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Abbreviations

Abbreviations	
3DP	3D printing
AM	Additive manufacturing
AMT	Additive manufacturing technologies
CAD	Computer-aided design
CAGR	Compound annual growth rate
EC	European Commission
ESIF	European Structural and Investment Funds
FoF	Factories of the Future
GDP	Gross Domestic Product
ICT	Information Communication Technology
KETs	Key enabling technologies
OEM	Original Equipment Manufacturer
PPP	Public private partnerships
RIS3	Smart specialisation strategy
RTDI	Research, technology. Development and innovation
VC	Value chain
WP	Work package

1. Introduction

This report document constitutes Deliverable D2.2 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 document is the result of the activities performed within task T2.2 “Synergies among EU regions: clusters & benchmark”, within the framework of work package 2 (WP2), titled “Mapping the AM landscape”.

The aim of Work Package 2 is to have an overall picture of the current situation of the AM field and community, with a view of the development of products and applications in lead markets. The specific objective of deliverable D2.2 is to update the information about regional strategies, competences and needs around Additive Manufacturing with the aim to have an overview of the European initiatives, ecosystem and the potential around these technologies. Results from this WP aim to support effort alignment, cross-fertilisation and potential new alliances in the field of AM.

1.1 A European policy framework to support industrial renewal

The transformation of global industry is a reality at every level – local, regional, national and European. We must embrace this transformation and make it work for both Europe’s industry and citizens. Tackling these challenges positively and seizing the opportunities generated by new technologies and environmental imperatives will ensure that industry in Europe is successful.

The development of Europe and the EU is based on industry. We have undergone industrial revolutions before and have come out stronger. This is happening now and, as before, with preparation and readiness to adapt, Europe’s industry and its citizens will emerge better off.”

Industry in Europe 2017 (European Commission)¹

The European Commission recognises the central importance of industry for creating jobs and growth. Industry is the backbone of the European economy, accounting for 80 % of Europe’s exports, for 80% of private research and innovation (R&I) and for providing over 50 million high-skilled jobs for citizens².

However, the recent economic crisis has led to the loss of some 3.5 million jobs since 2008 and a decline in manufacturing to 15 % of GDP, far behind the 20 % target of industry’s share by 2020, as set out by the Communication on “An integrated industrial policy for the globalisation era”^{3 4} a flagship initiative of the Europe 2020 strategy. Urgent reindustrialisation and modernisation of the European

¹ http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=9063

² See Commission President Jean-Claude Juncker’s introduction to Industry Day 2017

<http://ec.europa.eu/avservices/video/player.cfm?ref=I133697&videolang=INT&starttime=50&endtime=365&devurl=http://ec.europa.eu/avservices/video/player/config.cfm>

³ <http://ec.europa.eu/DocsRoom/documents/6313?locale=en>

⁴ <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52010DC0614&from=EN>

economy are therefore necessary to create new jobs. The European Commission has been allocating considerable financial resources to the development of the European industry. In fact, more than €740 bn in investment were mobilised through key programmes:

- **Juncker Investment Plan⁵**: Removing obstacles to investment, providing visibility and technical assistance to investment projects and making smarter use of financial resources. The plan is mobilising investments of at least €315 bn over three years.
- **Horizon 2020⁶**: The biggest ever EU research and innovation programme with nearly €80 bn of funding available from 2014 to 2020. Three pillars focusing on Excellence, Industry and Societal Challenges.
- **COSME⁷**: The EU programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises, running until 2020 with a budget of over €2 bn.
- **European Structural and Investment Funds (ESIF)⁸**: Five funds worth over €350 bn that each support economic development; The European regional development fund, the European Social Fund, the Cohesion fund, the European agricultural fund for rural development and the European maritime and fisheries fund.

Through H2020, the Commission intends to ensure that Europe produces world-class science, removes barriers and makes it easier for the public and private sectors to work together in delivering innovation, as well as Erasmus+ coverage of research. Also Public Private Partnerships (PPPs), such as Factories of the Future⁹, are of strategic importance for the European industry. The EC indicates that PPPs will leverage more than €6 bn public investments, with each euro of public funding expected to trigger additional investments to develop new technologies, products and services, aiming at consolidating the European industry as a leader on the global market.

These PPPs are based on roadmaps for RTDI activities which are the result of an open consultation process and have been positively evaluated by the European Commission with the help of independent experts. PPPs started being implemented through open calls under H2020, and the first Work Programme for 2014-15 allocated around €1.45 bn for eight PPPs, including Factories of the Future (FoF). The PPPs are expected to deliver the technologies needed for the new sustainable and competitive factories of the future. The FoF multi-annual roadmap for the years 2014-2020 sets a vision and outlines routes towards high added value manufacturing technologies for Factories of the Future, which will be clean, high performing, environmentally friendly and socially sustainable.. Another direct support to the development of the European industry is related to the identification of Key Enabling Technologies (KETs)¹⁰.

⁵ www.ec.europa.eu/invest-eu

⁶ www.ec.europa.eu/horizon2020

⁷ www.ec.europa.eu/cosme

⁸ www.ec.europa.eu/esif

⁹ http://ec.europa.eu/research/press/2013/pdf/ppp/fof_factsheet.pdf

¹⁰ https://ec.europa.eu/growth/industry/key-enabling-technologies_en

1.2 Key Enabling Technologies and Additive Manufacturing

As part of its strategy, the European Union mandated a High-Level Group (HLG) charged with the identification and selection of technologies that are expected to be decisive in tomorrow's economy. The focus was placed on horizontal technologies "enabling" multiple sectors, also called Key Enabling Technologies (KETs). The six KETs have the potential to increase the productivity and the energy efficiency of the industry, thereby leading to a competitive advantage and a cleaner European industry. These technologies are concerned with overcoming the so-called "Valley of Death" challenge, justifying public intervention. In the European context, the Valley of Death is mainly seen at the level of demonstration and close-to-market activities. Advanced Manufacturing Technologies (AMT) – which Additive Manufacturing (AM) is part of – are one of the KETs showing great potential. In order to foster the development and commercialisation of AMT, a Task Force was set up by the European Commission in 2013. Its emphasis was put on the challenges facing the commercialisation of AMT, including enabled products and the further deployment of this range of technologies. One of the most promising segments (with "particularly high growth" and a global market volume expected to reach \$11 bn in 2021) is 3D-printing, also perceived by many as the upcoming "New Industrial Revolution" leading to "high performance manufacturing". 3D-Printing in this context is usually called Additive Manufacturing, mainly referring to a set of dominant processes and their mobilisation in an industrial context.

Additive Manufacturing (AM) is defined as the "process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies". As for other manufacturing technologies, AM is concerned with its integration with other value chains because of its horizontal function in production processes. With multi-sectorial applications, it can enable the potential of industrial sectors to optimise their performance and the quality of their outputs. However, the AM landscape and European capabilities, in particular, appear to remain fragmented and missing links exist between the supply and demand sides. The application of AM technologies has, nonetheless been consolidating in different application areas such as in the medical, automotive and aerospace sectors, but many other application fields remain under-explored which may also include untapped AM potential.

According to Wohlers Report 2016¹¹, the AM industry grew by 25.9 % (compound annual growth rate - CAGR) reaching \$5.165 bn in 2015. This is in comparison with the CAGR for the previous three years on 33.8 %, and the CAGR for the industry over the past 27 years registering a score of 26.2 %. The AM industry is growing by more than \$1 bn for the second consecutive year. As AM is based on Computer-Assisted Design (CAD), one of the key drivers of this growth relates to the development of ICT and the digitisation of industry and related services. The recent "Path to digitise European industry¹²", elaborated by the European Commission, points in this direction. The EC plans to set up a European cloud that, as a first objective, will grant Europe's 1.7 million researchers and 70 million science and technology professionals a virtual environment to store, manage, analyse and re-use large amounts of research data. In addition, the EC will invest €500 million in a pan-EU network of digital

¹¹ Wohlers Report 2016 – Annual Worldwide Progress Report" – Terry Wohlers, Tim Caffrey, Ian Campbell, Wohlers Associates, Inc

¹² http://europa.eu/rapid/press-release_IP-16-1407_en.htm

innovation hubs (centres of excellence in technology). In these hubs, businesses can receive advice, test digital innovations and set up large-scale pilot production projects to strengthen internet of things, advanced manufacturing and technologies. The objective would be to address the fragmentation of European markets in order to “reap the benefits of digital evolutions such as the ‘Internet of Things’”. Digital transformation allows and enhances the smart integration of services and products.

2. Mapping EU regional capabilities in the area of AM

Regions, the managing authorities of the EU’s main investment tool, the European Structural and Investment Fund (ESIF) accounting for €454 bn for 2014-2020, can support the leverage for economic growth and jobs in key sectors of Europe. Priorities for spending this budget are identified with the support of Smart Specialisation Strategies¹³ (referred to as either RIS3 or S3), and can serve as a compass for strategic investment in research and innovation if prepared in dialogue with the regional quadruple helix. The ESIF can be used for the development of demand driven innovations, provide regional infrastructures and support test beds and living labs for the SMEs, RTOs and industry.

Obtaining regional data on Additive Manufacturing is not easy, however this core chapter will focus on three data inputs to give an overview of trends, main findings and conclusions of the current situation in 2017:

- EC report on Report on 3D-printing (June 2016);
- Industrial Modernisation Platform regions identified as interested in Additive Manufacturing – set up in 2016;
- Vanguard Initiative Report.

These three sources can be combined with the previous “FOFAM” H2020 Project study on regional capabilities which can be found on the FOFAM Project website.¹⁴

The level of detail of the three studies goes from a more general identification of the regions most interested in additive manufacturing to a detailed study of the 3D Printing Pilot under the Vanguard Initiative.

2.1 EC Report on 3D printing

The EC Report on “3D Printing: *current and future application areas, existing value chains and missing competences in the EU*”¹⁵ (June 2016) highlighted the need for collaboration between regions with AM technologies in order to develop effective value chains and thereby critical mass as regional AM supply capabilities present a fragmented landscape. It is clear from the quantitative analyses that Europe is facing strong competition from global players, primarily from the United States and Japan. Nevertheless, Europe still holds a strong position in terms of patenting, and some AM service

¹³ <http://s3platform.jrc.ec.europa.eu/>

¹⁴ http://www.fofamproject.eu/images/FoFAM_D2.2_Regional_capabilities.pdf

¹⁵ http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8937

providers, including some large multinational firms perform well in European specialisation areas such as aeronautics and electronics. Healthcare, energy and materials also fall under the scope. These players are mainly located in Western Europe. A number of leading European countries holding a global lead in specific areas are observed, including **Germany, the UK, the Netherlands, France, Belgium, Italy, Spain and Sweden**. The case studies show, however, that the regional repartition of current AM capabilities vary from one application area to another, mainly due to the differences observed in regional specialisation profiles.

Among the key players, German RTOs and Printer Manufacturers occupy a central position. This is particularly the case in the field of metal AM, which is seen as a main strength of the European economy. They are followed by large RTOs and well-performing service providers who plug into different value chains to develop thematic capabilities. Large multinational firms active in digital solutions, new materials, electronic devices, etc. are also part of the technology developers as they seek to develop internal capabilities that will allow them to innovate and derive value from a differentiating technology. Aerospace and healthcare seem to be on the forefront of public support at the European level.

However, publicly supported research and development also address areas such as sector-related AM applications (in the automotive field for instance) or the use of materials such as ceramics or biomaterials in AM processes. Cross-cutting issues are also being investigated, such as the combination of additive and subtractive forms of manufacturing. From a technical point of view, most research seems to be directed towards Selective Laser Melting and biomedical applications. For instance, a bibliometric analysis show that the main topics being researched in Europe relate to “Biomedical Implants with Electron Beam Melting and Selective Laser Melting”, “Mandibular Reconstruction Surgical Planning” and “Selective Laser Melting”. Subsequent analyses show that key players, including leading printer manufacturers and large multinational companies, are indeed active in Europe in these segments.

The application-driven case studies show that the AM sector is still getting off the ground and shaping up around key application areas. It is driven by factors such as materials or technologies used and management cultures, and these can vary from an application area to another. Although AM players (companies providing services, systems, and materials for AM) are very often active in different areas, the landscape of AM capabilities in the industry remains fragmented with varying levels of use (when comparing small mould making companies compared to large integrators). It is particularly fragmented in areas where links are directly established between AM players and end-users (customers), such as in food printing or in the decoration field, where consumer participation is of main importance to the value chain.

Some concentration effects can, however be observed. The AM software segment, for instance, is clearly dominated by a few strong players from **Flanders, Ile-de-France** and other Western regions, as well as some non-EU players also active in the EU. A similar pattern can be observed regarding AM powders.

- **German Lander – In the forefront**

Western European countries are clearly on the forefront of AM developments. Large German

landers, such as **Bavaria, Baden-Wurtemberg but also North Rhine-Westphalia** are beyond any doubt the regional systems where most AM capabilities and AM systems are concentrated. EOS, Concept Laser, SLM Solutions, Trumpf, VoxelJet and ExOne are leading companies in this domain. They cooperate with leading RTOS and companies from Germany (LZN and the Universities of Aachen and Düsseldorf as well as Fraunhofer, etc.) and the Netherlands (TNO).

- **French, UK and Italian regions – Follower regions**

They are followed by French regions such as **Ile-de-France** and **Rhône-Alpes**, where PEP, Fives, Gorgé, Phenix, etc. are active, as well as the **United Kingdom** where key players such as Renishaw and LPW lead the market. Italy is also developing capabilities, mainly in the Northern Regions of **Piemonte, Lombardy** and **Emilia-Romagna**, where large industrial players are willing to investigate AM in the fields of automotive and aerospace but also in packaging.

- **Northern Europe – Developing**

Northern Europe, including **Sweden**, but also **Finland** and to a more limited extent **Norway**, are also strongly developing capabilities in specific AM areas. For instance, in Sweden machine tool and automotive industries are current [and potential] customers of AM products and services.

- **Belgium, Austria and Spain – Key players**

Key players could also be identified in the Netherlands, in **South Netherlands**, for instance, in Belgium, **Flanders**, Austria, **Upper Austria** and Spain, **Asturias**. Belgium, with Materialise, Layerwise, and Melotte in **Flanders**, are among the Western European countries that draw on a strong knowledge base. New players in the field of food AM are also developing in **Cataluña** in a less common technological segment, one of meal printing.

- **Poland and Central and Eastern Europe – Discovery stage**

Although **Poland** is more advanced, countries such as **Slovenia, Croatia, Slovakia**, and the **Czech Republic** are only beginning to develop capabilities in the research sector. Investments are being made by manufacturers of printers to enter Eastern European markets but the state of play remains at a very early stage.

Fragmentation can be reduced by collaboration

The report notes that, while taking into account the fragmentation of the European AM landscape, there is a trend in that the concentration in particular Western European regions relates to a form of specialisation in specific supply or demand areas underlying the AM value chains analysed in this study. Whether these value chains are subject to missing or under-developed capabilities or not, the absence of a balance between Western and Eastern European regions remains clear.

Collaborations can take place between specific actors acting in a same (regional) ecosystem as observed in the field of AM for injection moulding, or across/along European value chain segments such as observed in the case of the collaborative projects and platforms linking the automotive and aerospace AM value chains. The levels of AM regional specialisation and related fragmentation in Europe, particularly calls for international and cross-regional collaboration.

Such collaboration (each being value chain-specific) could link Western and European regions

and the supply and demand in an open innovative manner. Communication, collaboration, exchange of experiences between the different actors (material providers, service providers and users such as hospitals or surgeons) is key. The same goes for universities and businesses. Especially at the level of materials, the very detailed and focused approach of material research is indicated as useful for the companies to further develop applications such as in healthcare.

Other collaboration opportunities could appear between the car interior value chain and the textile value chain through upholstery. International collaboration could take place between research centres and OEMs on this topic. Collaborations with other value chains could also take place on the basis of either the materials or the systems mobilised by the sector (plastics, composites, powder bed systems). Another example is in metallic structural parts for aircraft, where collaboration could take place across value chains on the topic of large metallic structural parts, and between the aeronautic, automotive, defence and space value chains.

Such collaborations could be organized at the EU level, and link key OEMs and integrators, but also 3DP service and printer providers active in those value chains across regions and along the value chain. Collaboration opportunities are also found in the areas of smaller structural, and non-critical, components across the aforementioned value chains, which could take place at EU level and involve similar players. Platforms, networks, projects and other collaborative settings would be appropriate to foster such collaboration, as already being carried out under H2020.

Collaboration across regions could also make the link between this value chain and other value chains by connecting demonstration and testing facilities across regions, such as also seen in the transportation and energy fields where common constraints apply.

2.2 Industrial Modernisation Platform

As an ex-ante conditionality for regions to obtain European Structural and Investment Funds in the period 2014-2020, all regions or countries had to prepare a smart specialisation strategy.¹⁶ As regions reported their smart specialisation strategies to the Smart Specialisation Platform in Seville¹⁷, these were mapped on to a European regional map identifying regions with similar sectoral interests. Although the map lacks granularity, it made it possible to identify smart specialisation sectors and thus for regions to identify regions with similar priorities (see eye@ris).¹⁸ Currently, there are more than 120 operational Smart Specialisation strategies with a budget of over €41 bn supporting regional ecosystems and the creation of new value chains.¹⁹

The implementation of smart specialisation strategies is often linked to relevant regional clusters as they are the means of actions on the ground. Hence, smart specialisation has raised the profile of current cluster policy at the EU level. One of the recent policy areas has been the European

¹⁶ http://ec.europa.eu/regional_policy/sources/docgener/informat/2014/smart_specialisation_en.pdf

¹⁷ <http://s3platform.jrc.ec.europa.eu/home>

¹⁸ <http://s3platform.jrc.ec.europa.eu/eye-ris3>

¹⁹ http://fofampproject.eu/images/D4.3_final_roadmap_FINAL.pdf

Strategic Cluster Partnerships for smart specialisation investment²⁰. The overall aim is to strengthen both industry participation and a European dimension in the implementation of national and regional smart specialisation strategies. The specific objective of the partnerships is to set up a partnering process for strategic inter-regional collaboration, through which, especially SMEs and other innovation actors in the clusters, can receive support in finding partners with complementary competences, accessing value chains that cut across national, regional and sectoral boundaries as well as facilitate their access to technology centres such as KETs infrastructures and digital innovation hubs.

