parts ✓ Spare parts & repair		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Reduced time to market *Environment & Social* Material resource saving Jobs reshoring in EU Increased number of jobs		

Action name	Quality and consistency of powder production		
Action n.	2	Sector	Automotive

Description of the challenge (current gap)

The AM industry need to define relevant properties and improve understanding and handling of powders.
Material quality and - control is a key factor for a quality controlled AM manufacturing process.
Implement new developments and benefit and encourage close links/cooperation with feedstock manufacturers. Connected to aerospace action n. 3

Proposed activities

- Involvement of powder and resin manufacturers in AM Platform
- Work on material quality, shape for powder and size in order to have a well-controlled material for the 3D process
- Encourage developments based on nanotechnologies and nanomaterials texturing, coatings, spheroidization, etc.
- Standard for measuring relevant properties
- Training in Powder handling
- Recycling improvement

Value chain segments				
	☐	Modelling	☐	Post Process
	☐	Design	☐	Product
	x	Material	☐	End of Life
	x	Process	☐	Complete VC

Current TRL	5-6	Target TRL	7

Type of Action	IA
Target Products	✓ Engine Components ✓ Auxiliary means of production and supports ✓ Embedded electronics ✓ Concept modelling, prototyping and design ✓ Niche, low volume parts ✓ Spare parts & repair
High expected impact on:	*Economic & Industrial* Increased product quality and performances Reduced time to market Potential for EU leadership *Environment & Social* Better environment Better personal health Better quality of life

Action name	**Increased process reliability and stability through in line control system, monitoring, automation and standardization**		
Action n.	3	**Sector**	Automotive
Description of the challenge (current gap)			
Process reliability and stability are key for a successful industrial process. Improvement of control technologies are needed to enable effective in process measurement as current ones are not robust enough			
Proposed activities			
● Monitoring and automation of the process, including loading/unloading, support removal and post processing ● Develop in-situ multiscale analysis methods by vision systems and image processing ● In process measurements (e.g. Insert sensors in the AM machine in order to monitor the quality of parts during the process) ● Study new solutions to improve the software that control the process ● Study the effect of process parameters on built components mechanical parameters ● Standardization of all process steps ● Methods to reduce the magnitude of residual stress ● Reduce porosity and surface defects ● Design of Experiments (DOE)			
Value chain segments	[x] Modelling [x] Design [x] Material [x] Process	[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	6	**Target TRL**	7
Type of Action	IA		
Target Products	✓ Engine Components ✓ Auxiliary means of production and supports ✓ Embedded electronics ✓ Concept modelling, prototyping and design ✓ Niche, low volume parts ✓ Spare parts & repair		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Reduced time to market Increased production capacity *Environment & Social* Jobs reshoring in EU Increased number of jobs Better environment		

Action name	Innovative solutions for higher production rates and cheaper systems		
Action n.	4	**Sector**	Automotive

Description of the challenge (current gap)

Economic use of AM requires lower cost per part, i.e. higher productivity or lower machine cost as well as reduced post processing material cost. One envisioned route is the hybridization, where more than one process is engaged in one machine. This development should be encouraged by market interests and competition

Proposed activities

- Process planning considerations.
- Encourage machine and equipment manufacturers from outside the AM scene to engage and develop concepts/demo projects needed for studying feasibility
- Process parameters optimization
- Machine speed improvement
- Software optimises deposition paths to minimise delays for cooling / curing and maintain stable thermal field
- Machine producers: increase the numbers of laser sources/workheads
- Development of low price materials (e.g. powder size distribution - wider to reduce cost).
- New design to have an AM design for minimal support requirements, resulting in decreased post processing.
- Arrayed AM heads on a common machine structure.
- Parallel AM

Value chain segments		
	[ ] Modelling	[ ] Post Process
	[x] Design	[ ] Product
	[x] Material	[ ] End of Life
	[x] Process	[ ] Complete VC

Current TRL	4-5	**Target TRL**	6

Type of Action	IA
Target Products	✓ Engine Components ✓ Auxiliary means of production and supports ✓ Embedded electronics ✓ Concept modelling, prototyping and design ✓ Niche, low volume parts ✓ Spare parts & repair
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Potential for EU leadership *Environment & Social* Increased number of jobs Jobs reshoring in EU Material resource saving

Action name	**Best practices, standardization, design and machine improvements towards increasing reproducibility of 3D printed automotive parts**			
Action n.	5		**Sector**	Automotive
Description of the challenge (current gap)				
The reproducibility of parts achieved by AM should be assessed and improved. Producing parts with standard properties requires development of standard procedures.				
Proposed activities				
● Create standards and certifications ● Definition of parameter exchange to get a higher reproducibility of the process ● Development of best-practice in feedstock and machine handling ● Round-Robin testing of materials and process parameters ● Machine accuracy and capability improvement ● Novel design approaches for AM. ● Experimentally-validated databases containing standard sets of process parameters per process/machine/material ● Standard post-processing (especially heat treatment) temperature profiles				
Value chain segments	☐ Modelling ☐ Design ☒ Material ☒ Process		☒ Post Process ☒ Product ☐ End of Life ☐ Complete VC	
Current TRL	6		**Target TRL**	7
Type of Action	IA/CSA			
Target Products	✓ Engine Components ✓ Auxiliary means of production and supports ✓ Embedded electronics ✓ Concept modelling, prototyping and design ✓ Niche, low volume parts ✓ Spare parts & repair			
High expected impact on:	*Economic & Industrial* Increased product quality and performances Potential for EU leadership Increased business generated *Environment & Social* Material resource saving Jobs reshoring in EU Increased number of jobs			

Action name	**Design strategies for the development of complex shaped structures (e.g. Lattice structures)**			
Action n.	6		**Sector**	Automotive
Description of the challenge (current gap)				
The ability of AM to produce optimised complex shapes can only be utilised if these shapes can be designed.				
Proposed activities				
● Develop algorithms to automatically generate stress optimized lattice structures (Preliminary design) ● Develop automated plausibility checks for structures under constraints (Preliminary design).Integrate CAD packages with AM process (Conceptual design) ● Integration of simulation into the design phase (both in the Preliminary and Detail design) ● Include material properties taking into account process defects in design loop ● Extension of topology optimization tools (including dynamic loads, cyclic loads, vibrations, shock absorption, optimal weight) ● Structural Integrity & Durability assessment (Detail design)				
Value chain segments	[x] Modelling [x] Design [ ] Material [ ] Process		[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	5-6		**Target TRL**	7
Type of Action	IA			
Target Products	✓ Concept modelling, prototyping and design ✓ Niche, low volume parts			
High expected impact on:	*Economic & Industrial* Reduced manufacturing cost Increased product quality and performances Potential for EU leadership *Environment & Social* Increased recycling Material resource saving Jobs reshoring in EU			

<table>
<tr><td>Action name</td><td colspan="4">Development and demonstrate strategies for cost-effective printing assemblies in one step</td></tr>
<tr><td>Action n.</td><td>7</td><td colspan="2">Sector</td><td>Automotive</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">Alignment and rolling out of design methodologies, training (demonstration material) and certification of design methods is suggested</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">● Development of new design strategies and tools, for the new material class, e.g. anisotropic properties and inhomogeneous microstructure, presence of residual stress. Select parts that are suitable for AM production.
● Benchmark costs (use expensive titanium fasteners vs. AM-driven one-piece design)
● Training of AM capabilities (including novel approaches for component fabrication).
● Team design for Multi-functional parts.</td></tr>
<tr><td>Value chain segments</td><td colspan="4">☐ Modelling
☐ Design
☐ Material
☒ Process
☒ Post Process
☒ Product
☐ End of Life
☐ Complete VC</td></tr>
<tr><td>Current TRL</td><td>6</td><td>Target TRL</td><td colspan="2">7</td></tr>
<tr><td>Type of Action</td><td colspan="4">IA</td></tr>
<tr><td>Target Products</td><td colspan="4">✓ Engine Components
✓ Auxiliary means of production and supports
✓ Embedded electronics
✓ Concept modelling, prototyping and design
✓ Niche, low volume parts
✓ Spare parts & repair</td></tr>
<tr><td>High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Increased product quality and performances
Increased production capacity
Increased business generated
<u>Environment & Social</u>
Jobs reshoring in EU
Increased number of jobs
Material resource saving</td></tr>
</table>