Moreover, of the 121 national and regional S3 strategies, three Strategic Thematic Platforms have been set up based on the most identified smart specialisation sectors, which are energy, industrial modernisation (including KETS) and agri-food.²¹

The Smart Specialisation Platform for Industrial Modernisation (S3P-Industry)²² aims at supporting EU regions committed to generating a pipeline of industrial investment projects following a bottom-up approach, through implementation through interregional cooperation, cluster participation and industry involvement. The key objective of this Platform (S3P-Industrial Modernisation) will be to provide a platform for and support the efforts of EU regions committed to work together in developing a pipeline of investment projects connected to their RIS3 priority areas related to industrial modernisation. The S3P-Industrial Modernisation is co-developed and co-led by the regions themselves, hence ensuring an active participation and commitment of the so-called quadruple helix actors, i.e. industry and related business organisations such as clusters, as well as research institutions, academia and civil society.

The Commission will mobilise a wide range of advice and support services to offer continuous support to the interregional partnerships to make this approach a real success, to the benefit of all EU regions and their stakeholders. See Figure 1 below.

²⁰ <https://www.clustercollaboration.eu/open-calls/towards-european-strategic-cluster-partnerships-smart-specialisation>

²¹ <http://s3platform.jrc.ec.europa.eu/s3-thematic-platforms>

²² <http://s3platform.jrc.ec.europa.eu/industrial-modernisation>

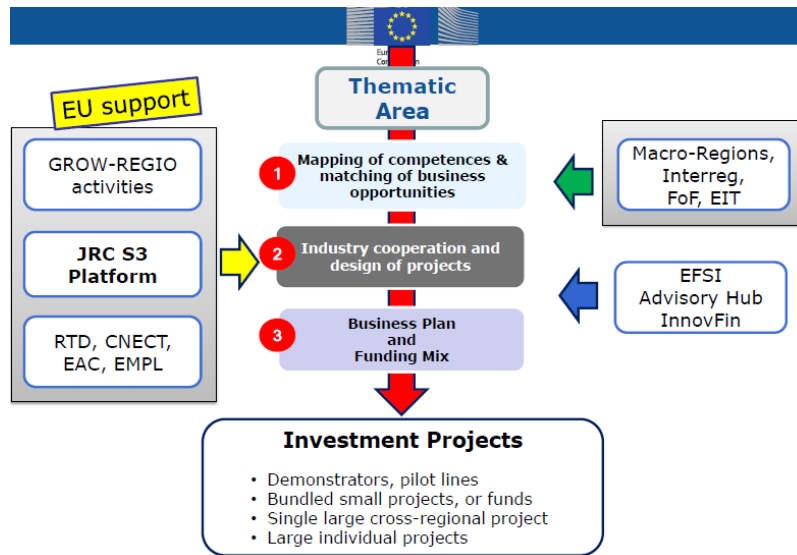


Fig.1: Overview of the Industrial Modernisation Thematic Platform



Fig.2: First Steering Committee in March 2017

The first Steering Committee meeting of the Smart Specialisation Platform for Industrial Modernisation took place on 17th March 2017 and gathered 16 EU lead regions as well as Commission services and the Committee of the Regions to discuss the way forward for strategic inter-regional collaboration. The 16 lead regions, representing 51 participant regions across the EU, have developed the following thematic areas so far:

- advanced manufacturing for energy applications,
- bio-economy,
- efficient and sustainable manufacturing,
- **3D printing**
- Medical technology
- industry 4.0
- innovative textiles
- nano-enabled products and

- production performance monitoring systems
- sports

At the meeting, several Commission services and the Committee of the Regions presented their support activities. The lead regions presented the state of play of their partnerships and outlined their specific needs for support to be able to generate investment projects on shared smart specialisation areas to foster industrial modernisation.

The work to be performed together by the regions, industrial partners and business intermediaries on the thematic areas mentioned above, facilitated and supported by EU activities, can be carried out in three different phases²³:

-Phase 1 – Mapping of competences and matching of business opportunities: *Specific activities are undertaken such as mapping of existing and missing competences, identifying concrete opportunities for cooperation between regions and their stakeholders.*

-Phase 2 – Industrial cooperation and design of concrete investment projects: *Regions and member states work together with their stakeholders to identify and design concrete investment projects*

-Phase 3 - Business Plan and Funding mix: *Industrial stakeholders supported by their regional authorities and EU support actions should develop a business plan and explore funding opportunities for financing their projects, looking at synergies among various funding sources*

The different regional partnerships established under the Platform will benefit from a number of EU support actions along each of the three phases. These actions are listed at Fig.3 below.

²³ <http://s3platform.jrc.ec.europa.eu/how-does-it-work>

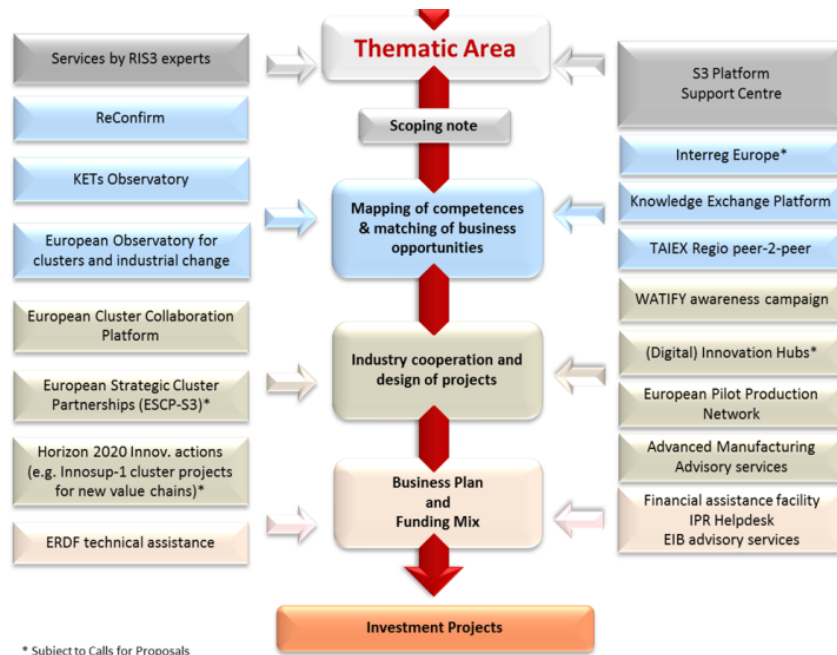


Fig.3: Direct EU support actions for the regional partnerships²⁴

The **3D printing area** of the Platform concerns the implementation of synergies in new 3DP value chains across regions based on smart specialisations of the regions. The key objective is to identify opportunities for joint-demonstration between regions, which will be based on a thorough mapping exercise and detection of complementarities between existing demonstration facilities and company needs. The proposed area, which is one of Vanguard Initiative's Pilot Projects, targets the accelerated deployment of new 3DP applications. The focus lies on applications at post-prototyping level (> TRL5).

2.3. Vanguard Initiative: 3D Pilot²⁵

The following section, provides a detailed overview of regional strengths through an in-depth analysis of the 3D Printing Pilot under the Vanguard Initiative. More specifically, it shows information on the distribution of value chain positions in which these actors are situated across ten selected regions (Fig.4). It also provides graphics on the sectoral distribution of these actors across regions and the distribution of materials and technologies used by these players. Moreover, in the annex, eight case studies of current projects in the health, hybrid materials, creative industries, machine tooling, smart bikes, 2D textiles and metal products under the Vanguard Initiative are presented and give more in-depth analysis of current regional collaboration.

²⁴ <http://s3platform.jrc.ec.europa.eu/eu-support>

²⁵ <http://s3vanguardinitiative.eu/cooperations/high-performance-production-through-3d-printing>



The Vanguard 3DP Pilot Initiative (VI) was established in January 2014 with the political commitment of EU regions to engage in growth-oriented collaborations based on combined strengths linked to EU priorities. These regions are committed to applying Smart Specialisation principles and priorities to support EU ambitions in the areas of Innovation and Industrial Policy.

The Vanguard 3DP Pilot Initiative launched five Pilot Actions, amongst which one focused on “High Performance Production through 3D Printing” in June 2014. The ultimate objective of this pilot platform is the construction of a network of industry-led demonstrators across regions in Europe to enhance the uptake of solutions provided by 3D-printing technologies in international value chains. The pilot platform was set-up to contribute to the European agenda for growth and jobs. A bottom-up approach based on the role of regions, clusters and smart specialisation in innovation and industrial renewal is key in the Vanguard 3DP Pilot Initiative approach.

Within this pilot a mapping survey has been performed which aimed at obtaining an overview of the presence of relevant actors across regions, and to learn about the precise ambitions and expectations of the regions with respect to 3D-Printing. This survey has been filled in by regional experts, resulting in a very detailed mapping that contains a wealth of information about the actors present in each region. This survey was the first step in mapping ‘capabilities’ in the participating regions. The ultimate aim of the exercise was to identify synergies and pilot projects for networked demonstrators between regions. A first questionnaire was completed by fifteen regions in the end of 2014. However, more recently other regions also stepped into the Vanguard 3DP Pilot Initiative and an additional survey was sent to these regions, such that there is now information on 19 regions.

In the process of Vanguard, the detailed analysis of the survey is only a first starting point to begin detecting potential synergies between regions. It has to be complemented by multilateral interactions between regions and regional experts. Based on this survey to identify synergies and complementarities across regions, there is now a good overview of the main actors present in the region as well as the available demonstration infrastructure.

For each actor in the regions of the Vanguard 3DP Pilot Initiative, information was collected on four key dimensions:

- The main 3DP application domains in which the region is active
- Its position in the value chain
- The main technologies it employs
- The main material classes it uses

The mapping exercise resulted in a database of close to 1000 actors, including technology facilities, research and technology organizations, relevant clusters and associations and companies, with approx. 650 private companies. Overall, 20 % to 25 % of companies reported are large companies, almost 80 % are micro-, small- to medium-sized companies, whereas small and micro-enterprises represent the bulk of companies with more than 60%.

The database, however, has to be cautiously interpreted as it is not exhaustive. Moreover, for several regions the survey was not filled in sufficiently to be representative. Accordingly, this report only takes the top 10 regions into account in terms of number observations of 3D printing actors, specifically regions that report at least 25 regional actors (fig. 4). The large majority of these regions are innovation leaders and industrially well-advanced. This will still provide an interesting starting point to understand regional specialisation and interests.

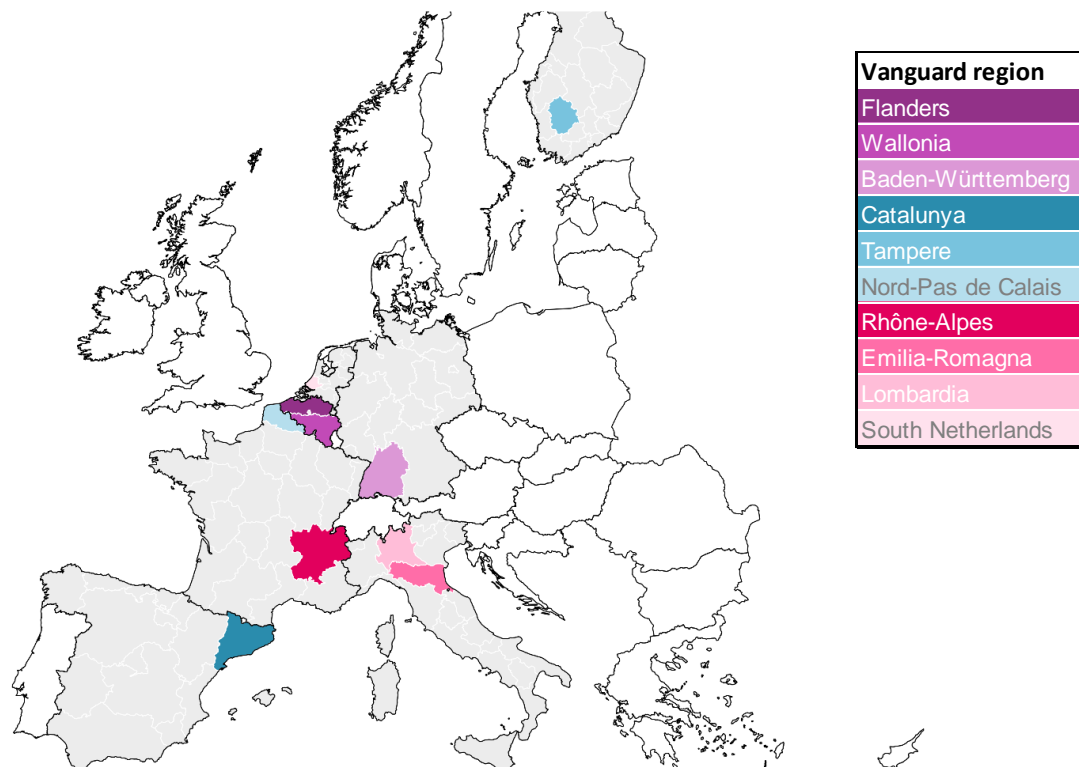


Fig. 4: The geographical coverage of the 10 regions of the Vanguard 3DP Pilot Initiative selected for this study.

Furthermore, it is important to bear in mind that the figures calculated are based on numbers of actors, without any 'weighting'. Accordingly, a small SME with 20 employees has the same weight as a large 100 employee company and all types of research centres have the same weight. Similarly, a one person cluster bears the same weight as a large company. In other words, the size of the actors is not taken into account in the analysis.

Another important remark is that one actor e.g. a company, a research centre, a service provider, can be active in more than one segment of the regional value chain, hence, in our data, slightly more than 20 % of the companies are active in two segments. A player can also be present in multiple application sectors, different technologies and can make use of multiple materials in their processes. As a result, an actor is often 'counted' multiple times in the analysis.

In order to compensate for these aspects, the data were normalised across the dominant axis of interest. In the case of the regions, the activities across the value chain, industry sectors, technology and materials were normalised across a given region. In the case of the enterprise size, the values were normalised across the various segments of the value chain. This approach allows for the concentration of activities to be obtained and compared. Similarly, the share of activities can be averaged across regions and presented to show where the average activities lie in the given Vanguard regions.

2.3.1 Value Chain Position

For the collection of data in Vanguard, especially for the survey, typologies for the value chain, sectors and 3DP technologies and materials were produced in close consultation with regional experts, such that all information gathered would be comparable while allowing for easy processing of the survey results. This resulted in the following value chain depiction for 3DP applications, as depicted in **Error! No se encuentra el origen de la referencia.** Figure 5. In this value chain, machines & modification, materials and design for AM feed into the process, which feeds into the post-process. At the front of the value chain you find leading edge application of 3DP. ICT & factory integration run parallel to the entire value chain and are integral for all parts.

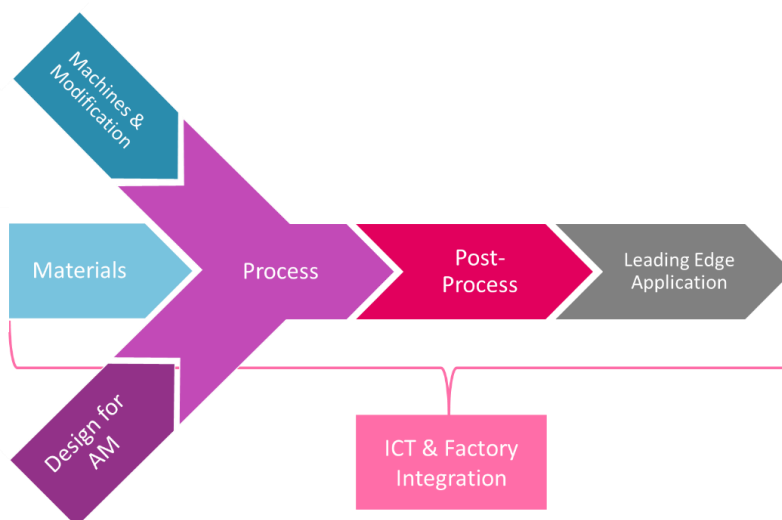


Fig. 5: 3DP value chain with segments (source: Sirris, stylised by Idea Consult).

The actors have indicated the segments in which they are active and it appears that most of the actors are active in more than one segment of the value chain. Therefore in Table 1a the percentage represents a concentration of activity in a particular segment of the value chain for a given region.

In the decentralised production that 3DP offers, the expectation would be that each region more or less has all segments of the value chain within its borders. However, this is far from being the case. Rather, there is a wide variation in the concentration of the activities in the segments of the value chain between regions. Furthermore, not all segments of the value chain are present in each region.

The activity of the actors in the Vanguard regions shown in part a) of the table is mostly found in the process segment of the value chain with 33 % on average. This is followed by machines and modification with 16 %, materials and design for AM both with 13 %, closely followed by leading edge application with 12 % on average. The post process does not seem to obtain the central attention of regions with an average of 8%. The data collected on ICT and factory integration and notably incomplete, however, the information for this segment of the value chain shows on average 5%. The distribution of enterprises along the segments of the value chain was also collected to obtain information on the size of the actors. The four depicted sizes are classified as follows: large: >250 employees and > € 50 million in turnover, medium: < 250 employees with ≤ € 50 million in turnover, small: < 50 employees with ≤ € 10 million in turnover and micro enterprises with < 10 employees and ≤ € 2 million in turnover. It is clearly apparent that on average 40 % of all actors are small, and on average 63 % of actors across all segments are small or micro sized enterprises.

From the activities across the segments 33 % of activity occurs in AM process, and from this table we see that 40 % of the actors are small enterprises and 27 % are micro enterprises in this segment. Overall, small and micro enterprises appear to be relatively concentrated in machines & modification, design for AM and post-process segments of the value chain. Meanwhile medium-sized and large enterprises appear to be relatively concentrated in materials, ICT and factory integration and leading edge applications.

Table 1: Position activity and actor size along the VC for Vanguard 3DP Pilot Initiative. Table a) depicts the activity of the actors in a given region in a certain VC segment. Table b) depicts the size of the actors along the VC segments (SOURCE: IDEA CONSULT BASED ON VANGUARD DATA.)

a)

			Value Chain Position							
			Machines & Modification	Materials	Design for AM	Process	Post-process	ICT & Factory Integration	Leading Edge Application	Total
Vanguard Region	Flanders	BE	16%	14%	5%	21%	2%	10%	33%	100%
	Wallonia	BE	10%	21%	14%	33%	2%	1%	19%	100%
	Baden-Württemberg	DE	21%	14%	7%	31%	14%	0%	14%	100%
	Catalunya	ES	13%	15%	26%	20%	11%	2%	13%	100%
	Tampere	FI	13%	7%	25%	41%	8%	7%	0%	100%
	Nord-Pas de Calais	FR	27%	13%	14%	29%	13%	0%	3%	100%
	Rhône-Alpes	FR	15%	15%	12%	37%	9%	6%	6%	100%
	Emilia-Romagna	IT	13%	3%	3%	74%	0%	6%	0%	100%
	Lombardia	IT	12%	21%	15%	24%	5%	8%	15%	100%
	South Netherlands	NL	18%	12%	9%	18%	15%	12%	18%	100%
	Average		16%	13%	13%	33%	8%	5%	12%	100%

b)

											Average
Actor size	Large enterprise		17%	33%	13%	21%	13%	32%	31%		23%
	Medium enterprise		11%	19%	9%	12%	13%	26%	28%		17%
	Small enterprise		42%	37%	47%	40%	50%	26%	33%		39%
	Micro enterprise		30%	11%	31%	27%	24%	16%	8%		21%
	Total		100%	100%	100%	100%	100%	100%	100%	100%	100%

Vanguard Region	Machines & Modification	Vanguard Region	Materials
Nord-Pas de Calais	27%	Lombardia	21%
Baden-Württemberg	21%	Wallonia	21%
South Netherlands	18%	Rhône-Alpes	15%
Flanders	16%	Catalunya	15%
Rhône-Alpes	15%	Flanders	14%
Tampere	13%	Baden-Württemberg	14%
Catalunya	13%	Nord-Pas de Calais	13%
Emilia-Romagna	13%	South Netherlands	12%
Lombardia	12%	Tampere	7%
Wallonia	10%	Emilia-Romagna	3%

Vanguard Region	Design for AM	Vanguard Region	Process
Catalunya	26%	Emilia-Romagna	74%
Tampere	25%	Tampere	41%
Lombardia	15%	Rhône-Alpes	37%
Wallonia	14%	Wallonia	33%
Nord-Pas de Calais	14%	Baden-Württemberg	31%
Rhône-Alpes	12%	Nord-Pas de Calais	29%
South Netherlands	9%	Lombardia	24%
Baden-Württemberg	7%	Flanders	21%
Flanders	5%	Catalunya	20%
Emilia-Romagna	3%	South Netherlands	18%

Vanguard Region	Post-process	Vanguard Region	ICT & Factory Integration
South Netherlands	15%	South Netherlands	12%
Baden-Württemberg	14%	Flanders	10%
Nord-Pas de Calais	13%	Lombardia	8%
Catalunya	11%	Tampere	7%
Rhône-Alpes	9%	Emilia-Romagna	6%
Tampere	8%	Rhône-Alpes	6%
Lombardia	5%	Catalunya	2%
Wallonia	2%	Wallonia	1%
Flanders	2%	Baden-Württemberg	0%
Emilia-Romagna	0%	Nord-Pas de Calais	0%

Vanguard Region	Leading Edge Application
Flanders	33%
Wallonia	19%
South Netherlands	18%
Lombardia	15%
Baden-Württemberg	14%
Catalunya	13%
Rhône-Alpes	6%
Nord-Pas de Calais	3%
Tampere	0%
Emilia-Romagna	0%

Fig. 6: Value chain segments key players visible through ranked Vanguard regions.

The set of tables depicted in Figure 6 each correspond to a segment of the value chain. For each table the Vanguard regions are ranked according to their relative activity in this segment of the value chain.

Specific regions are heavily concentrated in one segment of the value chain which can be seen, for example in the case of Emilia-Romagna being heavily skewed towards the process segment. This means that for the other segments of the value chain which the process is connected with, the Emilia-Romagna region relies on inputs from and outputs to other regions.

Regional ecosystems are relatively well populated in some segments and less in other segments, e.g. Wallonia concentrates activities in its 3DP ecosystem on materials, design and process, while it has relatively less activities, capability and probably actors in machines, post-processing and ICT integration. Indeed, Wallonia as a region is a part of a geographical trio in 3DP and Vanguard, namely, Flanders, Wallonia and South Netherland. Due to their geographic situation, these regions are able to cross-collaborate throughout the value chain. From the tables, it is apparent that Flanders is nearly a mirror to Wallonia in the value chain with higher activity in machines and modification, ICT & factory integration and leading edge application but with lower activity in the design for AM, process and post-process segments. The third part of the trio, South Netherland, is the sole leader on post-process, sharing a leading role with Flanders in machines and modification and ICT and factor integration, while nearly inactive in the materials, design for AM and process segments. Overall the regions are less than 150 km apart, therefore the sharing of the value chain is easily achieved.

Catalunya and Lombardia are two well established 3DP regions showing rather similar distributions of their value chain segments in their respective regions. Moreover, they are exemplary in their relatively evened out distribution across all value chain segments. The fact that both regions are often moving together indicates the potential for synergies and collaboration on several segments of the value chains as well as joint learning opportunities. Indeed, they have relatively comparable shares for machines and modification application with 13 % and 12 % respectively, as well as post-process, ICT & factory integration and leading edge. Lombardia leads the materials segment with 21 %, with Catalunya not far behind with just 15 % of its own value chain activities. Switching roles, Catalunya leads in activities on design for AM, followed closely by Tampere and Lombardia. In the process segment, Catalunya and Lombardia represent some of the more balanced value chain segment distributions, not concentrating on process, but rather having moderate shares across the spectrum.

2.3.2. Technology and Materials

The overall technology and material use in 3DP, as defined within the information collection of the Vanguard 3DP Pilot Initiative, was classified into the following. Technologies include: (i) VAT photo polymerisation, (ii) material jetting, (iii) binder jetting, (iv) powder bed fusion, (v) material extrusion, (vi) direct energy deposition, (vii) sheet lamination and (viii) other. Materials include: (i) polymer thermoset, (ii) polymer thermoplastic, (iii) ferrous metals, (iv) non-ferrous metals, (v) precious metals, (vi) industrial ceramics, (vii) structural ceramics, (viii) bio-materials and (ix) other.

The results of the information collected on technologies are presented in Table 2

(complemented with more regions from FoFAM project at table 3). Responses of indicate that some actors actively use several technologies, therefore the percentages depict the activity in the technologies per Vanguard region. What can be seen is that of the eight technologies indicated, 67% arise from three technologies, namely powder bed fusion, material extrusion and VAT photo polymerisation.

In the regional dimension, there seem to be three main strategies on the selection of technologies. Firstly, as with Emilia-Romagna and Nord-Pas de Calais, there is a strong specialisation in a singular technology within the core of the actors. Alternatively, a general scattering of technologies applied can be seen, for example in Catalunya, Lombardia and Rhône-Alpes. Finally, there is selective specialisation in a few key technologies. The latter appears to be the preferred methodology of Flanders, Wallonia, Baden-Württemberg, Tampere and South Netherlands.

Similarly, for the materials, actors indicate the use of several different materials in their AM applications, therefore the activity is measured as a normalised percentage across a given Vanguard region and presented in Table 4 (table 5 with FoFAM's). As with the technologies, most of the capabilities in materials use lie within a selection of the total spectrum. Specifically, activities lie in the use of plastic and metal materials, with roughly 80% of AM in Vanguard regions being focused on polymer thermoset, polymer thermoplastic, ferrous metals and non-ferrous metals. The use of precious metals, various ceramics and bio materials are all drastically lower.

Key players in the use of precious metals include, based on the share of overall activity, South Netherlands, Emilia-Romagna and Flanders. However, this information shows only the share of the use of that material by actors in the regions, and does not take into consideration the size or significance of those actors. It is known that Rhône-Alpes is a key player in the use of precious metals through key aerospace players such as Airbus, this information is however lost in such a survey.

Overall, it seems that the region of South Netherlands is again coupled with the regions of Wallonia and Flanders, where South Netherlands focuses on the use of less-frequented materials such as the precious metals and the ceramics. Flanders and Wallonia, however, show that they are in-tune in their similar shares of the use of the top four materials across all regions, including polymer thermoset, polymer thermoplastic, ferrous metals and non-ferrous metals.

Table 2: Distribution of technologies used in AM across Vanguard regions SOURCE: IDEA CONSULT BASED ON VANGUARD DATA.

			Technology								Total
			VAT Photo polymerisation	Material Jetting	Binder Jetting	Powder bed fusion	Material extrusion	Direct Energy Deposition	Sheet Lamination	Other	
Vanguard Region	Flanders	BE	20%	4%	8%	41%	22%	4%	2%	0%	100%
	Wallonia	BE	14%	22%	4%	41%	10%	10%	0%	0%	100%
	Baden-Württemberg	DE	38%	8%	0%	38%	15%	0%	0%	0%	100%
	Catalunya	ES	14%	23%	3%	18%	36%	2%	2%	4%	100%
	Tampere	FI	5%	5%	3%	23%	55%	10%	0%	0%	100%
	Nord-Pas de Calais	FR	0%	0%	0%	0%	0%	0%	0%	100%	100%
	Rhône-Alpes	FR	15%	14%	11%	24%	32%	2%	1%	1%	100%
	Emilia-Romagna	IT	6%	3%	3%	13%	69%	6%	0%	0%	100%
	Lombardia	IT	14%	18%	5%	14%	29%	8%	5%	9%	100%
	South Netherlands	NL	25%	25%	0%	25%	13%	0%	0%	13%	100%
Average			15%	12%	4%	24%	28%	4%	1%	13%	100%

Table 3: Technologies used according to region, resulting from FoFAM data

			AM Regional expertise								Total
			Powder bed fusion	Vat photopolymerization	Material jetting	Material extrusion	Sheet lamination	Direct energy deposition	Binder Jetting	All AM processes	
Region	Flanders	BE	x	x	x	x		x	x		6
	Wallonia	BE	x	x	x	x		x	x		6
	South Moravia	CZ	x	x	x				x		4
	Aragon	ES	x			x					2
	Asturias	ES	x	x			x		x		4
	Basque Country	ES									0
	Cataluna	ES								Forming & forging of metal, components and structure, aerostructures, maintenance and repair operations including composites. Machinery and industrial systems and components for manufacturing processes.	1
	Comunidad Valencia	ES	x	x	x	x	x	x	x	x	8
	Navarra	ES								Functional print	1
	Champagne Ardennes	FR	x					Being acquired			2
	Limousin	FR	x					x		Functional print	3
	Nord-Pas De Calais	FR									0
	Pays de Loire	FR	x		x				x		3
	Rhône Alpes	FR	x	x	x	x		x		x	6
	Emilia-Romagna	IT	x		x	x					3
	Lombardy	IT	x	x	x	x					4
	East Netherlands	NL	x	x	x	x	x		x		6
	North Netherlands	NL	x	x	x						3
	South Netherlands	NL	x	x	x	x	x	x	x	x	8
	West Netherlands	NL	x	x		x					3
	Norte Region	PT	x	x	x	x	x	x	x		7
	Örebro	SE	x					x		CT for quality and verification	3
	Birmingham City Council	UK	x		x	x					3
	Wales	UK	x								1
Total			20	12	13	12	5	9	9		7

Table 4: Distribution of materials used in AM across Vanguard regions SOURCE: IDEA CONSULT BASED ON VANGUARD DATA.

			Materials									Total
			Polymer thermoset	Polymer Thermoplastic	Ferrous metals	Non ferrous metals	Precious metals	Industrial Ceramics	Structural Ceramics	Bio-materials	Other	
Vanguard Region	Flanders	BE	16%	38%	18%	20%	5%	2%	0%	0%	2%	100%
	Wallonia	BE	13%	33%	13%	25%	2%	7%	3%	0%	3%	100%
	Baden-Württemberg	DE	50%	10%	20%	0%	0%	10%	0%	0%	10%	100%
	Catalunya	ES	28%	44%	8%	8%	1%	3%	2%	0%	8%	100%
	Tampere	FI	12%	51%	14%	14%	0%	7%	2%	0%	0%	100%
	Nord-Pas de Calais	FR	33%	33%	0%	0%	0%	0%	0%	0%	33%	100%
	Rhône-Alpes	FR	17%	33%	19%	19%	2%	3%	6%	1%	1%	100%
	Emilia-Romagna	IT	11%	57%	6%	11%	6%	3%	0%	0%	6%	100%
	Lombardia	IT	23%	27%	17%	10%	4%	1%	4%	0%	13%	100%
	South Netherlands	NL	6%	6%	22%	22%	11%	22%	11%	0%	0%	100%
	Average		21%	33%	14%	13%	3%	6%	3%	0%	8%	100%

Table 5: The materials used per region, based on FoFAM data

			AM Material							Total
			Metal	Polymer	Ceramic	Food	Bio-materials	General materials	Other	
Region	Flanders	BE	x	x	x		x	x		5
	Wallonia	BE	x	x	x					3
	South Moravia	CZ	x	x						2
	Aragon	ES	x	x	x		x			4
	Asturias	ES	x	x			x			3
	Basque Country	ES								0
	Cataluna	ES	x	x		x		x		4
	Comunidad Valencia	ES	x	x	x			x		4
	Navarra	ES							Functional print	1
	Champagne Ardennes	FR	x				x			2
	Limousin	FR			x		x			2
	Nord-Pas De Calais	FR		x	x		x			3
	Pays de Loire	FR	x	x						2
	Rhône Alpes	FR	x	x	x			x		4
	Emilia-Romagna	IT	x	x		x	x			4
	Lombardy	IT	x	x				x		3
	East Netherlands	NL	x	x			x			3
	North Netherlands	NL	x	x						2
	South Netherlands	NL	x	x	x	x	x	x		6
	West Netherlands	NL	x	x	x		x			4
	Norte Region	PT	x	x	x		x			4
	Örebro	SE	x	x						2
	Birmingham City Council	UK	x							1
	Wales	UK	x	x						2
	Total		20	19	10	3	11	6		1

2.3.2 AM industry sectors: an overview

Actors in the Vanguard regions indicated their activity in industry sectors as a part of the information gathering in the Vanguard 3DP Pilot Initiative. The industry sectors cover the range of 3DP application areas refined together with regional experts and include healthcare, aerospace,

automotive, machinery instruments and tooling, electronics, creative industries, textiles, construction, defence, energy and other.

Actors are active in several industry sectors, also called 'domain of application', in parallel within a given Vanguard region, why the activity is represented as a normalised percent of the indicated activity within a region. As indicated, the regions and industry sectors with too little data were removed, however the information collected remains partial for the regions.

For the ten regions selected, the average across all regions shows that most activity is concentrated in creative industries with 21 %, followed by machinery instruments and tooling with 20 % and healthcare and automotive each with 14 %. These are followed by electronics with on average 11 % and aerospace with 10 % (see table 6).

Colour coded fields indicate where activity is more concentrated, where white fields indicate low to not present activity. In general, actors appear rather evenly distributed across domains of application. Notable exceptions are Emilia Romagna (creative industries) and Tampere (machinery), where activities tend to be more concentrated on a few domains. For a more detailed regional breakdown please see Figure 7.

Table 6: Industry sector activity in Vanguard 3DP Pilot Initiative (SOURCE: IDEA CONSULT BASED ON VANGUARD DATA.)