Action name	Obtaining industrially relevant larger certified build envelopes		
Action n.	8	**Sector**	Automotive
Description of the challenge (current gap)			
While AM processes are maturing, “conventional” machine manufacturers might come in and help to take current machines to the next level of machine design and engineering.			
Proposed activities			
● Encourage machine and equipment manufacturers from outside the AM scene to engage and develop concepts. This development is already in progress. ● Collaboration with the AM industry and research community is highly recommended ● Study and design new solutions for the use of more than 1 energy source in the build envelope ● Expand to other AM tech (B.J). ● Implement R&D results in high TRL industry solutions (focusing on hybrid manufacturing)			
Value chain segments	☐ Modelling ☐ Design ☐ Material ☒ Process	☒ Post Process ☒ Product ☐ End of Life ☐ Complete VC	
Current TRL	5-6	**Target TRL**	
Type of Action			
Target Products	✓ Engine Components ✓ Auxiliary means of production and supports ✓ Embedded electronics ✓ Niche, low volume parts ✓ Spare parts & repair		
High expected impact on:	*Economic & Industrial* Increased business generated Potential for EU leadership Increased number of private companies involved *Environment & Social* Jobs reshoring in EU Increased number of jobs Material resource saving		

<table>
<tr><td>Action name</td><td colspan="4">Development, optimization and validation of hybrid manufacturing</td></tr>
<tr><td>Action n.</td><td>9</td><td colspan="2">Sector</td><td>Automotive</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">Exploiting the capability of AM by integrating or combining AM with other processes in the manufacturing stream</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">● Create advantage by combining small complex and functional AM parts with large volume parts with only stability as a function
● Development of combined AM/subtracting with very good control of final product geometry and properties
● Hybrid solutions should not necessarily be implemented within the same machine: develop techniques for AM integration in the industrial production system and/or Hybrid fabrication processes using multiple AM and other processes
● Processing of inlays
● Joining technologies, e.g. by welding, to join AM with AM or conventional materials to form a larger or complex geometry part. Attention should be paid to the interface of the joints and residual stress in the heat affected zones due to property mismatch and/or forced fitting
● Have a manufacturing deployment assigning to AM only some finishing add on standard optimised parts</td></tr>
<tr><td>Value chain segments</td><td colspan="4">☐ Modelling ☒ Post Process
☐ Design ☐ Product
☐ Material ☐ End of Life
☒ Process ☐ Complete VC</td></tr>
<tr><td>Current TRL</td><td colspan="2">4-5</td><td>Target TRL</td><td>6</td></tr>
<tr><td>Type of Action</td><td colspan="4">RIA</td></tr>
<tr><td>Target Products</td><td colspan="4">✓ Engine Components
✓ Auxiliary means of production and supports
✓ Embedded electronics
✓ Concept modelling, prototyping and design
✓ Niche, low volume parts
✓ Spare parts & repair</td></tr>
<tr><td>High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Increased product quality and performances
Potential for EU leadership
Increased IPR protection
<u>Environment & Social</u>
Increased number of jobs
Reduction of CO2 emission
Jobs reshoring in EU</td></tr>
</table>

Action name	Characterization of the behavior of AM components in large assemblies and of large assemblies		
Action n.	10	**Sector**	Automotive
Description of the challenge (current gap)			
To test the whole structure, to simulate/molding to integrate AM properties			
Proposed activities			
● Assembly guidelines. ● Access the AM properties. ● Implementation of AM Properties in FE/CAD. ● Check current testing rules. ● Manufacturing process in components integrating AM assembling parts.			
Value chain segments	☐ Modelling ☐ Design ☒ Material ☒ Process	☒ Post Process ☒ Product ☐ End of Life ☐ Complete VC	
Current TRL	5-6	**Target TRL**	7
Type of Action	IA		
Target Products	✓ Engine Components ✓ Concept modelling, prototyping and design ✓ Niche, low volume parts		
High expected impact on:	*Economic & Industrial* Potential for EU leadership Increased product quality and performances Increased production capacity *Environment & Social* Jobs reshoring in EU Material resource saving Increased number of jobs		

CONSUMER GOODS AND ELECTRONICS

<table>
<tr><td>Action name</td><td colspan="4">Convergence among custom design , electronics, smart/4D printing materials and artificial intelligence enabling better control of AM processes and quality and reliability of customized products</td></tr>
<tr><td>Action n.</td><td>1</td><td colspan="2">Sector</td><td>Consumer Goods and Electronics</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">The use of design possibilities of AM in customization is not optimal. Actions needed to help implement this benefit for the sector(s). Also the link with intelligent AM parts (with embedded electronics) needs to be established. In order to allow for full-scale flexible electronics a stronger linkage between materials, design and advanced electronics is necessary as one of the key enablers in this segment. In this context an important challenge is open innovation.</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">● Use customization supported by automated software tools to bring AM into the products/parts
● Drafted pre-CAD files depending on product families allowing further enhancement of design features. (Application independent)
● Process chain modelling concepts
● Improved topology optimisation tools
● Establish linkages between electronics design and AM geometry design in one design system towards first time right production of intelligent (IoT) AM products
● Establish linkages between materials, design and advanced electronics
● Implementation of demonstration projects</td></tr>
<tr><td>Value chain segments</td><td colspan="4">[x] Modelling
[x] Design
[x] Material
[x] Process
[ ] Post Process
[ ] Product
[ ] End of Life
[ ] Complete VC</td></tr>
<tr><td>Current TRL</td><td>4-5</td><td>Target TRL</td><td colspan="2">6</td></tr>
<tr><td>Type of Action</td><td colspan="4">RIA</td></tr>
<tr><td>Target Products</td><td colspan="4">✓ Wearables
✓ Household utensils
✓ Sensors and Antennas
✓ Entertainment
✓ Basic electronic components
✓ Spare Parts & Repair
✓ Other Electronics
✓ Packaging
✓ Art</td></tr>
<tr><td>High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Increased business generated
Increased number of private companies involved
Increased IPR protection</td></tr>
</table>

Action name	Convergence among custom design , electronics, smart/4D printing materials and artificial intelligence enabling better control of AM processes and quality and reliability of customized products
	Environment & Social Jobs reshoring in EU Increased number of jobs Material resource saving