			Industry Sector											Total
			Healthcare	Aerospace	Automotive	Machinery, instruments, tooling	Electronics	Creative Industries	Textiles	Construction	Other	Defense	Energy	
Vanguard Region	Flanders	BE	24%	11%	9%	28%	12%	16%	0%	0%	0%	0%	0%	100%
	Wallonia	BE	11%	26%	21%	14%	4%	9%	0%	2%	9%	2%	4%	100%
	Baden-Württemberg	DE	13%	10%	17%	27%	20%	10%	0%	0%	3%	0%	0%	100%
	Catalunya	ES	6%	1%	18%	17%	14%	26%	0%	0%	17%	0%	0%	100%
	Tampere	FI	11%	7%	2%	39%	18%	21%	0%	0%	2%	0%	0%	100%
	Nord-Pas de Calais	FR	13%	6%	10%	11%	9%	19%	5%	0%	27%	0%	0%	100%
	Rhône-Alpes	FR	15%	12%	10%	27%	4%	23%	3%	3%	3%	0%	0%	100%
	Emilia-Romagna	IT	5%	3%	20%	3%	0%	63%	0%	0%	8%	0%	0%	100%
	Lombardia	IT	16%	11%	19%	19%	14%	10%	5%	0%	7%	0%	0%	100%
	South Netherlands	NL	26%	10%	10%	18%	10%	15%	0%	0%	10%	0%	0%	100%
	Average		14%	10%	14%	20%	11%	21%	1%	0%	9%	0%	0%	100%

Figure 7 depicts the results of the analysis with sorted tables per industry sector, where the Vanguard region for which this industry sector ranks highest as a portion of their activities is at the top. This information is complemented with the sectors regional coverage table of FoFAM project (table 7). The top six industry sectors are depicted here. The other industry sectors did not obtain enough information across regions to be considered interesting, and are therefore left out. Generally, it can be said that actors are fairly well distributed across the six domains of application depicted in the tables: creative industries, machinery instruments & tooling, healthcare, automotive, electronics and aerospace. Nevertheless, some regions are exceptionally concentrated on specific sectors. These include Emilia-Romagna, specialised in creative industries with 63 % of their activities falling in this industry sector and Tampere with 39 % of their sector activity taking place in machinery. Rhône-Alpes is fairly evenly distributed throughout the sectors, with between 4 % and 27 % of activity in all domains, however with a slight specialisation in machinery instruments & tooling, and it is the second most focused region on aerospace with 12 % of its activity.

On the other hand, regions such as Catalunya concentrate their activities on four of the six main sectors, with 26 % in creative industries, followed by automotive, machinery instruments & tooling and electronics. The linkages between these sectors can be found, therefore encouraging synergies in the activities of the actors in these sectors within a region. Actors in Catalunya more or less leave out sectors such as healthcare and aerospace.

Certain regions are found to be key players based on the percentage of their activities in a certain sector. Specifically for healthcare, South Netherlands and Flanders are the leading actors. The automotive sector ranks Wallonia as the region with the greatest share, however several regions fall into a very similar range of values, which could easily shift. Thus, the other regions that are key players in automotive include Emilia-Romagna, Lombardia, Catalunya and Baden-Württemberg.

The electronics sector is led by Baden-Württemberg and Tampere according to their share of activity within the region in this sector. Finally, aerospace is shown to be led in shares of the activity within the region by Wallonia, however many actors are active with between 10 % and 12 % of their overall activities, indicating that, this highly specialised sector with a rather lower number of actors, still has significant regional importance.

Vanguard Region	Creative Industries	Vanguard Region	Machinery, instruments, tooling
Emilia-Romagna	63%	Tampere	39%
Catalunya	26%	Flanders	28%
Rhône-Alpes	23%	Rhône-Alpes	27%
Tampere	21%	Baden-Württemberg	27%
Nord-Pas de Calais	19%	Lombardia	19%
Flanders	16%	South Netherlands	18%
South Netherlands	15%	Catalunya	17%
Baden-Württemberg	10%	Wallonia	14%
Lombardia	10%	Nord-Pas de Calais	11%
Wallonia	9%	Emilia-Romagna	3%

Vanguard Region	Healthcare	Vanguard Region	Automotive
South Netherlands	26%	Wallonia	21%
Flanders	24%	Emilia-Romagna	20%
Lombardia	16%	Lombardia	19%
Rhône-Alpes	15%	Catalunya	18%
Baden-Württemberg	13%	Baden-Württemberg	17%
Nord-Pas de Calais	13%	Rhône-Alpes	10%
Tampere	11%	Nord-Pas de Calais	10%
Wallonia	11%	South Netherlands	10%
Catalunya	6%	Flanders	9%
Emilia-Romagna	5%	Tampere	2%

Vanguard Region	Electronics	Vanguard Region	Aerospace
Baden-Württemberg	20%	Wallonia	26%
Tampere	18%	Rhône-Alpes	12%
Catalunya	14%	Flanders	11%
Lombardia	14%	Lombardia	11%
Flanders	12%	South Netherlands	10%
South Netherlands	10%	Baden-Württemberg	10%
Nord-Pas de Calais	9%	Tampere	7%
Rhône-Alpes	4%	Nord-Pas de Calais	6%
Wallonia	4%	Emilia-Romagna	3%
Emilia-Romagna	0%	Catalunya	1%

Fig. 7: Industry sector activity for the regions of the Vanguard 3DP Pilot Initiative. (SOURCE: IDEA CONSULT BASED ON VANGUARD DATA)

Table 7: Sector coverage FoFAM regions²⁶. For the EU regions covered in the FoFAM study, coverage is marked with yes/ no information.

			Industry Sector					Total
			Medical and Dental	Aerospace	Automotive	Consumer/electronics	Other	
Region	Flanders	BE	x	x	x	x	orthopedic, shoes	5
	Wallonia	BE	x	x	x	x		4
	South Moravia	CZ	x	x	x	x		4
	Aragon	ES	x	x	x			3
	Asturias	ES	x	x	x	x	Construction; Bioprinting	5
	Basque Country	ES						0
	Cataluna	ES	x		x	x	Food, Chemistry, Energy and Resources, Industrial Systems, Design, Sustainable mobility & Cultural industries based on the experience	4
	Comunidad Valencia	ES	x		x	x		3
	Navarra	ES	x		x	x		3
	Champagne Ardennes	FR	x	x	x	x	x	5
	Limousin	FR	x	x				2
	Nord-Pas De Calais	FR						0
	Pays de Loire	FR		x	x			2
	Rhône Alpes	FR	x	x	x	x	x	5
	Emilia-Romagna	IT	x		x			2
	Lombardy	IT	x	x	x	x		4
	East Netherlands	NL	x	x	x	x		4
	North Netherlands	NL				x		1
	South Netherlands	NL	x	x	x	x		4
	West Netherlands	NL	x	x		x		3
	Norte Region	PT	x	x	x	x	Machinery and Equipment; Creative Industries	5
	Örebro	SE		x	x		General industry	3
	Birmingham City Council	UK	x		x	x		3
	Wales	UK	x	x	x			3
	Total		19	16	19	16		7

²⁶ http://www.fofamproject.eu/images/D4.3_final_roadmap_FINAL.pdf

2.3.2.2 Creative industries, consumer goods

One can note some key value chain differences when considering the area of consumer goods. The 3DP study²⁷ analysed in that regard two different landscapes, the 3D-printed textiles and lighting and other home decoration products²⁸.

In the former, the role of open-source designs and data as well as of decentralised networks and platforms is of key importance to this niche under development. Although not yet at full maturity, this field can be associated to regional capabilities related to the presence of main 3D-printing companies, like service providers and printer manufacturers, as well as to key research efforts being performed in different areas across Europe. Such key capabilities are mainly observed in Western European regions and in Poland. These also encompass companies which develop their expertise in home decoration printing and that might not be active in other 3D-Printing areas, although the diversity of this particular segment is developing across Europe. From the user side, a more fragmented view can be observed. Areas subject to a high level of urban concentration is one of the main areas of development of consumer printing, whether by individual consumers or through fablabs. Regions Noord Netherlands, East Netherlands, West Netherlands, and South Netherlands, Brussels-Capital region, Flanders and Nord-Rhine Westphalia concentrate around fablabs, which are complemented by a high density of fablabs across France, the UK, Italy and Germany. Poland, Czech Republic and Latvia are also countries where capabilities could be identified, which are rather associated to the supply side (presence of companies providing 3D-printing devices and/or services in the first place).

The textile area is even less mature from a market perspective. New developments, however, point to a clear evolution from research to commercial successes. Companies and RTOs in Germany, Belgium, the Netherlands and the UK are consolidating their capabilities in this field. In some of the most active fields of textile printing, including sportswear, shoe and protective clothing manufacturing, have companies such as Nike or Feetz developed commercial approaches and have a market lead. In Europe they compete with the German player Adidas. There is a scattered landscape of European designers, mainly located in Denmark, the UK and the Netherlands, involved in those developments, but not illustrating the presence of structured capabilities yet. A stronger landscape appears when considering Smart Textiles, an area where successful research is being conducted in RTOs and universities in the UK, Italy, Ireland, Germany, Finland, as well as in the Netherlands. When considering this area, capabilities can be extended to the particular value chain in which smart textiles are used.

2.3.2.3 Industrial Equipment/business machines and tooling

The printing of components for machines will greatly vary from the printing of tools such as mould inserts, cutting guides, jigs and fixtures. Regional capabilities will therefore vary from one value chain to another. Although the cases of AM in the machinery sector are mainly anecdotal, as they are not representative of a full deployment of AM in the sector and are at this point of time predominantly subject to industrial secrecy, the printing of mould inserts has reached a clear level of maturity. Here, however, a second challenge is encountered, the particularity that an area as mould printing can be associated to a wide range of value chains. Mould inserts can indeed be printed for automotive

²⁷ See <http://ec.europa.eu/DocsRoom/documents/18741/attachments/1/translations/en/renditions/native>

²⁸ Such as furniture, vessels (vases, bowls, cups, etc.), sculptures, and others

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companies, toy makers, or in the packaging industry, involving different industrial players and different modus operandi.

In addition to RTOs and taking the example of metal AM for injection moulding, capabilities on the following value chain segment were identified²⁹:

- In terms of material provision, European regions, mainly Western, include **North Rhine-Westphalia, Flanders, Skåne** and **Cheshire** are leading but face a tough competition from American companies.
- Regions where key printer manufacturers are located in Europe included **Warwickshire, Staffordshire, Schleswig-Holstein, Bavaria** (most likely the leading region in this area due to the presence of several industry leaders), **Baden-Württemberg**, as well as **Auvergne**. Although these are not the only players at stake, they are known to be at the core of the manufacturing of 3D-printers used to manufacture metal injection moulds.
- Regional capabilities are then scattered when coming to the segment of mould makers. Mould-making companies are often small companies, except for OEM and a selected number of Tier suppliers of different industrial sectors. The industry is therefore characterized by a high level of fragmentation which is coupled to a high level of specialization.
- Regions where key service providers were located include, for example, **Flanders, Scotland, Bavaria, Rhineland-Palatinate, Northern Ireland, Rhône Alpes, Ile-de-France**. One of the particularities of those companies is that they sometimes are even seen as competitors to the mould-making industry.
- Examples of end-users were also referred to as to illustrate the broad outreach potential of the mould-making industry. These include for instance LEGO (**Jutland, DK**), Berker (**North Rhine-Westphalia, DE**), car manufacturers located in Germany (**Bavaria and Baden-Württemberg**), and French and Swedish car manufacturers such as Renault and Volvo (both active in **Rhône-Alpes**).

These are illustrative of the complexity and wide spread of, not the supply side of AM in Europe, but rather of the demand- and lead-user sides. Unless a sectorial approach to industrial machines is adopted, a similar difficulty remains when trying to identify regional capabilities. Examples mentioned in this area are Dutch, Italian and German companies (such as Atlas CopCo, ASML, IMA.it, Schunk and Siemens for instance) implementing initiatives for the printing of spare parts that find direct links with industrial machinery.

2.3.2.4 Health

This sector is a sector where most of the key industrial players who are not 3D-Printing

²⁹ See http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8937

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specialists are U.S. companies. Still, a few EU players are active in this area and it is clear that Europe's 3D-Printing industry has developed strongly in the area of medical implants and the one of medical devices, with companies such as ARCAM, Materialise and other usual suspects being known for their success in those sectors for instance. The dental area, which is already mature, does not seem to be the area where the competitiveness of the EU will be at play. The same goes for hearing aids. Those are specific products that have reached market maturity and that were a good fit for additive technologies. Other areas, however, show a greater deal of potential for the future.

One of them is bio-printing³⁰ in which, despite a lack of industrial players and a low TRL as this area is still under construction, European research is still competitive in spite of a clear lead from the U.S. However, it should be noted that although U.S. companies are usually deemed to lead the commercial exploitation of bio-printing, the business area itself is seen as immature and only a few companies have managed to identify business niches to sustain their commercial activities. Among other aspects, the technical limitations of the printers currently available appears to be a constraining factor together with the associated cost and complexity of printing human tissues. However, the sector is developing quite rapidly and in the longer-run could bring breakthrough benefits to patients. A more mature area is implant printing where technical progress, among other factors, can lead to a greater market outreach. The same goes for prosthetics.

Healthcare is a broad area encompassing different value chains. These are driven by the type of material at stake in the first place, ranging from human cells in the area of bio-printing to the additive manufacturing of titanium implants. Some successful projects were funded in this area under FP7, such as the ARTIVASC 3D which deals with "Artificial vascularised scaffolds for 3D-tissue-regeneration". European Additive Manufacturing (AM) players are very much active in a number of healthcare areas. Based on publication analyses, the consortium led by IDEA Consult and commissioned by the European Commission to provide an overview of Additive Manufacturing value chains in Europe found that two of the key research fronts for Europe are "Biomedical Implants EBM and SLM" and "Mandibular Reconstruction Surgical Planning"³¹.

The study also reports strong capabilities in value chains such as the 'hard and inert implants' and the 'surgical tools' value chains which are mainly concentrated in Western European regions with either a strong healthcare industry or a strong presence of AM players. For instance, **Bavaria, Flanders, Asturias, Denmark, Emilia Romagna**, are said to be key regions in the area of surgical planning, to which the United Kingdom, the Netherlands and France should be added when considering areas such as implants printing. Companies such as Renishaw (UK) and ARCAM (SE) have developed clear business lines on the 3D-Printing of implants. When considering the area of surgical planning tools, one can see that regions such as **Bavaria** and **Baden-Württemberg** gather key printer manufacturers, while a

³⁰ see Murphy and Atala, 2014

³¹ Source: http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8937

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region such as **Flanders** gathers an ecosystem of service providers (Materialise), research and technological entities (K.U. Leuven, Sirris), Printer Manufacturer (Layerwise, now part of 3D Systems) hospitals and medical companies³².

In addition to individual capabilities, networking activities are progressively shaping up. Current developments in the Vanguard 3DP Pilot Initiative for example relate to the setting up of cross-regional demonstration activities in the areas of 3D-Printed orthoses, implants and prostheses.

2.3.2.5 Automotive

An initial differentiation can be made between structural and non-structural components, and a second between plastic and metal-based components (which does correlate with the former). Taking the example of non-structural plastic-based components for car interiors report a number of regions involved in Automotive AM that mainly spread across Western European Regions were identified³³.

Among the various segments identified, components capabilities can be identified in service provision (**Flanders** and **Wallonia** with Materialise and Sirris) and printer manufacturing (Layerwise and Phoenix System – both now 3DS and respectively operating from **Flanders** and **Ile-de-France**, Gorgé in **Ile-de-France** and **Rhône-Alpes-Auvergne**). In the automotive area, the role of clusters and RTOs is of key importance, such as demonstrated by the strong presence of the Spanish ASERM and the PEP-IPC cluster. The value chain remains driven by OEMs and integrators, besides **Rhône-Alpes-Auvergne** and **Ile-de-France** (Renault, Volvo), **Piemonte** and **Lombardy** but also **Emilia Romagna** (where Ferrari or Lamborghini are active in the area) or Ängelholm (Koenigsegg), **Västergötland** and **Bohuslän** (Volvo) were listed.

Similar to the aeronautic AM area, one of the key concentrations of all types of players is found in Germany with SLM-Solutions (**Schleswig-Holstein**), EOS and ConceptLaser (**Bavaria**) from the side of printer manufacturers, and Fraunhofer (**Bavaria, Hesse**), LZN (**Hamburg - Lower Saxony**) and other players in **Baden Württemberg** from the side of RTOs, as well as the broad range of automotive manufacturers (Audi, BMW, etc.) and OEMs (EDAG in **Hesse** and the French OEM Faurecia for example).

Although it has mainly been limited to prototyping, tooling or short series, such as vintage cars and customisation, 3D-Printing is still relevant to the automotive sector. Yet, the issue of technology efficiency leaves an interrogation mark on the space it will occupy in the future, besides tooling and prototyping. While sectors such as aerospace are in need of batches ranging from one to a few tens of thousands parts or products, the automotive sector deals with millions of outputs. Automotive companies, whether tier suppliers or integrators, remain among the key European lead-users of AM world-wide with an absorption capacity similar to the one found in large industrial groups from the aeronautic industry. Interesting developments are sometimes driven by both sides of the broader

³² See the illustrations provided by the current PROSPEROS project, available at <http://www.grensregio.eu/projecten/prosperos>

³³ Available at <http://ec.europa.eu/DocsRoom/documents/18741/attachments/1/translations/en/renditions/native>

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automotive value chain and it appears to be relevant to integrate this sector in the list of areas under the scope of the AM-Motion project. 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. Moreover, processes are being put in place as to facilitate the characterisation and normalisation of AM in the automotive sector, and very recent progress was made with, for instance, the new EOS acquisition(s) by Audi in Germany or the promotion of the Canadian URBEE 2 vehicle.

One of the particularities of the automotive value chains (whether plastic or metal-based) is their outreach to Eastern European regions, such as Polish regions where both research and industrial applications of AM are growing. For plastic-based non-structural car interior components, the DG Grow study reports strong capabilities in **Flanders, Wallonia, Auvergne Rhône-Alpes, Ile-de-France, Piemonte, Lombardy, Emilia Romagna, Catalonia, Schleswig-Holstein, Bavaria, Hesse, Hamburg - Lower Saxony, Baden Württemberg, Ängelholm, Västergötland and Bohuslän.**

The repartition of the capabilities across these regions follows a pattern similar to the one observed in the aeronautic sector, where the value chain segments are mainly located around the key automotive clusters and well-known 3D-Printer manufacturers and service providers. Companies either absorb the technology directly, by means of leasing and/or acquisition, or call upon service provisions from key service providers such as Materialise, etc. An outstanding concentration of different value chain segments, such as service providers, OEM, integrators and printer manufacturers but also software providers and RTOs, can be observed, however, in German regions such as **Bavaria and Baden Württemberg.**

2.3.2.6 Aerospace

This is the area where EU has a leadership and can keep advancing. One of the key drivers (optimization) will remain key along with its potential spill-over to other sectors. Such a driver played quite an important role in the further development of design an interface software provided by companies from US but also European regions (Belgium, French, German, British in the lead) which grasped the opportunity to innovate in this field. Companies such as Altair and Dassault are at the core of such a development. Europe has key players in this sector which covers all segments of the value chains under scope. The FoFAM project focused on metallic structural components, an area where EU is clearly leading (in contrast to plastic-based non-structural components).

For metallic structural airplane components, the study coordinated by IDEA Consult on behalf of the European Commission³⁴ reports strong capabilities for instance in **North Rhine-Westphalia, Flanders, Bavaria, North Holland, Flanders, Auvergne, Cheshire, Ile-de-France, Burgundy, Baden-Württemberg, Midi-Pyrénées, Västergötland, Staffordshire, Schleswig-Holstein, Sør-Trøndelag, Hamburg - Lower Saxony, Hesse, Auvergne Rhône-Alpes, South Holland, Veneto, Emilia-Romagna, Cranfield, Sheffield, Manchester, Hauts de France, Piemonte/(Liguria), and Skirosky (Masovian**

³⁴ And available at <http://ec.europa.eu/DocsRoom/documents/18741/attachments/1/translations/en/renditions/native>

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Voivodeship).

The correlation between the presence of industrial aeronautic clusters and the central role of the aforementioned regions in the aeronautic value chains is clear. In that context, a distinction was made by the research team between the different stages of the “metallic structural components for aircraft” value chain. While the main printer manufacturers were found in German Länder (with companies such as EOS, SLM Solutions and ConceptLaser), other providers were found in Sweden (Arcam AB), and the UK (Renishaw), to which should be added the broad range of service providers collaborating with the aeronautic sector in **Flanders** (Materialise), **Ile-de-France**, etc.

One of the key drivers of the diffusion of AM across regions in this area was found to be integrators and Tier-1 suppliers. Their active role in adapting the use of AM to their production chains led those large companies to produce both structural and non-structural components made of different materials as to integrate them into final systems. In addition to GKN and Rolls-Royce, companies such as Safran/SNECMA, Zodiac, and others closely collaborate with each other but also with RTOs (TWI, TNO, etc.) and universities across European regions (**Cranfield**, **Sheffield**, etc.).

Despite the development of AM capabilities by American players (e.g. Boeing, Bombardier and Lockheed Martin in various European regions including Sikorsky or the UK), Airbus most likely remains one of the most important players in the AM industry world-wide. Besides the thousands of non-structural polymer components printed for its aircrafts, the company took a significant step when it launched its bionic titanium bracket for the A350 XWB. The company is today a key driver of AM industrial developments and developed AM capabilities across Europe (among others in German, French and Spanish regions).

3. Accelerating AM development and deployment across European value chains

Chapter 2 identified the fact that many regions have good AM capabilities, and the in-depth Vanguard study further uncovered areas of strengths and opportunities for collaboration. This collaboration is already between regions under the S3 Industrial Modernisation Platform and can be seen as an exchange of information based around the ‘learn’ and ‘connect’ stages (see figure 8 below).

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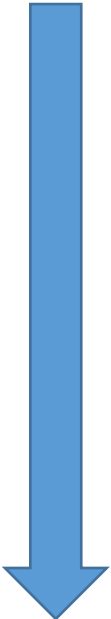
Upscale 	Learn	<ul style="list-style-type: none"> • Developing scoping papers • Mapping • Identify lead regions 	<ul style="list-style-type: none"> • Industry inspired
	Connect	<ul style="list-style-type: none"> • Developing scoping papers • Mapping 	
	Demonstrate	<ul style="list-style-type: none"> • Networked demonstration • Pilot lines and first of kind facilities 	<ul style="list-style-type: none"> • Industry driven
	Commercialise	<ul style="list-style-type: none"> • Launch of new ventures • New value chains 	<ul style="list-style-type: none"> • Industry owned

Fig. 8: Vanguard Initiative methodology (based on Vanguard presentations see RIM Plus Workshop³⁵)

The Vanguard Initiative has moved further forward and following the in-depth mapping, it has encouraged regional stakeholders to identify cross-regional opportunities which has led to a list of 15 cross-regional demo cases, developed through a number of selection criteria (i.e. four criteria identified: technologies readiness (above TRL 5), added value compared to intra-regional initiatives, industrial relevance and European impact) leading to a selection of seven interregional demo cases (Table 8 and annex).³⁶ Each case consists of:

- Combined complementary demonstration facilities between regions
- Groups of companies wishing to access the shared facilities to carry out demonstration, validation and certification activities at lower costs.

³⁵ <https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/sites/default/files/report/Vanguard%20Initiative.pdf>

³⁶ http://s3vanguardinitiative.eu/sites/default/files/contact/image/3d_pilot_-_plenary_meeting_22sept2015_minutes_final_4_0.pdf

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Table 8: Identified 3D Printing collaborations in the Vanguard Initiative in 2015

	Topic	Lead region	Participating regions
Case 1	Hybrid materials 3D Printing for Automotive component	Emilia-Romagna	Aragon, Norte, Saxony, Baden-Württemberg, Lombardy
Case 2	Metal products 3D Printing for Automotive components, tools and moulds	Aragón	Emilia-Romagna, Norte
Case 3	Acceleration platform for 3D Printed Complex Parts in Machinery & Tooling	Wallonia	Lombardy, Aragon, Catalonia, Norte and Örebro Län)
Case 4	Creative industries: Customized Consumer Goods in Fashion, Furniture, Lighting and Visual Communication	Catalunya	Flanders, South Netherlands, Lombardia
Case 5	Adding a dimension to 2D printed textiles	Lombardy	Flanders, South Netherlands, Nord Pas de Calais
Case 6	3DP Smart Bike	Flanders	South Netherlands, Lombardy, Catalonia
Case 7	Customized Insoles & Ortheses	Emilia Romagna	No regions in 2015

3.1 EU Digital Innovation Policy

Industry is one of the pillars of the European economy – the manufacturing sector in the European Union accounts for 2 million enterprises, 33 million jobs and 60 % of productivity growth. Europe stands on the brink of a new industrial revolution, driven by new-generation information technologies such as the Internet of Things (IoT), cloud computing, big data and data analytics, robotics and **3D printing**. These new advances open new horizons for industry to become more adventurous, more efficient, to improve processes and to develop innovative products and services.

European industry is strong in digital sectors such as electronics for automotive, security and energy markets, telecom equipment, business software and laser and sensor technologies. Europe also hosts world-class research and technology institutes. Nevertheless, high-tech sectors face severe competition from other parts of the world and many traditional sectors and small and medium enterprises (SMEs) are still lagging behind. Furthermore, there exists large disparities in the level of digitisation between regions.

The European Commission launched on April 2016 the first industry-related initiative of the

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Digital Single Market package.³⁷ Building on and complementing the various national initiatives for digitising industry, such as Industry 4.0 and Smart Industry, the Commission will use its policy instruments, financial support, coordination and legislative powers to trigger further public and private investments in all industrial sectors, and thereby create the framework conditions for Europe's digital industrial revolution.

The role of digitalisation has also become significant for the manufacturing sector as it allows quantum leaps in productivity in addition to changing and integrating the value chain through digital connectivity of suppliers, the plant, distributors and even the product. Recent studies show that a new industrial revolution, driven by new-generation information technologies and digitisation of products and services, can add more than €110 bn in annual revenue in Europe over the next five years.³⁸

Digitalisation of industry also allows for flexibility in production, for mass customization, increased speed, improved product quality and better productivity. Research shows that data-driven supply chains can speed up the manufacturing process by 120 % in terms of the time needed to deliver orders and by 70 % in terms of the time it takes to get products to market. Conversely, this also puts a lot of pressure on the companies operating in the sector to constantly stay ahead. For companies to remain competitive, they need to continually make large improvements in their processes. Hence, companies need to:

- Reduce time to market (shorter innovation cycles, more complex products, larger data volumes)
- Enhance flexibility (individualized mass-production, volatile markets, high productivity)
- Increase quality (closed loop quality processes, traceability and integrated genealogy)
- Increase efficiency (energy efficiency and resource efficiency as key competitive factors)

The European Commission has set up plans with the aim of mobilising up to €50 billion of public and private investments in support of the digitisation of industry. This is directed towards:

- €37 billion investment to boost digital innovation.
- €5.5 billion towards national and regional investments in digital innovation hubs.
- €6.3 billion for the first production lines of next-generation electronic components.
- €6.7 billion for the European Cloud Initiative.

In addition to the plan of mobilising investment for the digitisation of industry, the EC will also:

- help coordinate national and regional initiatives on digitising industry by maintaining a continuous EU-wide dialogue with all actors involved. A governance framework will be set up with Member States and industry.
- focus investments in EU's public-private partnerships and strongly encourage the use of the

³⁷ <https://ec.europa.eu/digital-single-market/digital-single-market>

³⁸ <https://ec.europa.eu/digital-single-market/en/digitising-european-industry>

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opportunities offered by the EU Investment Plan and European Structural and Investment Funds.

- invest €500 million in a pan-EU network of digital innovation hubs (centres of excellence in technology) where businesses can obtain advice and test their digital innovations.
- set up large-scale pilot projects to strengthen internet of things, advanced manufacturing, technologies in smart cities and homes and connected cars or mobile health services.
- adopt future-proof legislation that will support the free flow of data and clarify ownership of data generated by sensors and smart devices. The Commission will also review rules on safety and liability of autonomous systems.
- present an EU skills agenda that will help give people the skills needed for jobs in the digital age.

Günther H. Oettinger, Commissioner for the Digital Economy and Society has noted that, *"Europe has a very competitive industrial base and is a global leader in important sectors. But Europe will only be able to maintain its leading role if the digitisation of the industry is successful and reached fast. Our proposals aim to ensure that this happens. It requires a joint effort across Europe to attract the investments we need for growth in the digital economy."*³⁹

3.1.1 Digital Innovation Hubs and their relevance to AM

Across the EU, approx. 60 % of large industries and 90 % of SMEs feel that they are lagging behind in terms of digital innovation.⁴⁰ Similarly, there are strong digitisation discrepancies between industrial sectors. Digital innovation hubs can help ensure that every company, small or large, high-tech or not, can exploit the opportunities that digitalisation offers. There are already several initiatives from the European Commission to shape the pan-European network of Digital Innovation Hubs (DIH) with the focus on helping SMEs to master their digital transformation. These initiatives include:

- Innovation for Manufacturing SMEs (I4MS)
- Smart Anything Everywhere (SAE)
- iHub
- Open Data Incubator Europe (ODINE)
- European Institute of Innovation & Technology (EIT) and Knowledge and Innovation Community (KIC)
- European Coordination Hub for Open Robotics Development (ECHORD++)
- Access Center for Photonics Innovation Solutions and Technology Support (ACTPHAST)
- Supercomputing Exercise for SMEs (SESAME NET)

The Digitising European Industry initiative (DEI) aims to ensure that any industry in Europe, big

³⁹ http://europa.eu/rapid/press-release_IP-16-1407_en.htm

⁴⁰ <https://ec.europa.eu/digital-single-market/en/digital-innovation-hubs>

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or small, wherever situated and in any sector, can fully benefit from digital innovations to help upgrade its products, improve its processes and adapt its business model to the digital age. This requires not only a dynamic digital sector in Europe but also the full integration of digital innovations across all sectors of the economy. The DEI initiative is based on an ambitious collective effort involving public and private stakeholders across Europe at regional, national and EU level.

A key element of the DEI is Digital Innovation Hubs (DIHs), which aims at supporting businesses, notably SMEs and non-tech industry, in their digital transformation. The European Commission plans to invest €500 m from Horizon 2020 on Digital Innovation Hubs. The aim is to support:

- Networking and collaboration of digital competence centres and cluster partnerships.
- Supporting cross-border collaboration of innovative experimentation activities.
- Sharing of best practices and developing a catalogue of competences by end of 2016.
- Mobilising regions with no Digital Innovation Hub to join and invest.
- Wider use of public procurement of innovations to improve efficiency and quality of the public offer

A Digital Innovation Hub (DIH) is a support facility that helps companies become more competitive by improving their business/production processes, products and services by means of digital technologies. DIHs act as a one-stop-shop to digitalise business, serving companies within their local region as well as beyond. They help customers address their challenges in a business- focused way and with a common service model, offering services that are not readily accessible elsewhere.

The services available through the DIHs enable any business to access the latest knowledge, expertise and technology for testing and experimenting with digital innovations relevant to its products, processes or business models. DIHs also provide connections to investors, facilitate access to financing for digital transformations, help connect users and suppliers of digital innovations across the value chain, and foster synergies between digital and other key enabling technologies.

DIHs are therefore in a very strong position to transmit expertise to a wider audience and this capacity should be harnessed. The following section of the report will introduce the methodology underpinning DIHs and help to show how they can be instrumentalised to increase the uptake of AM across the EU.

3.1.2 Digital Innovation Hubs as Tools for Digital Transformation

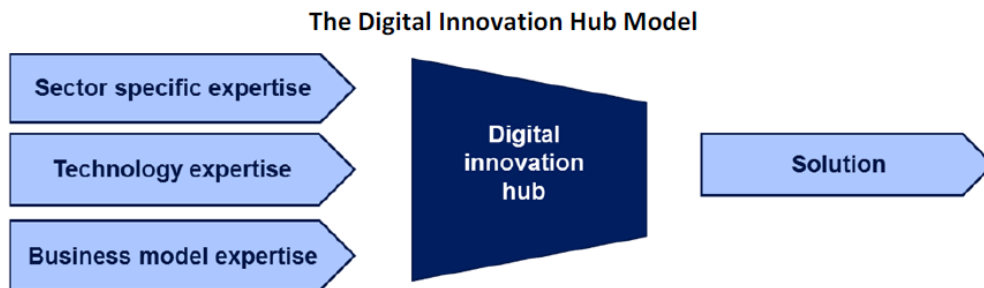


Fig. 9: The Digital Innovation Hub model⁴¹

To ensure the ongoing strategic governance of the timely and efficient implementation of the Digitising European Industry initiative COM(2016)180), two high-level Roundtables per year will be held between the three Commissioners Oettinger, Bieńkowska and Moedas. The first Roundtable kicked off the governance and coordination framework for the "Digitising European Industry" initiative outlined in the Communication. The Roundtable dealt with the overall political objectives and strategy of the Digitising European Industry initiative and the concept of the European Platform of National Initiatives, as well as gave an overview of national initiatives. It was followed by a political commitment by the various stakeholders to implement concrete DEI actions.

The Roundtable gathered about 120 high-level representatives⁴² from the Ministry as well as formational initiatives, where national policy initiatives for Digitising Industry are already in place. Presidents of the boards of the European Public Private Partnerships under Horizon 2020 and Director Generals of European Associations representing relevant industries and social partners were also present to this Roundtable to ensure the widest awareness and dissemination of the Digitising European Industry initiative.

According to the 'Roundtable on Digitising European Industry Working Group 1'⁴³, Digital Innovation Hubs hold significant potential to support and assist SMEs, and especially start-ups could become key actors in bringing digitisation to all industry sectors. The DEI 1 Working Group (WG1) community strongly supports the proposed European network of Digital Innovation Hubs as a means of supporting businesses, and especially SMEs and non-technology intensive industry, in seizing the

⁴¹ https://ec.europa.eu/futurium/en/system/files/ged/dei_working_group1_report_dec2016_v1.2.pdf

⁴² http://ec.europa.eu/information_society/newsroom/image/document/2016-50/160920_minutes_dei_roundtable_40641.pdf

⁴³ <https://ec.europa.eu/digital-single-market/en/news/roundtable-digitising-european-industry-commissioner-oettinger-september-2016>

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opportunities of digital transformation.

The key messages from the WG1's discussions so far in terms of achieving this goal are:

- Europe has a wealth of knowledge and experience in hub-type initiatives on which to draw in implementing such a network. Solid examples are evident at European, national and regional levels and further instances are set to emerge as a result of policies designed to accelerate and give direction to digital transformation. At present, however the available and emerging provision is not sufficiently visible either to industry or to other hubs and initiatives. Much greater transparency is required, so as to facilitate both access for companies and mutual learning between service providers.
- Digital Innovation Hubs must cater for a wide spectrum of needs and as such will have multiple facets. They must be agile and demand-led, and build sustainable innovation ecosystems, not just gateways to services. While there can be no one-size-fits-all approach, Hubs should be united by common values based on independence, a commitment to excellence and customer service, and a proactive, innovative approach.
- Digital Innovation Hubs should offer a broad range of services accessible through multiple entry points. Core services should include: awareness creation around the business potential of digital technologies, innovation scouting, visioning and strategy development, working with companies to assess their digital maturity and develop appropriate plans, brokering relationships with service providers, mentoring and training, and cost-effective access to specialist experimentation, test beds and production facilities. The available services should complement rather than compete against existing public and private service offerings.
- Digital Innovation Hubs have to pioneer a new and distinctive approach. They must be evangelists for digitisation within their constituencies. They must be highly client focused while having collaboration and networking as a defining characteristic. They must instil entrepreneurial thinking and embed a digital culture in companies while being firmly rooted in practical business solutions. They must have a strong physical presence while also operating effectively in the digital space. And they must have flexible business models that are able to adapt and evolve over time as circumstances and funding regimes change.
- Establishing and strengthening a European network of Digital Innovation Hubs will require, among other measures: mapping service provision and sharing information; building capacity and skills in both breadth and depth; building collaboration between digital and other high tech innovation hubs; and creating incentives for SMEs and others to engage with the network. A 'light touch' governance is foreseen with minimal central coordination.
- Recognition of hubs on the basis of national/regional funding and adherence to a lean and flexible set of network guidelines are envisioned as the key elements of the quality assurance regime.
- Mobilising the many investment tools and funding programmes available represents a major challenge. The aim should be to create an 'investment triangle' between region- technology-

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funding, with the three elements being co-located. Further consideration is required on the roles of national/regional versus European funding, mechanisms for combining and scaling different funding sources, and investment approaches for regions with little or no existing infrastructure. In general, the approach should be stay local where possible.