<table>
<tr><td>Action name</td><td colspan="4">Materials development targeting multi-material parts (including multi-material electronics)</td></tr>
<tr><td>Action n.</td><td>2</td><td colspan="2">Sector</td><td>Consumer Goods and Electronics</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">New developments in this area should be made to enable AM of functional parts. Material properties such as optical, magnetic, conductive, fluidics, are not implemented in AM well enough today. Broader availability of multi-material parts could lead to higher demand from consumers.</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">● Development of higher performance polymer material able to produce 3D components with the same or enhanced properties as injected parts e.g. metallic, high tech ceramics
● Development of multi-materials e.g. coated coloured material or parts local properties
● AM materials that are comparable to established materials: materials like metal, ceramics and glass, where still important gaps (apart from polymers) in terms of properties exist.
● Conductive materials in AM
● Advanced materials with new material and atomistic models</td></tr>
<tr><td>Value chain segments</td><td colspan="4">☐ Modelling
☒ Design
☒ Material
☐ Process
☐ Post Process
☐ Product
☐ End of Life
☐ Complete VC</td></tr>
<tr><td>Current TRL</td><td>4-5</td><td>Target TRL</td><td colspan="2">6</td></tr>
<tr><td>Type of Action</td><td colspan="4"></td></tr>
<tr><td>Target Products</td><td colspan="4">✓ Wearables
✓ Household utensils
✓ Sensors and Antennas
✓ Entertainment
✓ Basic electronic components
✓ Spare Parts & Repair
✓ Other Electronics
✓ Packaging
✓ Art</td></tr>
<tr><td>High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Increased product quality and performances
Potential for EU leadership
Reduced manufacturing cost
<u>Environment & Social</u>
Material resource saving
Better personal health
Better quality of life</td></tr>
</table>

Action name	Promoting mass customization of AM consumer products, including collective design (co-creation) and fabrication strategies		
Action n.	3	Sector	Consumer Goods and Electronics
Description of the challenge (current gap)			
AM enables the involvement of the consumer in the design of their tailor made product. Tools should be developed / rolled out to unlock this capability. The perspective of the “creative industry sector” (fashion, art, sports, jewellery) has a strong focus on this aspect. It is important to develop new curricula (linked to cross-cutting actions), appropriate tools platform to simplify customisation. In order to meet clients requirements, it is important to undestand why a particular product should be customised. It is important to promote collective design and fabricatio and connect ART/design/engineering to imagine new products			
Proposed activities			
● Creation of an online platform able to manipulate CAD data, allowing both engineers and customers to interact with the final product geometry ● Use customization supported by automated software tools (including multi-material, conductivity, electronic functionality) to bring AM into the products/parts. Not only for design, but also directly to relevant manufacturing & logistics processes as integrated approach ● Mechanisms for modularisation of products ● Analysis of process chains, allowing “configuration” of products in a detailed manner ● The creation of good product databases ● Demonstration projects ● Customisation perspectives should include both B2C, but also B2B perspectives (focus not only on consumer side) ● Introduce AM/3D printing to design schools, develop curricula ● Integration of design software used in ART and design with engineering AM software.			
Value chain segments	[x] Modelling [x] Design [x] Material [x] Process	[x] Post Process [x] Product [ ] End of Life [ ] Complete VC	
Current TRL	5-6	Target TRL	7
Type of Action	IA/CSA		
Target Products	✓ Wearables ✓ Household utensils ✓ Entertainment ✓ Basic electronic components ✓ Spare Parts & Repair ✓ Packaging ✓ Art		
High expected impact on:	*Economic & Industrial* Increased production capacity Reduced time to market Increased business generated		

Action name	Promoting mass customization of AM consumer products, including collective design (co-creation) and fabrication strategies
	Environment & Social Jobs reshoring in EU Increased number of jobs Material resource saving

Action name	Innovating strategies to improve aesthetics and surface quality and facilitate or even avoid post-processing steps (e.g. through continuous processes without layering)		
Action n.	4	**Sector**	Consumer Goods and Electronics
Description of the challenge (current gap)			
AM for consumer puts high requirements for surface quality. Mostly post processing is needed to achieve acceptable level of part quality. Use of the characteristics of materials and manufacturing processes to produce functional and aesthetically pleasing objects. Aesthetics play obviously a key role regarding clients and it is an important factor for product acceptance and commercialization.			
Proposed activities			
● Development of parts with a specific "look and feel" ● Introduction of new process concepts related to continuous processes without layering (e.g. by learning from and further developing Carbon 3D and Printvalley machines) ● Improved topology optimization tools ● Reduction of surface roughness (also for internal structures) ● Utilizing products made by conventional technologies as inserts/basis for Additive & subtractive tailoring ● Colouring, nano-structuring to enhance surface properties wear, wettability, antifouling, dust free ● Work on material and process with material ageing behaviour ● Develop processes for post processing but also the AM process in such a way that post processing becomes more obsolete. Innovative support solutions. Role of automation and support infrastructure in this field (e.g. robotics).			
Value chain segments	☐ Modelling ☐ Design ☒ Material ☒ Process	☒ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	6	**Target TRL**	7
Type of Action			
Target Products	✓ Wearables ✓ Household utensils ✓ Sensors and Antennas ✓ Entertainment ✓ Basic electronic components ✓ Spare Parts & Repair ✓ Other Electronics ✓ Packaging ✓ Art		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Reduced time to market Increased number of private companies involved		

Action name	Innovating strategies to improve aesthetics and surface quality and facilitate or even avoid post-processing steps (e.g. through continuous processes without layering)
	Environment & Social Reduction of CO2 emission Material resource saving Better quality of life

Action name	Predictive, self-learning and holistic multi-physical modelling approaches for modelling AM processes leading to increased product functionality		
Action n.	5	Sector	Consumer Goods and Electronics
Description of the challenge (current gap)			
Part final properties are directly linked to material properties and part design. Predictive modelling. Guidelines & tools for first time right minimal design (including design history and structural modelling and simulations) must be developed.			
Proposed activities			
● Develop models able to predict final properties and process parameters ● Predictive modelling: model material, processes leading to first time right production of products. Self-learning models with iterative corrections will yield first time right products. ● Develop holistic modelling approaches using multiphysics simulation and going from process parameters and simulation to product mechanical properties, via thermal mapping/history of the workpiece. ● Implement stochastic/empirical modelling techniques utilizing a large volume of data (knowledge repository). ● Electronics design and AM geometry design in one design software system			
Value chain segments	[x] Modelling [x] Design [ ] Material [ ] Process	[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	5-6	**Target TRL**	7
Type of Action			
Target Products	✓ Wearables ✓ Household utensils ✓ Sensors and Antennas ✓ Entertainment ✓ Basic electronic components ✓ Spare Parts & Repair ✓ Other Electronics ✓ Packaging ✓ Art		
High expected impact on:	*Economic & Industrial* Increased business generated Increased production capacity Increased number of private companies involved *Environment & Social* Material resource saving Better environment Increased recycling		

<table>
<tr><td>Action name</td><td colspan="4">Improving process sustainability through flexible and hybrid manufacturing and industry 4.0 approaches</td></tr>
<tr><td>Action n.</td><td>6</td><td>Sector</td><td colspan="2">Consumer Goods and Electronics</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">New developments including the manufacturing processes in this area should be made to enable AM of functional parts. Flexible and hybrid processes, incl. incorporation in existing production processes or adaptation to existing interfaces, are essential. Economic use of AM requires lower cost per part, i.e. higher productivity or lower machine cost</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">● Development of more flexible/combination 3D processes
● Develop hybrid process, incl. incorporation in existing production processes or adaptation to existing interfaces, with high throughput
● Equipment for integration of conductive tracks, Pick and Place of electronic components
● Process comprises: multi-material, conductive tracks, electronics,
● Intelligent/IoT AM parts drive the manufacturing cycle (which will be hybrid) themselves (4.0 approach).
● Processes for thermally conductive & fire retardant, composite, Cermets, metal, carbon AM made products Develop convergent processes towards smart devices with multi-functionalities
● Increase production speed for 3D printers, nowadays big pieces (20 cm x 20 cm x 20 cm) can take many hours (>10H). Should be nice print faster</td></tr>
<tr><td>Value chain segments</td><td colspan="4">[ ] Modelling
[ ] Design
[x] Material
[x] Process
[x] Post Process
[x] Product
[ ] End of Life
[ ] Complete VC</td></tr>
<tr><td>Current TRL</td><td>4-5</td><td>Target TRL</td><td colspan="2">6</td></tr>
<tr><td>Type of Action</td><td colspan="4">RIA</td></tr>
<tr><td>Target Products</td><td colspan="4">✓ Wearables
✓ Household utensils
✓ Sensors and Antennas
✓ Entertainment
✓ Spare Parts & Repair
✓ Packaging</td></tr>
<tr><td>High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Increased production capacity
Reduced time to market
Increased business generated
<u>Environment & Social</u>
Material resource saving
Better environment
Increased number of jobs</td></tr>
</table>

<table>
<tr><th colspan="2">Action name</th><th colspan="4">3D capturing technologies</th></tr>
<tr><td>Action n.</td><td>7</td><td colspan="2">Sector</td><td colspan="2">Consumer Goods and Electronics</td></tr>
<tr><td colspan="6">Description of the challenge (current gap)</td></tr>
<tr><td colspan="6">When personalised data is used in the AM design to provide tailored, personalised AM built products, (personal) 3D data capture (in an easy, accessible but safe way) needs to be established</td></tr>
<tr><td colspan="6">Proposed activities</td></tr>
<tr><td colspan="6">● Creation of algorithms/tools that will enable usage of low-cost commercially available equipment in order to capture 3D geometry e.g. SW/APP to 3Dscan / capture from mobile device and create the 3D cad model. Then further elaborate. Cheap/Easy to use for high market penetration.</td></tr>
<tr><td colspan="2">Value chain segments</td><td colspan="4">[x] Modelling
[x] Design
[ ] Material
[ ] Process
[ ] Post Process
[ ] Product
[ ] End of Life
[ ] Complete VC</td></tr>
<tr><td>Current TRL</td><td colspan="2">5-6</td><td colspan="2">Target TRL</td><td>7</td></tr>
<tr><td colspan="2">Type of Action</td><td colspan="4">IA</td></tr>
<tr><td colspan="2">Target Products</td><td colspan="4">✓ Wearables
✓ Household utensils
✓ Sensors and Antennas
✓ Entertainment
✓ Spare Parts & Repair
✓ Packaging
✓ Art</td></tr>
<tr><td colspan="2">High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Increased business generated
Increased number of private companies involved
Increased production capacity
<u>Environment & Social</u>
Material resource saving
Increased number of jobs
Jobs reshoring in EU</td></tr>
</table>

INDUSTRIAL EQUIPMENT AND TOOLING

Action name	**New design approaches and tools for assembly of complex multi-material and multi-component parts**		
Action n.	1	**Sector**	Industrial Equipment and Tooling
Description of the challenge (current gap)			
Design and modelling to integrate behaviours between forged and AM parts			
Proposed activities			
● Create a new design approach and tools that include every part of a sub-system and support the merging process of the components ● Quantify and create new behaviour models ● Increase the chamber dimension in order to produce larger parts, which in turn will allow several components to be merged together without an assembly step.			
Value chain segments	[x] Modelling [x] Design [x] Material [x] Process	[x] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	5-6	**Target TRL**	7
Type of Action	IA		
Target Products	✓ Mould Inserts ✓ Scientific & Measurement Instruments ✓ Tooling and guides ✓ Industrial AM Equipments ✓ Industrial AM Softwares ✓ High Performance Tool Materials		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Increased business generated *Environment & Social* Material resource saving Reduction of CO2 emission Better environment		

Action name	Hybrid Manufacturing: introduction of AM processes into existing workflow		
Action n.	2	**Sector**	Industrial Equipment and Tooling
Description of the challenge (current gap)			
Industrial implementation of AM requires inclusion with and embedding with other technologies in a hybrid setting			
Proposed activities			
● Development of a higher number of solutions that cover different combination of AM processes and other technologies such as subtractive ones (i.e. Laser cladding and milling processes and turning process, etc.) ● Create/use standards for alignment of systems for complete workflow. Integration of the software system (Hybrid - cutting - deposition technologies - cleaning and re-deposition). ● Understanding the effects of the mix of 'hot' and 'cold' process			
Value chain segments	☐ Modelling ☐ Design ☒ Material ☒ Process	☒ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	5-6	**Target TRL**	7
Type of Action	IA		
Target Products	✓ Scientific & Measurement Instruments ✓ Tooling and guides ✓ Industrial AM Equipments		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased business generated Increased production capacity *Environment & Social* Jobs reshoring in EU Better environment Increased number of jobs		

Action name	Standardisation: material and product testing and process monitoring for improved quality control of manufactured parts		
Action n.	3	Sector	Industrial Equipment and Tooling
Description of the challenge (current gap)			
To cope with the hesitation of AM in this sector, a guideline/route for guaranteeing quality should be presented			
Proposed activities			
● Outline a series of standard tests (non-destructive), specific for AM able to evaluate the quality of the manufactured parts ● Material properties at the microstructure. Process monitoring with closed loop parameters adaptation			
Value chain segments	☐ Modelling x Design x Material x Process	x Post Process x Product ☐ End of Life ☐ Complete VC	
Current TRL	6	**Target TRL**	7
Type of Action	IA/CSA		
Target Products	✓ Scientific & Measurement Instruments ✓ Industrial AM Equipments ✓ Industrial AM Softwares ✓ High Performance Tool Materials		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Increased number of private companies involved *Environment & Social* Material resource saving Jobs reshoring in EU Reduction of CO2 emission		

<table>
<tr><td>Action name</td><td colspan="4">Innovative strategies, technologies and processes increasing the dimensional and surface accuracy of final parts</td></tr>
<tr><td>Action n.</td><td>4</td><td colspan="2">Sector</td><td>Industrial Equipment and Tooling</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">To realise net shaped parts, most of the time post processing is required; how to optimize this? In parallel, search for new techniques leading to higher surface properties while avoiding/reducing post-processing.</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">● Try to understand if requests on surface finishing and dimensional tolerances are necessary
● Innovative techniques, which reduce/avoid post processing.
● Consider these limits during the design phase, in order to better understand the parts and overcome the problem.
● Develop solutions for finishing of internal channels
● Find solutions to reduce or tailor residual stress during process (consolidation objectives for thermal treatment) and process simulation
● Investigate process parameters to improve surface parameters, in particular on down-skin regions.</td></tr>
<tr><td>Value chain segments</td><td colspan="4">☐ Modelling ☒ Post Process
☐ Design ☐ Product
☒ Material ☐ End of Life
☒ Process ☐ Complete VC</td></tr>
<tr><td>Current TRL</td><td>5-6</td><td>Target TRL</td><td colspan="2">7</td></tr>
<tr><td>Type of Action</td><td colspan="4">IA</td></tr>
<tr><td>Target Products</td><td colspan="4">✓ Mould Inserts
✓ Scientific & Measurement Instruments
✓ Industrial AM Equipments</td></tr>
<tr><td>High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Increased product quality and performances
Increased IPR protection
Increased business generated
<u>Environment & Social</u>
Material resource saving
Increased recycling
Jobs reshoring in EU</td></tr>
</table>