3.1.3 Digital Innovation Hubs: An Agenda for Action

A Europe-wide network of Digital Innovation Hubs able to support any business at ‘working distance’ is ambitious but definitely achievable. The DEI WG1 recommends the following areas as priority actions in realizing this objective. Certain actions are already planned or underway, while others require further elaboration.

- **Continue to build consensus between stakeholders over the nature and direction of the European network of Digital Innovation Hubs.** Actions should aim to improve and grow the information base on as well as for DIHs beyond the initial DIH Catalogue and ensure high-level political support for DIH investments through the DEI Roundtables and other policy forums. (Action Lines 1-3)
- **Launch pilot actions aimed at developing synergies and building larger initiatives.** These pilot actions should be varied in their scope and intent, aiming to demonstrate mechanisms for upgrading existing competence centres to Digital Innovation Hubs. This will facilitate knowledge transfer within the DIH network, combine different funding sources within scalable projects, create synergies with hubs active in other advanced technologies, and federate existing projects funded by different agencies into larger initiatives. (Action Line 4)
- **Intensify outreach to regions with few DIHs.** Partnering/sponsorship programmes should be established, where regions can work with other regions who already have successful Hubs, to better understand what they are and the benefits they can bring. New Hubs would draw on guidance and support from these other regions and might even set up formal relationships (i.e. become satellite hubs). Regions could use ESIF, EFSI or other sources of funding to set up DIHs and to generally foster collaboration between Hubs. (Action Line 5)
- **Utilise H2020 investments to enhance EU added value.** Horizon 2020 (together with COSME) will be a powerful catalyst in seeding and growing the DIH ecosystem. By focusing on actions that enhance EU added value, H2020 (with contributions also from other EU programmes) will become the linking pin in the DIH and other high-tech hub initiatives. (Action Line 6) Hence, EU funds should be used to create a network between EU, national and regional infrastructures as well as to help converge EU-schemes under the DEI umbrella. Funds should also be used to promote cross-border experiments and to make DIH business models more sustainable.
- **Mobilise investment by the Member States.** Continuing investment at national and regional

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level will be essential to realising a truly pan-European DIH network. In addition to developing digitisation policies and providing investment for Digital Innovation Hubs, national and regional authorities must also stimulate their own local ecosystems and foster synergies with other enabling technologies. This means, for example, showcasing how DIHs may be setup and run, engage local/regional hubs and competence centres in the DIH concept, showcase how European funding could be used to create DIHs and generally create space for bottom-up initiatives. (Action Line 7)

- **Activate the European network of Digital Innovation Hubs.** Building on the solid foundations established through WG1, European stakeholders should take immediate action to operationalise individual DIHs and begin the work of creating an European network. This should include concerted effort in relation to hub business models, common systems, methods and tools and collaboration and governance structures. (Action Line 8)

The message from industry is that speed is of the essence! The benefits for the European economy and society from digitisation are huge and our international competitors are already setting their own course. Europe must act now to make Digital Innovation Hubs a reality.⁴⁴

3.1.4 Other European Initiatives

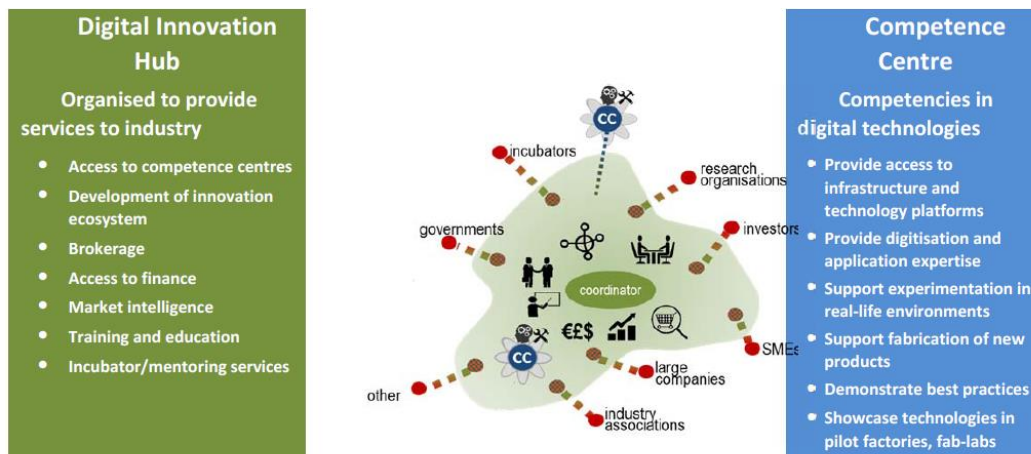


Fig. 10: Competence centres as the core of Digital Innovation Hubs

As mentioned above, similar measures to competence centres and/or Digital Innovation Hubs are supported under several European programmes, primarily related to the framework programmes for research and innovation. Examples include:

- **I4MS** consists of 11 large Innovation Actions funded by FP7 and H2020. It supports SMEs active

⁴⁴ https://ec.europa.eu/futurium/en/system/files/ged/dei_working_group1_report_feb2017.pdf

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in the manufacturing sector to improve their products and processes by letting them experiment with digital technologies, such as HPC cloud-based simulation/analytics services, industrial robotics systems, laser based manufacturing, smart cyber-physical systems, and Internet of Things. A network of competence centres provides access to competences and technology transfer to SMEs through competitive calls for experiments. Successful candidates receive funding for the experiment, from which both technology suppliers and user SMEs may benefit. So far €110m of European funding has been invested in I4MS since 2013. A further €28m has been invested through a similar network of competence centres supported under SAE, which supports SMEs to improve their products through the inclusion of advanced ICT components and systems.

- **FIWARE Accelerators and Hubs** is a series of business incubators and accelerators for start-ups and SMEs that make use of the FIWARE technologies developed under the Future Internet PPP. The Future Internet PPP has developed an open source platform (FIWARE) offering APIs to developers. In order to make these technologies (enablers) better known the European Commission funded 16 accelerators to promote their deployment in real world applications. Around €100m was invested in FP7. The accelerators organised open calls on specific domains, such as health, media, smart cities, agrifood, and Industry 4.0. SMEs, start-ups and web developers were able to apply for up to €100,000 to develop their application. The initiative attracted over 10,000 submissions, from which more than 1000 SMEs and start-ups were selected to be part of the FIWARE business acceleration programme. Each of the 16 accelerators has developed its own partner network, linking offices and innovation hubs sometimes in distant countries, connecting tutors, mentors, developers and entrepreneurs, building bridges between people and places, assembling an open community around technology. The accelerators collaborated to exchange experiences and were also linked to European regions in order to take advantage of local ecosystems and regional smart specialization.
- **Data Experimentation Incubators** is a series of incubators being set up under H2020 ICT WP 2016-17 (Big Data PPP: cross-sectorial and cross lingual data integration and experimentation). The objective is to foster exchange, linking and re-use of data, as well as to integrate data assets from multiple sectors and across languages and formats. This should lead to the creation of secure environments where researchers and SMEs can test innovative services and product ideas based on open data and business data, and should lead to new innovative companies and services for the data economy.
- **ECHORD++** is an initiative to bring robots from the lab to the market. Activities include the Robotics Innovation Facilities (RIFs), which allow SMEs to try out new business ideas and make field tests at zero risk. It also helps manufacturing SMEs with small lot sizes and the need for highly flexible solutions to try out innovative robotics technologies. ECHORD++ also supports public authorities that are looking for robotics technology at competitive prices for tender processes.

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- Pilot Lines in Nanotechnology and Advanced Materials.** The PILOTS call activities under the NMBP17 work programmes in Horizon 2020 and FP7 have resulted in 30 projects with a combined funding of €150m. These PILOT projects aim to help transfer new technology developed under Horizon 2020 into industry by providing open access for up-scaling and pilot testing to SME users. Additional investments by Member States, public or private organisations have contributed to establishing a variety of pilot up-scaling facilities across Europe, mainly in the EU-15 countries. The locations of the 107 pilot lines are shown in the map below.



Fig. 11: Pilot Lines in Nanotechnology and Advanced Materials

The pilots use many different raw materials, processes, and products, and address diverse sectors and markets, from automotive, aerospace, defence, energy storage, and construction industry to cosmetics, health and packaging. The aim, together with the European Pilot Production Network (EPPN), should be to establish a strategic approach to promote technology take-up and the use of these services in production.

3.1.5 Digital Innovation Hubs in Practice

Many examples and models of existing Digital Innovation Hubs can be found across Europe. Cases profiled at the Working Group Meeting⁴⁵ included the following, all of which emphasize an

⁴⁵ <https://ec.europa.eu/futurium/en/dei-implementation/terms/all/Digital%20Innovation%20Hubs>

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ecosystem approach.

As mentioned above, **I4MS** consists of 11 large Innovation Actions funded by FP7 and H2020, which provides support to SMEs active in the manufacturing sector. Amongst other things, the hubs let SMEs experiment with digital technologies to improve their products and processes.

Another of these networks is **Fortissimo**, which provides SMEs with easy and cost-effective access to advanced simulation, visualisation and data analytics. The SMEs are provided with expertise, tools and means to tap into European Cloud of HPC resources and software applications to design high-tech products and ultimately boost their business. To date over 100 SMEs have been involved in 94 experiments across its 16 innovation hubs.

In the UK, the High Value Manufacturing Catapult has established a Manufacturing Technology Centre⁴⁶ in **Coventry in the West Midlands** region to assist UK companies in applying advanced manufacturing system solutions. The MTC focuses on TRLs 4-6 (applied research and development), helping companies to bridge 'the valley of death' in deploying new solutions in their businesses. Around €48m has been invested in four specialist centres, each of which includes match funding from industry. The MTC funding is split roughly equally between core public funding, commercial funding and competitively won R&D. The MTC now has an established ecosystem comprising of universities, industrial partners, as well as a Business Launch Centre and an Advanced Manufacturing Training Centre. It is very much end-user driven, focusing on a matrix that matches enabling technologies (connectivity, data technologies, autonomous systems) against industrial needs (product quality, equipment health, flexible systems). The results have been impressive: an independent evaluation has shown that for every €1.2 of core public funding received the MTC produces €18 in net benefits to the UK economy.

Regions with no existing infrastructure present a particular challenge. Some form of partnering/sponsorship programme may need to be established, where regions work with other regions that already have successful Hubs. New Hubs could then draw on guidance and support from these other regions and might even set up formal relationships (i.e. become satellite hubs). European funds could be utilised for this and to generally foster collaboration between Digital Innovation Hubs.

3.2 Regions and cities of digital transformation

In order to leverage regional economic growth and jobs, the Strategic Policy Forum on Digital Entrepreneurship has developed a Blueprint for Cities and Regions of Digital Transformation⁴⁷. Effectively this is a smart policy guidebook for regions and cities to build successful local innovation

⁴⁶ <http://www.the-mtc.org/who-we-are/who-we-are>

⁴⁷

[file:///C:/Users/director/Downloads/Blueprint%20for%20cities%20and%20regions%20as%20a%20launch%20pads%20for%20digital%20transformation%20\(2\).pdf](file:///C:/Users/director/Downloads/Blueprint%20for%20cities%20and%20regions%20as%20a%20launch%20pads%20for%20digital%20transformation%20(2).pdf)

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ecosystems.



Fig.12: Key drivers of digital cities

The Blueprint was based on a comparative analysis of thirteen European cities and regions which have pioneered in digital transformation and restored spectacular economic growth amidst economic downturn. The Forum identified four main attributes characterizing the most successful regional and local initiatives, and building on this issued a number of relevant policy recommendations, addressed to all local stakeholders, to effectively support cities and regions. These include:

- 1) Leadership and collaboration for a smart governance of the local digital ecosystem.
- 2) Digital skills and entrepreneurs to accelerate the digital transformation process.
- 3) Access to data and technologies for applied solutions to local challenges.
- 4) Key infrastructures and investments for digital launch pads.

In addition, in September 2016 the Commission launched the action 'Transforming Regions and Cities into Launch pads for Digital Transformation and Industrial Modernisation', which provides professional advice and support to regions in shaping their local digital ecosystems. It aims at intensifying experimentation and networking, helping local companies and organisations innovate, and boosting investments in industrial modernisation.

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Table 10: Four criteria for digital cities and city and regional examples

	Regions and cities as examples			
Leadership and collaboration for a smart governance of the local digital ecosystem;	Nice (FR)	Espoo (FI)	Lund (SW)	
Digital skills and entrepreneurs to accelerate the digital transformation process;	Luxembourg Nyuko Webforce	Espoo (FI) Nokia	Lodz (PL) ICT Central Cluster	
Access to data and technologies for applied solutions to local challenges;	Tallinn (EE) e-government Smart government cards	Espoo (FI) Digi Espoo (FI)	Trento Smart City	Bristol
Key infrastructures and investments for digital launch pads		Espoo (FI) Espoo 2020	Lodz (PL) Special Economic Zone	

3.3 National initiatives

There are also a number of national initiative that clearly exemplify how AM can be enhanced. Two particularly illustrative examples have been identified below.

3.3.1 Field Labs in the Netherlands

Field Labs are practical environments in which companies and knowledge institutions develop, test and implement effective smart industry solutions. Field Labs meet the need for physical and digital space for experimentation and accompanying facilities. In addition, Field Labs strengthen connections with research, education and policy on a specific Smart Industry theme. They ensure an interdisciplinary approach (e.g. manufacturing in combination with ICT) and link that to domains where the Netherlands can really make a difference such as agro-food. The Team Smart Industry intends to give priority to encouraging and accelerating the Field Labs such as Multi-material 3D printing as well as developing completely new value chains based on the next generation of 3D print technologies and the associated data management systems⁴⁸.

***The Port of Rotterdam** will also have its own 'Additive Manufacturing Field Lab'⁴⁹ with new metal printers and a centre for the development of knowledge in metal printing, 3D scanning, 3D

⁴⁸ <https://www.smartindustry.nl/site/assets/files/1740/smart-industry-action-agenda-summary.pdf>

⁴⁹ <http://www.innovationquarter.nl/nieuws/port-rotterdam-gets-additive-manufacturing-fieldlab-3d-metal-printers>

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design and certification. The Field Lab provides port-related businesses with shared space in which to accelerate developments and collaborate on applications for maritime industries. Over the past year, a 3D printing pilot project to make spare parts for maritime industries has already been underway at the site. The three initiators of this project - Port of Rotterdam, RDM Makerspace, and Innovation Quarter - are also supporting the establishment of the AM Field Lab. The Port Authority is now taking steps to start up a limited liability company that will be responsible for the Field Lab and for the required initial investment.⁵⁰

* In **Flevoland**, a Dutch consortium consisting of private-sector companies, research institutes, two colleges and a university has been granted €2,354,471 in subsidies by the EU's European Regional Development Fund (ERDF) for an Automated Composite Manufacturing (ACM) Pilot Plant project in Marknesse⁵¹. The plant was opened in early 2015, thanks in part to support from the Flevoland provincial authority and a joint venture with Fokker Landing Gear.

The NLR-Netherlands Aerospace Centre is the initiator of the project, which has a total investment outlay of €5.9m. The ERDF subsidy will be used to conduct research into the automation of composite product manufacturing processes. The ACM Pilot Plant is one of the first so called 'Smart Industry Field Labs' to be created in the west of the Netherlands under the Smart Industry policy of the Dutch Ministry of Economic Affairs. It is also the first project in the province of Flevoland to be approved in the new subsidy eligibility period.

NLR is collaborating on this ERDF-subsidized project with Fokker Landing Gear, Label Breed / Kaptein Roodnat, Ampyx Power, PAL-V, Corellian, Bright Composites, VABO Composites and Omron Europe. The Netherlands Organization for Applied Scientific Research (TNO), Delft University of Technology, Fontys University of Applied Sciences and Windesheim University of Applied Sciences are also contributing through various research and education projects.

The purpose of the project is to develop, until the market introduction stage, new composite products that are lighter and/or more affordable than other products currently available on the market. NLR's ACM Pilot Plant will be used in many project activities. Furthermore, the ACM Pilot Plant project will strengthen the competitiveness and capacity for innovation of the regional manufacturing industry, and will support the provincial authority's policy of putting Flevoland on the map as Europe's main hub for composite product research and development.

Jan-Nico Appelman, a member of the Flevoland Provincial Executive noted that "the Field Lab will give regional small and medium-sized enterprises access to facilities that would otherwise be out of reach or far too expensive. The provincial authority is therefore very pleased with this contribution to the further development of NLR's Field Lab."

In conclusion, it is clear that DIHs have the capability to enhance the uptake and usage of AM

⁵⁰<http://www.innovationquarter.nl/sites/default/files/InnovationQuarterFinal%20Report%203D%20Printing%20Marine%20Spares%20.pdf>

⁵¹<https://nag.aero/updates-activities/updates/dutch-smart-industry-field-lab-to-receive-e-2-3-million-eu-funding/>

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throughout Europe. Through their role as a one-stop-shop for helping regional businesses digitise and develop, they can help their customers work out how AM can be utilised in a wide range of manners.