Action name	Innovative cost-effective machines (including robotic machines with artificial intelligence algorithms, multi-voxel machines etc.) enabling higher production rates		
Action n.	5	**Sector**	Industrial Equipment and Tooling
Description of the challenge (current gap)			
Economic use of AM requires lower cost per part and further development of advanced machine (eg. direct deposition machines, machines for finishing large structures, robotic machines with artificial intelligence algoritms, assisting laser or electron beam with sources with alternative cheaper technologies etc.).			
Proposed activities			
● Teach users how to design the part position into the build envelope ● New machine conception: Machine producer to increase the numbers of heat sources/workheads; Multi-voxel machines; Integration of artificial intelligence and robotics ● New technology development - Patents ● EU Community to encourage investment in the second generation of AM Machines			
Value chain segments	[x] Modelling [x] Design [x] Material [x] Process	[x] Post Process [x] Product [ ] End of Life [ ] Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
Target Products	✓ Industrial AM Equipments		
High expected impact on:	*Economic & Industrial* Increased production capacity Increased product quality and performances Reduced time to market *Environment & Social* Material resource saving Jobs reshoring in EU Increased number of jobs		

<table>
<tr><td>Action name</td><td colspan="4">Novel manufacturing processes increasing quality and consistency of powder production</td></tr>
<tr><td>Action n.</td><td>6</td><td colspan="2">Sector</td><td>Industrial Equipment and Tooling</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">Material quality and control is a key factor for a quality controlled AM manufacturing process</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">● Optimization of the feedstock manufacturing process in order to narrow the properties range
● Ceramic filled resins development for large size parts
● Deepest monitoring of the quality control parameter during the manufacturing process.
● Powder characterisation and definition of powder properties by process machine</td></tr>
<tr><td>Value chain segments</td><td colspan="4">☐ Modelling ☐ Post Process
☐ Design ☐ Product
☒ Material ☐ End of Life
☒ Process ☐ Complete VC</td></tr>
<tr><td>Current TRL</td><td>6</td><td>Target TRL</td><td colspan="2">7</td></tr>
<tr><td>Type of Action</td><td colspan="4">IA</td></tr>
<tr><td>Target Products</td><td colspan="4">✓ Scientific & Measurement Instruments
✓ Industrial AM Equipments
✓ High Performance Tool Materials</td></tr>
<tr><td>High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Increased business generated
Increased production capacity
Increased product quality and performances
<u>Environment & Social</u>
Material resource saving
Jobs reshoring in EU
Reduction of CO2 emission</td></tr>
</table>

Action name	Larger certified build chambers		
Action n.	7	Sector	Industrial Equipment and Tooling
Description of the challenge (current gap)			
AM processes building box quality and - control is a key factor for a quality controlled AM manufacturing process			
Proposed activities			
● Understand what could be defined as "large part" and the relative market (is it worth it to do it in AM?) ● Study and design new solutions for the use of more than 1 energy source in the build envelope ● Development of multi laser array light engine process and associated equipment ● Equipment development for large size (filled) resin based materials ● Evaluate the value to cost of an AM large part – is it cost effective to manufacture large parts using AM?			
Value chain segments	☐ Modelling ☐ Design ☐ Material ☒ Process	☒ Post Process ☒ Product ☐ End of Life ☐ Complete VC	
Current TRL	6	**Target TRL**	7
Type of Action	IA		
Target Products	✓ Industrial AM Equipments		
High expected impact on:	*Economic & Industrial* Increased production capacity Reduced manufacturing cost Increased product quality and performances *Environment & Social* Material resource saving Jobs reshoring in EU Increased number of jobs		

Action name	**Novel tooling materials and moulds for AM processes**		
Action n.	8	**Sector**	Industrial Equipment and Tooling
Description of the challenge (current gap)			
New classes of material required Specific compositions for specific AM processes (Laser - EB). Cost-effective plastic mould materials are also required for small series (e.g. In injection molding)			
Proposed activities			
● Define the actual bottleneck with actual materials ● Define new materials for tooling ● Treating the outer surface of plastic mould, that could have different from the inner microstructures. ● Develop a composite materials based on plastic matrix with high thermal conductivity and low thermal expansion			
Value chain segments	☐ Modelling ☐ Design ☒ Material ☒ Process	☒ Post Process ☒ Product ☐ End of Life ☐ Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
Target Products	✓ Mould Inserts ✓ Tooling and guides ✓ High Performance Tool Materials		
High expected impact on:	*Economic & Industrial* Reduced time to market Increased production capacity Increased product quality and performances *Environment & Social* Material resource saving Reduction of CO2 emission Better quality of life		

Action name	Software for graded materials and density		
Action n.	9	Sector	Industrial Equipment and Tooling
Description of the challenge (current gap)			
It is important to develop/optimise softwares tuned for graded materials and hybrid process that can be easily integrated in open platform			
Proposed activities			
● Design and simulation of graded materials and hybrid processes ● Prediction of material part specification based upon powder, technology, parameters			
Value chain segments	[x] Modelling [x] Design [ ] Material [ ] Process	[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	6	**Target TRL**	7
Type of Action	IA		
Target Products	✓ Industrial AM Softwares ✓ High Performance Tool Materials		
High expected impact on:	*Economic & Industrial* Increased production capacity Increased business generated Reduced time to market *Environment & Social* Jobs reshoring in EU Increased number of jobs Material resource saving		

Action name	New equipment and technologies for expanding additive manufacturing towards nanoscale		
Action n.	10	Sector	Industrial Equipment and Tooling
Description of the challenge (current gap)			
To expand the additive technology towards micro and nanoscale, processes and equipment serving that scale should be further developed			
Proposed activities			
● Development of materials and associated health and safety protocols suitable for nano-scale production. ● Understand what could be defined as "small feature" and the relative market ● Development of equipment for nano-scale 3D structures ● Technologies like 2 photon polymerisation deliver micro structures, to be expanded and extended			
Value chain segments	[x] Modelling [x] Design [x] Material [x] Process	[x] Post Process [x] Product [ ] End of Life [ ] Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
Target Products	✓ Industrial AM Equipments		
High expected impact on:	*Economic & Industrial* Reduced manufacturing cost Increased production capacity Reduced time to market *Environment & Social* Jobs reshoring in EU Increased number of jobs Material resource saving		

CONSTRUCTION

Action name	Improving processing knowledge and availability of AM materials for the construction sector		
Action n.	1	**Sector**	Construction
Description of the challenge (current gap)			
Knowledge on interaction between process and material to develop materials with the right properties for the process like mixing, pumping, applying by extrusion, spraying or binder jetting, drying. Note: Most production processes in the construction sector are far more robust then AM processes and are far less sensitive for small changes of material properties. AM feed stock materials need to meet narrow specifications with which te industry is not familiar. Development of materials, processes and design rules are strongly related.			
Proposed activities			
● Study on interaction between material properties and AM process like rheology, shear rate, fast solidification, binding between layers, shrinkage, etc. Determination of characteristic materials properties (e.g. particle size distribution and consistency for optimal AM processing)			
Value chain segments	[ ] Modelling [ ] Design [X] Material [X] Process	[X] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
Target Products	✓ Unconventional buildings (prototypes, decorative façades, art, design, heritage reconstruction) ✓ Structural parts like bridges, floors, walls ✓ Low risk parts with complex shapes e.g. for garden and landscape decoration ✓ Special buildings (army, nuclear disaster, army buildings, lunar base) ✓ Organic shaped complex (structural) parts with integrated functions		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Potential for EU leadership Reduced manufacturing cost *Environment & Social* Material resource saving Reduction of CO2 emission Better environment		

Action name	Methodologies to integrate concrete reinforcements in AM construction		
Action n.	2	**Sector**	Construction
Description of the challenge (current gap)			
Concrete reinforcement to withstand tensile and bending forces is mostly not possible in combination with AM. Development of methodologies to integrate reinforcements in to the AM-materials is needed. Note: New lightweight (natural) fibre materials are available and might be a solution for an alternative braiding - integration into the construction. Out of the box concepts for hybrid solutions should be encouraged.			
Proposed activities			
● Investigation and assessment of reinforcement materials (e.g. steel, glass, carbon, natural fibres) and development of applying these fibres/rods into/onto the construction. Simulation of optimal fibre distribution w.r.t. tensile (and bending) properties. Hybrid technologies such as post processes like placing external and internal tensile rods should be considered.			
Value chain segments	☐ Modelling ☒ Design ☒ Material ☒ Process	☒ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
Target Products	✓ Unconventional buildings (prototypes, decorative façades, art, design, heritage reconstruction) ✓ Structural parts like bridges, floors, walls ✓ Special buildings (army, nuclear disaster, army buildings, lunar base) ✓ Organic shaped complex (structural) parts with integrated functions		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Reduced time to market Increased business generated *Environment & Social* Increased number of jobs Jobs reshoring in EU Reduction of CO2 emission		

<table>
<tr><td>Action name</td><td colspan="4">Strategies toward standardisation: AM alignment with existing standards and building codes and research for improvement of specifications and standardisation of material properties.</td></tr>
<tr><td>Action n.</td><td>3</td><td></td><td>Sector</td><td>Construction</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">From one side, existing norms and building codes will continue to exist. AM needs to adapt/improve to be able to meet their requirements. From another side,current material specifications are not accurate and discriminatory enough for AM. New standards should be prepared and drafted. Materials with accurate specs are required in order to obtain reproducible AM-processes.</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">● Find ways to specify the materials properties that are of importance to get a reproducible AM-process and introduce them into a new version of the standard.</td></tr>
<tr><td>Value chain segments</td><td colspan="4">☐ Modelling
☒ Design
☒ Material
☒ Process
☒ Post Process
☐ Product
☐ End of Life
☐ Complete VC</td></tr>
<tr><td>Current TRL</td><td>4-5</td><td>Target TRL</td><td colspan="2">6</td></tr>
<tr><td>Type of Action</td><td colspan="4">RIA</td></tr>
<tr><td>Target Products</td><td colspan="4">✓ Unconventional buildings (prototypes, decorative façades, art, design, heritage reconstruction)
✓ Structural parts like bridges, floors, walls
✓ Low risk parts with complex shapes e.g. for garden and landscape decoration
✓ Special buildings (army, nuclear disaster, army buildings, lunar base)
✓ Organic shaped complex (structural) parts with integrated functions</td></tr>
<tr><td>High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Reduced manufacturing cost
Reduced time to market
Increased number of private companies involved
<u>Environment & Social</u>
Jobs reshoring in EU
Better environment
Material resource saving</td></tr>
</table>

Action name	Cost-effective printing equipment for construction applications		
Action n.	4	Sector	Construction
Description of the challenge (current gap)			
Currently used concrete printing equipment is basic but functional. An improvement step in the direction of speed, control, accuracy, adaptability, size, adaptability, transportability etcetera is still to be done. There is need to learn from experience in other sector.			
Proposed activities			
● Assessment of currently used printers and development of improved versions which better need the requirements (speed, cost, control, accuracy, adaptability, size, adaptability, transportability, cleanability)			
Value chain segments	☐ Modelling ☐ Design ☐ Material ☒ Process	☒ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
Target Products	✓ Unconventional buildings (prototypes, decorative façades, art, design, heritage reconstruction) ✓ Structural parts like bridges, floors, walls ✓ Low risk parts with complex shapes e.g. for garden and landscape decoration ✓ Special buildings (army, nuclear disaster, army buildings, lunar base) ✓ Organic shaped complex (structural) parts with integrated functions		
High expected impact on:	*Economic & Industrial* Reduced manufacturing cost Reduced time to market Increased number of private companies involved *Environment & Social* Jobs reshoring in EU Material resource saving Increased number of jobs		

<table>
<tr><th>Action name</th><th colspan="4">Integration of ergonomics, design and art in 3D printing built environment and related tools.</th></tr>
<tr><td>Action n.</td><td>5</td><td colspan="2">Sector</td><td>Construction</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">Involvement of stakeholder to include ergonomy, art, design and esthetic aspects in 3D printed construction.For example, art would bring invaluable dimension to 3D printed constructions. Similarly the consideration of ergonomy in tools is very big opportunity for safer tools.</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">● Demonstrate the co-creation and multidisciplinarity process in relevant environment promoting ergonomy, art, design and aesthetic aspects.</td></tr>
<tr><td>Value chain segments</td><td colspan="4">[X] Modelling
[X] Design
[ ] Material
[ ] Process
[X] Post Process
[X] Product
[ ] End of Life
[ ] Complete VC</td></tr>
<tr><td>Current TRL</td><td>5-6</td><td colspan="2">Target TRL</td><td>7</td></tr>
<tr><td>Type of Action</td><td colspan="4">IA/CSA</td></tr>
<tr><td>Target Products</td><td colspan="4">✓ Unconventional buildings (prototypes, decorative façades, art, design, heritage reconstruction)
✓ Structural parts like bridges, floors, walls
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<tr><td>High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Increased number of private companies involved
New types of ventures started
Potential for EU leadership
<u>Environment & Social</u>
Better quality of life
Better personal health
Material resource saving</td></tr>
</table>

<table>
<tr><th>Action name</th><th colspan="4">Co-production and user participation for added-value construction.</th></tr>
<tr><td>Action n.</td><td>6</td><td></td><td>Sector</td><td>Construction</td></tr>
<tr><td colspan="5">Description of the challenge (current gap)</td></tr>
<tr><td colspan="5">Customer/Multi-Stakeholders participation in design of the building/structure.</td></tr>
<tr><td colspan="5">Proposed activities</td></tr>
<tr><td colspan="5">● Development of procedures and tools. Application of parametric design rules.</td></tr>
<tr><td>Value chain segments</td><td colspan="4">☐ Modelling
☒ Design
☐ Material
☐ Process
☐ Post Process
☒ Product
☐ End of Life
☐ Complete VC</td></tr>
<tr><td>Current TRL</td><td>5-6</td><td></td><td>Target TRL</td><td>7</td></tr>
<tr><td>Type of Action</td><td colspan="4">IA/CSA</td></tr>
<tr><td>Target Products</td><td colspan="4">✓ Unconventional buildings (prototypes, decorative façades, art, design, heritage reconstruction)
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<tr><td>High expected impact on:</td><td colspan="4"><u>Economic & Industrial</u>
Reduced time to market
Increased number of private companies involved
New types of ventures started
<u>Environment & Social</u>
Better quality of life
Better personal health
Jobs reshoring in EU</td></tr>
</table>

Action name	Design for construction in AM, integrated with building information modelling (BIM) systems and topology optimisation		
Action n.	7	**Sector**	Construction
Description of the challenge (current gap)			
New design rules coupled with process/materials/functionality need to be drafted. Integration with the currently used Building Information Modelling (BIM) system is required. Note: Tool functionalities include: New level of knowledge including graded structures, honeycomb structures, integration of new materials & reinforcements, sensors functions (acoustic, isolation, piping, wiring, topology optimization. New functionalities will be incorporated when they become available. BIM is a digital representation of all physical and functional properties of a builing, A BIM model is a shared knowlegde repository/source with information of the building and is used as a reliablie bassis during the whole lifecyle of the building.			
Proposed activities			
● Integrate design requirements, material performance and process requirements into design tools. This should be coupled to simulations on FEM to ensure topology optimization (lightweight, minimal material use, optimal reinforcement meshing).			
Value chain segments	[X] Modelling [X] Design [ ] Material [ ] Process	[ ] Post Process [ ] Product [ ] End of Life [ ] Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
Target Products	✓ Unconventional buildings (prototypes, decorative façades, art, design, heritage reconstruction) ✓ Structural parts like bridges, floors, walls ✓ Special buildings (army, nuclear disaster, army buildings, lunar base) ✓ Organic shaped complex (structural) parts with integrated functions		
High expected impact on:	*<u>Economic & Industrial</u>* Reduced time to market Increased product quality and performances Potential for EU leadership *<u>Environment & Social</u>* Material resource saving Better environment Reduction of CO2 emission		