3.4 A lack of skills in workforce is impeding potential the potential growth of AM

One of the most crucial areas for the uptake and acceleration of additive manufacturing (AM) across Europe is skills. The importance of relying on a competent workforce has emerged as a pressing priority in Europe's quest to industrialize AM, and thus, a paradigm shift in education is needed to provide workers with the digital skills required in this digital age.⁵²

To secure the acquisition of new skills and keep pace with technological developments, industry is already introducing innovative training methods. Here, research and innovation hubs can also help develop and transfer such skills, acting as catalysers for investment and for business and job creation.

This will be discussed further in deliverable 2.3.

4. Conclusion

This report has analysed the current industrial strategy of the EU with specific reference to Additive Manufacturing (AM). It is quite clear that increasingly, EU industrial strategy is combining a thematic focus e.g. KETS with a more focused regional strategy based around the synergies provided by Structural Funds and Smart Specialisation Strategies, and increasingly Thematic Platforms, specifically Vanguard Initiative, Industrial Modernisation Thematic Platforms and strategic cluster partnerships.

The AM regional landscape is also largely dominated by Western European and can be characterised by fragmentation. However, hotspots can be identified, which was done in Chapter 2, where three studies indicated EU regions with good AM capacities. The third example of the Vanguard 3D Pilot illustrated an in-depth study of 3D printing competences and capacities in ten EU regions.

A strengthened AM sector will require the general support of an EU industrial strategy but there is also a need to encourage regions to share their capacity and competence, thereby encouraging regions to develop critical mass themselves by linking into relevant value chains and exploiting opportunities at the EU level. These opportunities are particularly seen by the increased interest in developing EU-wide platforms and pilot lines linked to shared smart specialisation strategies, such as:

- Thematic platforms – Industrial Modernisation and Vanguard Initiative
- Strategic Cluster Partnerships

At the same time, there is now much more support for Industry 4.0 and digitisation of industry.

⁵² Additive Manufacturing and 3D Printing European Conference 25th May 2016 at the European Parliament in Brussels

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The Digital Innovation Hubs programme is a good example of more funding being devoted to the support of the digitisation of EU industry with a specific focus on SMEs. There are, however, still numerous barriers to the development of AM, which includes both finance but also, as highlighted by this study, the need for the development of skills in this emerging industry. It seems as if the AM industry has not been as active as other sectors in Sector Skills Alliances, Knowledge Alliances or the Blueprint on Sectoral Skills.

4.1 Recommendations

In order to develop regional capacity in AM technologies, this report recommends four actions that should be encouraged throughout the AM Motion project.

1. To reduce the East/West divide, more attention should be given to Teaming and Twinning projects⁵³ that would include a digital industry focus.
2. Support and enhance collaboration in the Industrial Modernisation Thematic Platform as well as also support the 3D Printing Pilot under the Vanguard Initiative. Regions involved in either or both of these initiatives should be encouraged to communicate their activities to a wider audience. Regions should also seek opportunities under EU cluster policies and projects.
3. Regions with competences and capacity in AM should consider developing Digital Innovation Hubs, or national equivalents such as Field Labs in the Netherlands, linked to AM technologies.
4. There is a concern for the lack of skills needed in a fast-growing technology area. More training is needed at all levels, and again regions with AM as a smart specialisation might consider working closely with schools⁵⁴ with Erasmus+ funding as well as building links to traditional digital training organisations. Regions with strong AM capabilities as well as clusters should also consider developing future sector skills alliances, knowledge alliances and lobby for AM skills to be developed as a future Blueprint Sector Skills.

⁵³ Teaming and twinning http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-sewp_en.pdf

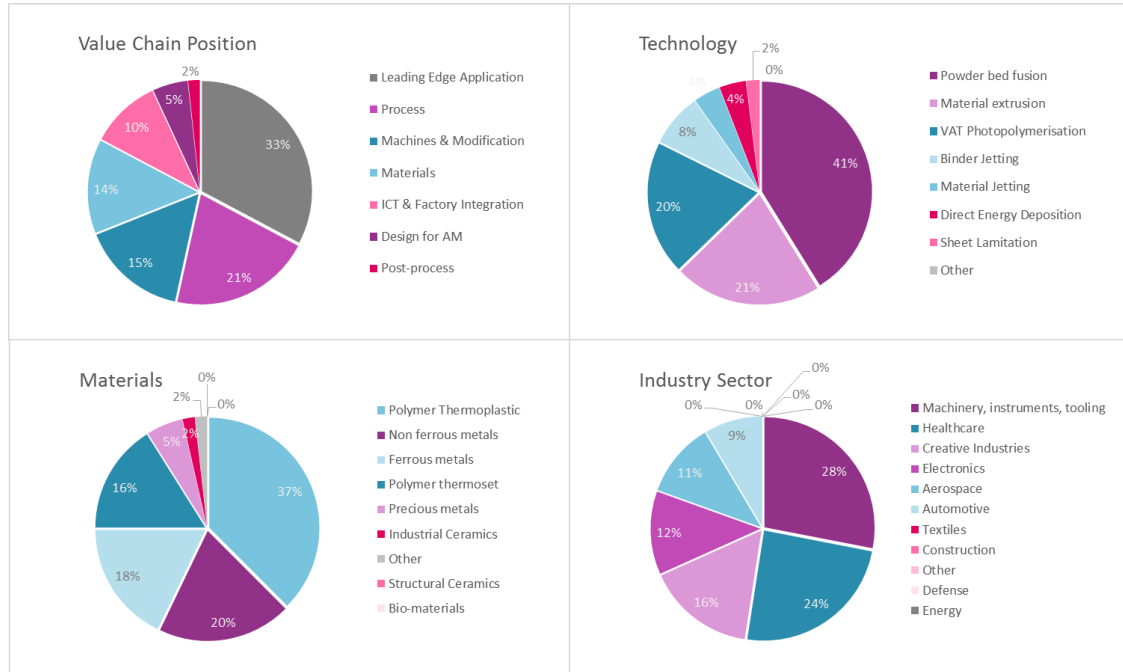
⁵⁴ <https://tltl.stanford.edu/project/fablearn-labs>
<https://en.danilodolci.org/fablab/>

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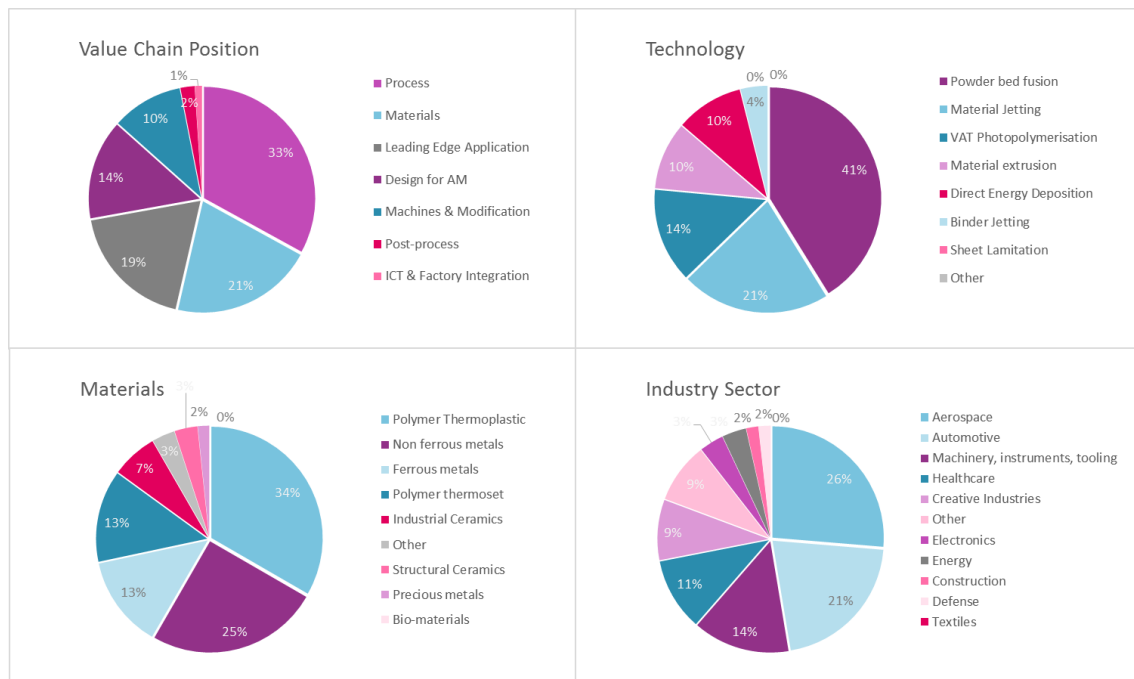
5. Annex: Results per region from the Vanguard Initiative

SOURCE: IDEA CONSULT BASED ON VANGUARD DATA

Flanders- Table 11: An overview of 3DP amongst actors (N=36) in Flanders (BE).

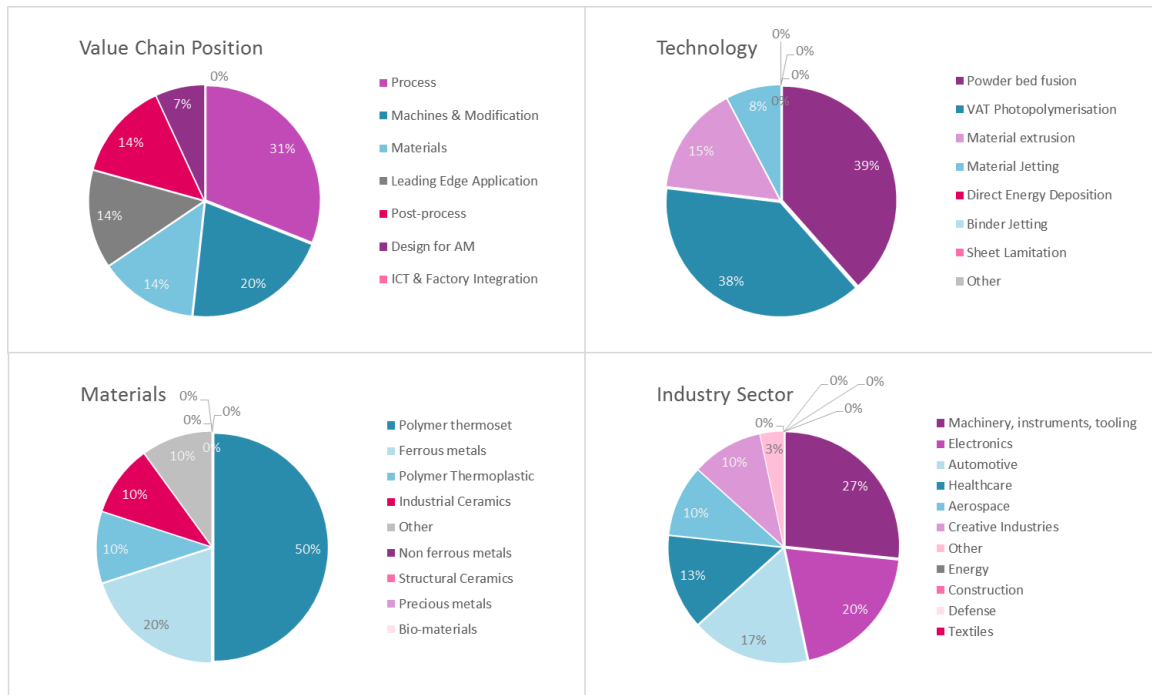


Wallonia - Table 12: An overview of 3DP amongst actors (N=38) in Wallonia (BE).

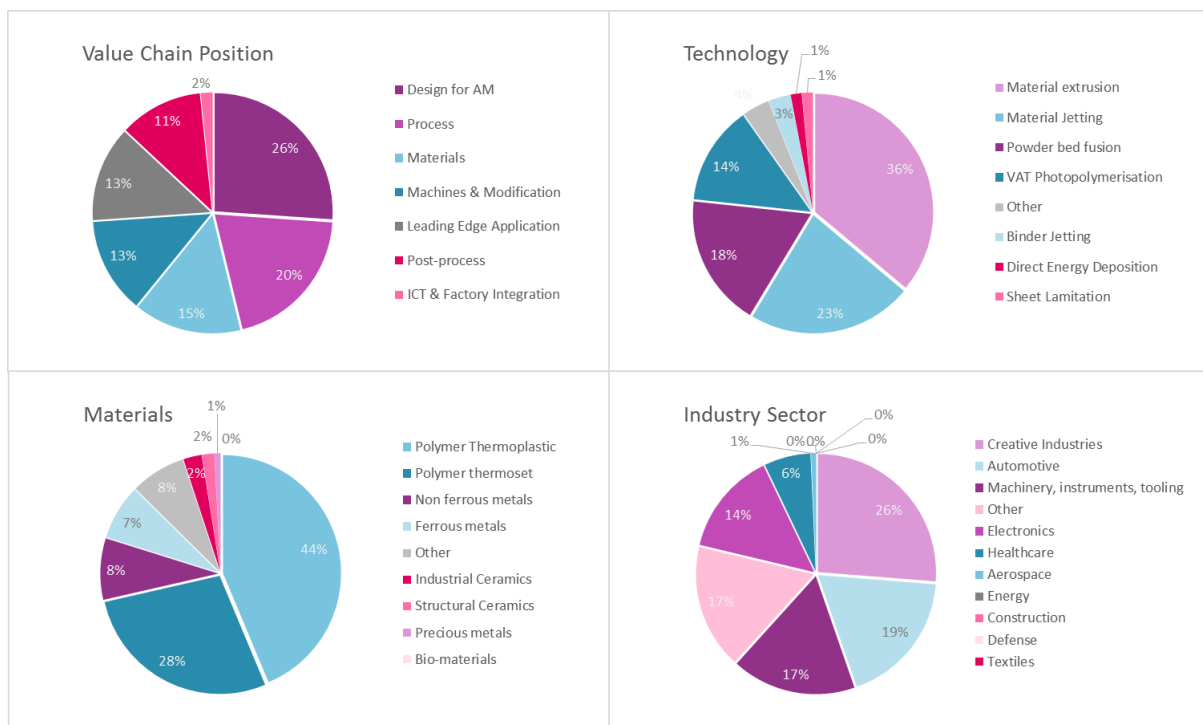


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Baden-Württemberg-Table 13: An overview of 3DP amongst actors (N=27) in Baden-Württemberg (DE)

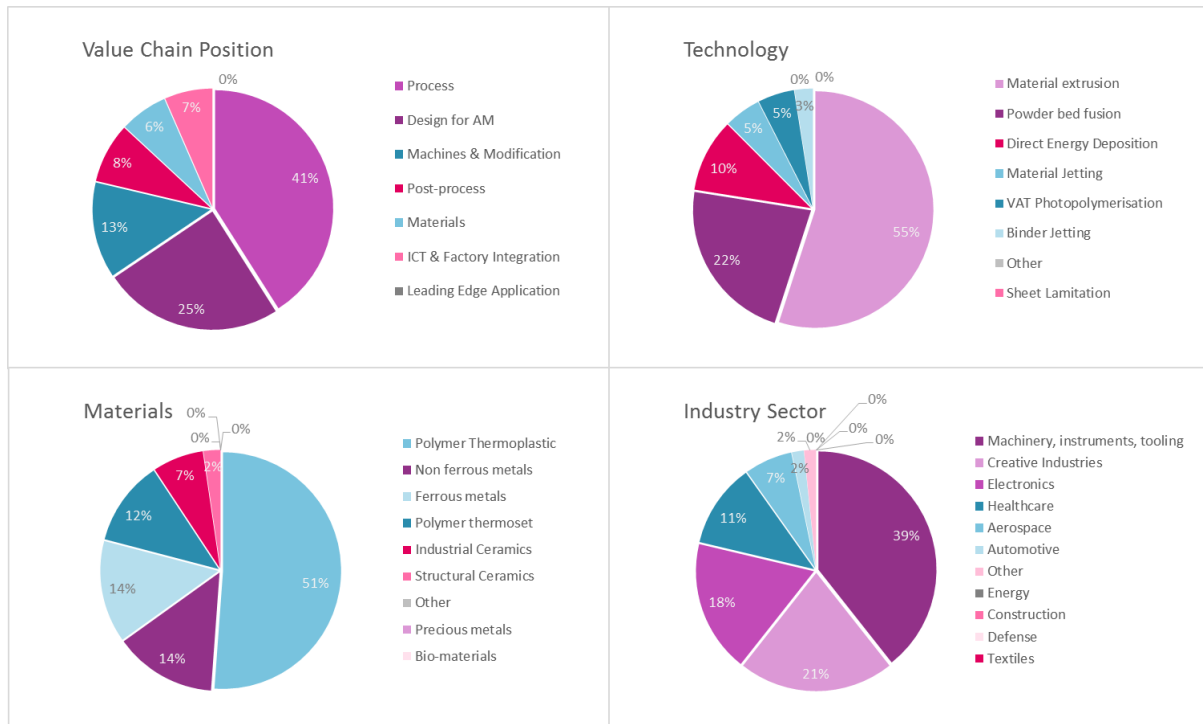


Catalunya-Table 14: An overview of 3DP amongst actors (N=101) in Catalunya (ES).