Action name	Multimaterial printing and integrating components in to the build		
Action n.	8	Sector	Construction
Description of the challenge (current gap)			
Currently used concrete printing equipment is monomaterial only and a single process is applied.			
Proposed activities			
●Development of new processes/hybrid processes to integrate components and multi material in to the build is required.			
Value chain segments	[ ] Modelling [ ] Design [X] Material [X] Process	[X] Post Process [X] Product [ ] End of Life [ ] Complete VC	
Current TRL	3-4	**Target TRL**	5-6
Type of Action	RIA		
Target Products	✓ Unconventional buildings (prototypes, decorative façades, art, design, heritage reconstruction) ✓ Structural parts like bridges, floors, walls ✓ Low risk parts with complex shapes e.g. for garden and landscape decoration ✓ Special buildings (army, nuclear disaster, army buildings, lunar base) ✓ Organic shaped complex (structural) parts with integrated functions		
High expected impact on:	*Economic & Industrial* Potential for EU leadership New types of ventures started Increased product quality and performances *Environment & Social* Reduction of CO2 emission Material resource saving Jobs reshoring in EU		

Action name	Novel AM cost-effective manufacturing processes with high production rates validated in industrially-relevant construction products		
Action n.	9	**Sector**	Construction
Description of the challenge (current gap)			
Economic use of AM requires lower cost per part, i.e. higher productivity or lower machine cost. One envisioned route is the hybridization, where more than one process is engaged in one machine. This development should be encouraged by market interests and competition			
Proposed activities			
● Process planning considerations. ● Encourage machine and equipment manufacturers from outside the AM scene to engage and develop concepts/demo projects needed for studying feasibility ● Process parameters optimization ● Machine speed and precision improvement ● Users: learn how to design the part positions ● Software optimises deposition paths to minimise delays ● Mixing different materials (different properties each one) having by this way different applications with the same new material obtained.			
Value chain segments	[ ] Modelling [ ] Design [X] Material [X] Process	[X] Post Process [X] Product [ ] End of Life [ ] Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
Target Products	✓ Structural parts like bridges, floors, walls ✓ Special buildings (army, nuclear disaster, army buildings, lunar base) ✓ Organic shaped complex (structural) parts with integrated functions		
High expected impact on:	*Economic & Industrial* Increased production capacity Reduced manufacturing cost New types of ventures started *Environment & Social* Reduction of CO2 emission Better environment Increased recycling		

ENERGY

Action name	**Development of new materials with improved performances (light weight, strong, high temperature, reliable) and/or smart (e.g. 4D printed materials, sensorised materials etc.)**			
Action n.	1		**Sector**	Energy
Description of the challenge (current gap)				
Material quality (e.g. powder composition morphology) and reliability of AM produced parts during their life time is essential for energy applications. Development of reliable, cost-effective, high performance materials (light weight, strong, high temperature, reliable) and special /smart materials. The action may include advanced research on 4D printed materials.				
Proposed activities				
● Mapping/Database of alloys already explored/validated for AM processes, also to identify gaps of alloys to be explored Development of programmable materials by 4D printing, starting for example by carbon fibre, rubber, fabrics, and wood. ● Lightweight materials (e.g. titanium alloys) ● Extreme operating temperatures superalloys for turbine components ● Improved dynamic (fatigue) materials properties: Development of new alloys with improved dynamic properties and the development of advanced composites including high mechanical resistance ceramic particles in metal matrix ● Development of materials with improved creep and oxidation resistance ● Development of new routes for powder production to enable cheaper powders ● Development of wire feedstock with chemistry tailored for AM applications ● Expanding material research towards broad industry and low or medium-value applications. High grade metals will not become viable for e.g. the renewable sector with shorten product life cycles.				
Value chain segments	☐ Modelling ☒ Design ☒ Material ☒ Process		☐ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	4-5		**Target TRL**	6
Type of Action	RIA			
Target Products	✓ Turbines parts ✓ Oil and gas industry products ✓ Renewable Energy industry components ✓ Energy storage ✓ Electromechanical and 3D electronic components ✓ Floating Platforms components ✓ Concept modelling, prototyping and design ✓ Spare parts & repair			

Action name	**Development of new materials with improved performances (light weight, strong, high temperature, reliable) and/or smart (e.g. 4D printed materials, sensorised materials etc.)**
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased business generated Increased production capacity *Environment & Social* Material resource saving Jobs reshoring in EU Increased recycling

Action name	Process of new multi-materials/multi-voxel materials		
Action n.	2	**Sector**	Energy
Description of the challenge (current gap)			
Enabling the use of multi material /multi-voxel materials, graded material including reliable modeling tools and optimized processes			
Proposed activities			
● Development of new machine concepts (new printing heads) e.g. for graded material/multi-voxel properties and multi material combinations and the development of modelling tools to support this activity ● Fatigue and fracture toughness properties; effect of defects ● Development of process parameter required for multi-materials AM ● Residual stress in materials, caused by AM process and miss-match of different material properties (i.e. elastic modulus and coefficient of thermal expansion) ● New data-format to overcome STL format and be able to define voxels of the part (important for gradient structures)			
Value chain segments	☐ Modelling ☐ Design ☒ Material ☒ Process	☐ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	2-3	**Target TRL**	4-5
Type of Action	RIA		
Target Products	✓ Turbines parts ✓ Oil and gas industry products ✓ Renewable Energy industry components ✓ Energy storage ✓ Electromechanical and 3D electronic components ✓ Floating Platforms components ✓ Concept modelling, prototyping and design ✓ Spare parts & repair		
High expected impact on:	*Economic & Industrial* Increased production capacity Potential for EU leadership Increased product quality and performances *Environment & Social* Increased recycling Material resource saving Reduction of CO2 emission		

Action name	Improved process control and reproducibility of nozzle-based AM techniques		
Action n.	3	Sector	Energy
Description of the challenge (current gap)			
Repeatability, reproducibility and performance of AM processes can be improved using knowledge and tools, in order to get predictable outcome of the process. Lack of availability of suitable monitoring systems for AM; Incorporation into existing machines to control quality during building process. Linked with cross-cutting gap.			
Proposed activities			
● Implement real thermal field mapping (from machine sensors) to determine residual stresses. ● Data regarding mechanical properties, dimensional accuracy, surface roughness etc. coupled with the respective machine characteristics and process parameters ● Develop in-situ multiscale analysis methods by vision systems and image processing ● In line control towards zero defects ● Make use of established know-how in polymer fused deposition modelling (FDM), injection moulding and Powder Injection Moulding (PIM) ● Interaction with the "design" and "modelling" VC segments, i.e. design and process iterations ● Structural integrity analysis: design against fatigue and design for damage (defect) tolerance			
Value chain segments	☐ Modelling ☐ Design ☐ Material ☒ Process	☒ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	4-6	Target TRL	7
Type of Action	IA		
Target Products	✓ Turbines parts ✓ Oil and gas industry products ✓ Renewable Energy industry components ✓ Energy storage ✓ Electromechanical and 3D electronic components ✓ Floating Platforms components ✓ Concept modelling, prototyping and design ✓ Spare parts & repair		
High expected impact on:	*Economic & Industrial* Potential for EU leadership Increased business generated New types of ventures started *Environment & Social* Jobs reshoring in EU Increased number of jobs Material resource saving		

Action name	**Demonstration of AM higher productivity and cost-effective manufacturing in the energy sector**				
Action n.	4		**Sector**	Energy	
Description of the challenge (current gap)					
Economic use of AM requires lower cost per part, i.e. Higher productivity or lower machine cost.					
Proposed activities					
● Higher throughput, by intelligent process management precision = slow, large structures = speed, design for better productivity and cost efficient use of AM technology - All these will be encouraged by the development and demonstration of market ready AM processes. ● Development of low price materials. ● Reduction of production/printing time.					
Value chain segments	[ ] Modelling [ ] Design [x] Material [x] Process		[x] Post Process [x] Product [ ] End of Life [ ] Complete VC		
Current TRL	4-5		**Target TRL**	6	
Type of Action	RIA				
Target Products	✓ Turbines parts ✓ Oil and gas industry products ✓ Renewable Energy industry components ✓ Energy storage ✓ Electromechanical and 3D electronic components ✓ Floating Platforms components ✓ Concept modelling, prototyping and design ✓ Spare parts & repair				
High expected impact on:	*Economic & Industrial* Increased production capacity Increased product quality and performances New types of ventures started *Environment & Social* Reduction of CO2 emission Better environment Jobs reshoring in EU				

Action name	Increasing manufacturing performances through hybrid manufacturing		
Action n.	5	Sector	Energy
Description of the challenge (current gap)			
Exploiting the capability of AM by integrating or combining AM with other processes in the manufacturing stream			
Proposed activities			
● Development of a higher number of solutions that cover different combination of AM processes and other technologies such as subtractive ones (i.e. Laser cladding and milling processes and turning process, etc.) ● Reliable interfaces for optical measuring-systems for automatic change from a technology to the other			
Value chain segments	☐ Modelling ☐ Design ☐ Material ☒ Process	☒ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	5	**Target TRL**	6-7
Type of Action	IA		
Target Products	✓ Turbines parts ✓ Oil and gas industry products ✓ Renewable Energy industry components ✓ Energy storage ✓ Electromechanical and 3D electronic components ✓ Floating Platforms components ✓ Concept modelling, prototyping and design ✓ Spare parts & repair		
High expected impact on:	*Economic & Industrial* Increased production capacity Increased product quality and performances Reduced time to market *Environment & Social* Jobs reshoring in EU Material resource saving Better environment		

Action name	Production of larger structures through AM technologies, robotics and artificial intelligence		
Action n.	6	Sector	Energy
Description of the challenge (current gap)			
Increasing the size envelopes and the productivity of the printers at a reasonable cost is needed.			
Proposed activities			
● Development of new machines with larger build envelopes, higher productivity, and integrated post-processing ● Assembly operations to be reduced towards the end of the production line ● Address critical issues such as reliability of the process both over a large area, and over long building times, integrating robotics, in-line control system and artificial intelligence. For example detection and elimination of faults with 100% certainty, achieve consistency of properties and minimize tension over a large build area and volume.			
Value chain segments	☐ Modelling ☐ Design ☒ Material ☒ Process	☒ Post Process ☒ Product ☐ End of Life ☐ Complete VC	
Current TRL	4-5	**Target TRL**	6
Type of Action	RIA		
Target Products	✓ Turbines parts ✓ Oil and gas industry products ✓ Renewable Energy industry components ✓ Energy storage ✓ Floating Platforms components ✓ Concept modelling, prototyping and design ✓ Spare parts & repair		
High expected impact on:	*Economic & Industrial* Increased production capacity Reduced time to market Increased product quality and performances *Environment & Social* Jobs reshoring in EU Material resource saving Better environment		

Action name	**Strategies for improving surface quality : new materials, processes and post-processes**			
Action n.	7		**Sector**	Energy
Description of the challenge (current gap)				
Surface finishing can improve the accuracy and also fatigue properties of a workpiece as cracks can start at the surface of the part. New materials, processes (e.g. Avoiding the need for post-processes), more effective post processes.				
Proposed activities				
● Research into the effect of post processing operations and automation of post processing. ● Development of new materials and processes avoiding the need for post-processing ● Develop new cost-effective surface finishing processes for example combination of AM and subtractive manufacturing ● Reduce and control particles size of powder ● Optimisation of post-processing, e.g. on balance of cost (time, money) vs. material quality (residual stress, defect size, strength)				
Value chain segments	☐ Modelling ☐ Design ☐ Material ☒ Process		☒ Post Process ☐ Product ☐ End of Life ☐ Complete VC	
Current TRL	4-5		**Target TRL**	6
Type of Action	IA			
Target Products	✓ Turbines parts ✓ Oil and gas industry products ✓ Renewable Energy industry components ✓ Energy storage ✓ Electromechanical and 3D electronic components ✓ Floating Platforms components ✓ Concept modelling, prototyping and design ✓ Spare parts & repair			
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased business generated Potential for EU leadership *Environment & Social* Increased number of jobs Jobs reshoring in EU Material resource saving			

Action name	Scalability and modularity factors to promote de-localised manufacturing in the energy sector		
Action n.	8	Sector	Energy
Description of the challenge (current gap)			
Equipment and machinery for accelerated and large scale AM production should be developed with scalability and modular behaviour in mind. For future energy needs, de-localised manufacturing will become the standard in order to lower costs and accelerate projects.			
Proposed activities			
● Research should highlight the scalable/modular expansion constraints and opportunities for certain AM processes, based on broad parameters (material types, deposition methods, part characteristics, electric control, software limits, simulation limits, build strategies, physical constraints, environmental boundaries, sustainability and energy needs, etc.) ● System and machine development has to meet cost and size goals by looking beyond immediate system delivery - and build strategy for further development and relevance to large, medium-value products. ● For practical development; determine system interfaces that are influenced or will influence scalability/modularity. Define steps to overcome or initiate new research.			
Value chain segments	[ ] Modelling [ ] Design [x] Material [x] Process	[x] Post Process [x] Product [ ] End of Life [ ] Complete VC	
Current TRL	1-3	**Target TRL**	4-5
Type of Action	RIA		
Target Products	✓ Turbines parts ✓ Oil and gas industry products ✓ Renewable Energy industry components ✓ Energy storage ✓ Floating Platforms components ✓ Concept modelling, prototyping and design ✓ Spare parts & repair		
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Increased business generated *Environment & Social* Material resource saving Increased number of jobs Increased recycling		

Action name	**Digital twin including all simulations and process parameters that can enable the production of "equivalent" spare parts in a few days**			
Action n.	9		**Sector**	Energy
Description of the challenge (current gap)				
Today digital representation of the part produced has conflicting representations: the CAD-model, the STL file and possibly a point of cloud of scanned coordinates. All these has to be taken care of in long term storage structures (LOTAR-type). Today no such storage system using standards apparently exist				
Proposed activities				
● Coordination between ISO 10303, ASTM, etc.. Looking at the object in a lifecycle perspective allowing info and all aspects related to the object creation process are available for the future to understand and improve or reproduce the part. ● Development of digital twin technologies for rapid and cost-effective spare part manufacturing				
Value chain segments	[x] Modelling [x] Design [x] Material [x] Process		[x] Post Process [x] Product [ ] End of Life [ ] Complete VC	
Current TRL	5		**Target TRL**	6-7
Type of Action	IA/CSA			
Target Products	✓ Concept modelling, prototyping and design ✓ Spare parts & repair			
High expected impact on:	*Economic & Industrial* Increased product quality and performances Increased production capacity Increased business generated *Environment & Social* Material resource saving Jobs reshoring in EU Increased number of jobs			