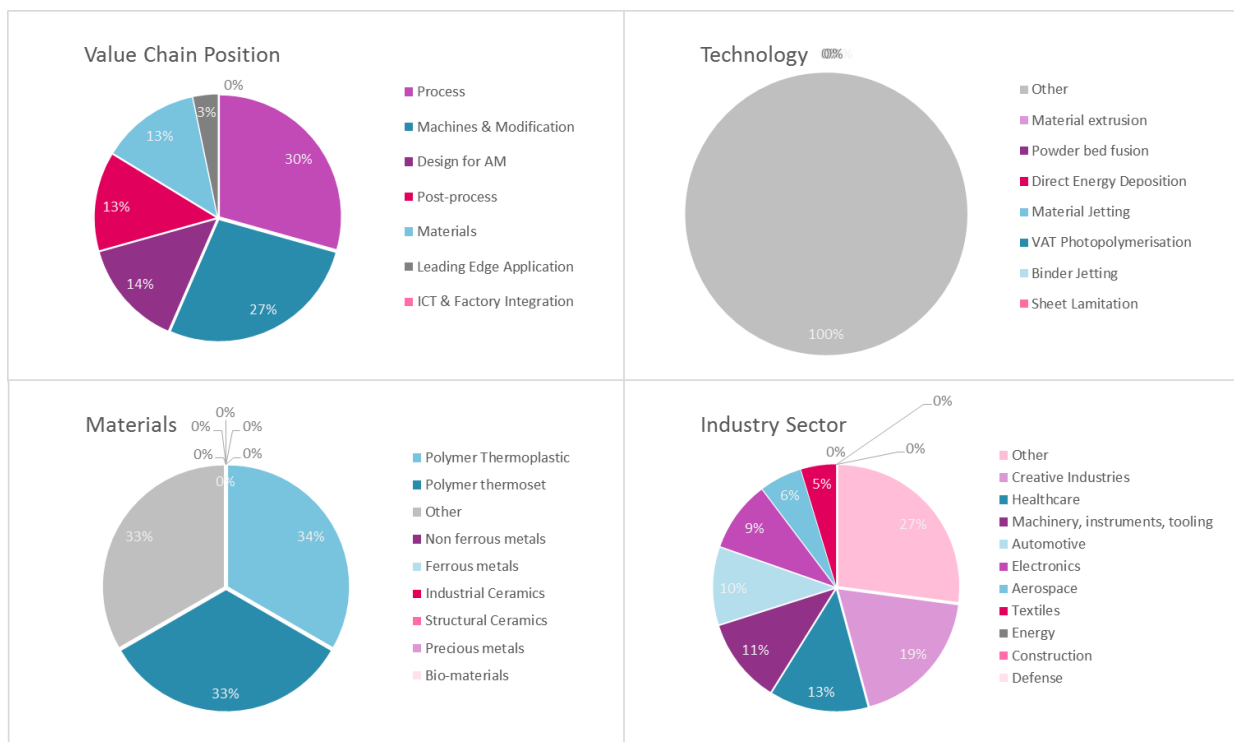


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Tampere-Table 15: An overview of 3DP amongst actors (N=39) in Tampere (FI).

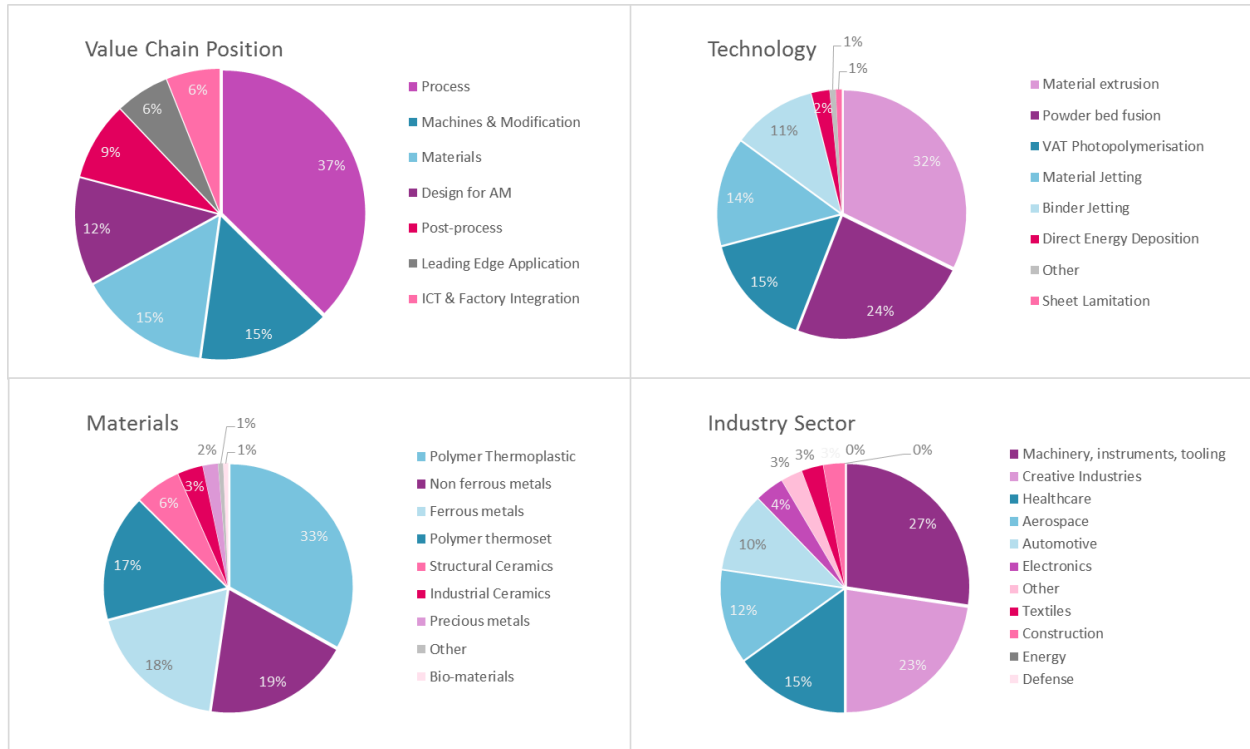


Nord-Pas de Calais-Table 16: An overview of 3DP amongst actors (N=40) in Nord-Pas de Calais (FR).

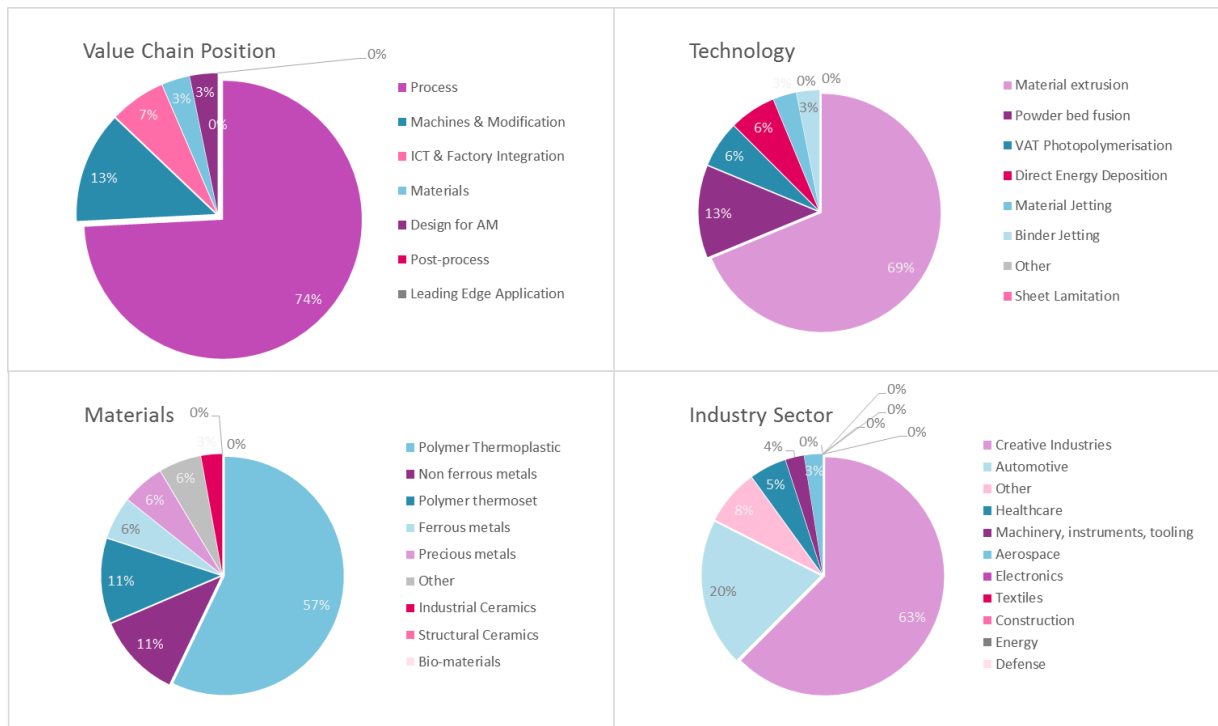


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Rhône-Alpes-Table 17: An overview of 3DP amongst actors (N=120) in Rhône-Alpes (FR).

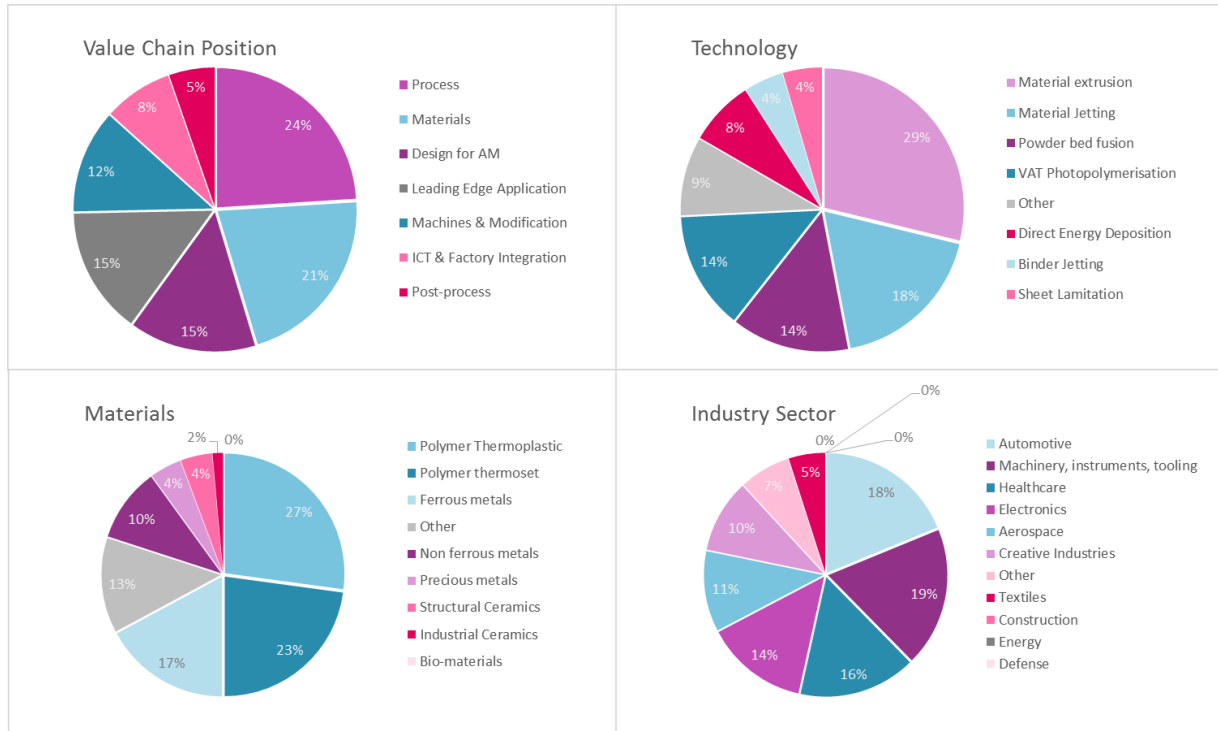


Emilia-Romagna-Table 18: An overview of 3DP amongst actors (N=45) in Emilia-Romagna (IT).

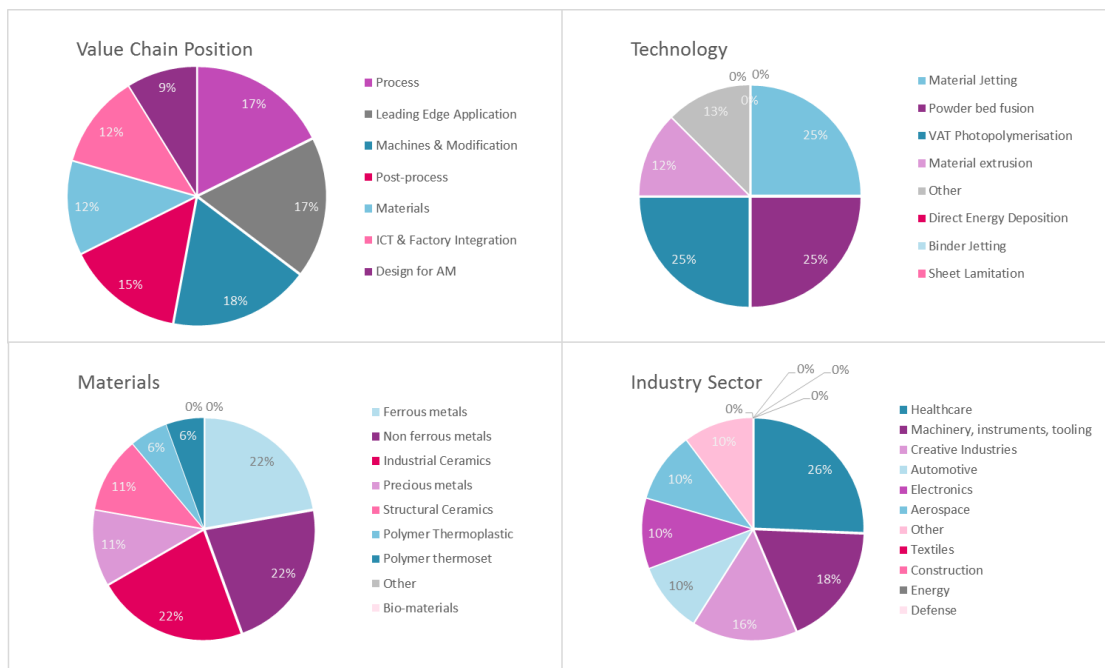


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Lombardia-Table 19: An overview of 3DP amongst actor (N=36) in Lombardia (IT).



South Netherlands-Table 20: An overview of 3DP amongst actors (N=56) in South Netherlands (NL).



Cases for joint-demonstration

5.1 Case for joint-demonstration “3DP in Health: Joint-Demonstration platform for orthosis, exoskeleton and exoprosthesis components”

Leader: Emilia Romagna; **Co-Leaders:**

Positioning Note

Description of the application(s) envisaged, with detailed description of the combination ‘Technology-Material-Infrastructure-Services’ (TMIS).

Emilia-Romagna (ER) S3 recognizes Health and Wellness Technologies as one of the main regional specialization areas of competitiveness, and “Prosthesis and Rehabilitation Systems” as one of the Technology Priority in this sector.

ER region wants therefore to use at the best of its capacity scanning, modelling and manufacturing technologies for the production of **customized orthotics, exoskeletons and exoprosthetics**, which can potentially benefit considerably of the modern 3D printing.

In particular, ER has large experience on

- **ORTHOSES:**
Plantar orthoses and orthotic insoles for foot care (pathological conditions, but also comfort, safety, and sport), as well as joint orthosis, for the treatment of lower and upper limb joints (splint, joint braces, etc.), for spine and neck.
- **EXO-SKELETONS AND EXO-PROTHESES:**
Multi-component passive or active devices used for supporting or rehabilitating or replacing parts of the body with functional deficits; in particular the shells and sockets in contact with the body segments are addressed.

In this respect, the current technology and market can be classified as here below, where the general status for TRL is also reported, according to our knowledge.

TABLE 1	Mono-material	Multi-material	Electronics embedded
<i>Orthosis</i>	TRL8-9	TRL5-8	TRL2-4
<i>Exoprostheses or exoskeletons (shell, socket, etc.)</i>	TRL7-9	TRL5-8	TRL2-4

It is intended that the priority in addressing these issues is along the columns here above, i.e. mono-material first, multi-material and electronics embedded (sensors, device, interfaces etc.) to be taken on board in a later wave of activities.

For both types of products, the present pilot line is going to develop the following activities:

- i. Surveying the current state-of-the-art;

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- ii. Selection of major potential demonstration and exploitation areas, in relation to typical applications for technology demonstrations;
- iii. Develop complete procedures for the full process from imaging scans to final devices, which includes reliable instruments, robust computer based modelling and analyses, design, check;
- iv. Develop relevant material and design strategies , as well as reference geometries and mechanical stiffness according to the anatomical complex, the target person/patient, and also in relations to functional requirements for each component application;
- v. Develop adequate 3DP processing parameters;
- vi. Develop adequate interface treatments for active sensors and actuators to be integrated;
- vii. Produce a number of components for the feasibility and mechanical testing phase: safety, static, fatigue, wear, etc...;
- viii. Develop a complete basic testing campaign: toxicity, bacterial adhesion, antifungal susceptibility, biofilm formation etc.
- ix. Develop a complete functional testing campaign: wearability, mobility, stability, efficacy, etc.;
- x. Start relevant clinic trials with a coordinated Lab / Hospital inside the ER health-care system.

SECTOR	SUBSECTOR	MATERIALS	TECHNOLOGIES	RESEARCH Infrastructures
Orthopedics ; Physical Medicine and Rehabilitation; Neurology	Personalised Orthoses, exoskeletons and exoprosthetics	PLA, ABS, PPL, etc. Biocompatible materials (ISO certified resins)	3D Printing conventional technologies FDM (Fused Deposition Modelling) Reverse Engineering technologies High Performance Laser Scanner 3D System sense scanner CAD Technology Modelling Software Instruments and techniques for functional assessments	Istituto Ortopedico Rizzoli (IOR), University of Bologna (UniBO), Mirandola Science and Technology park for Medicine (TPM); Centro Protesi INAIL in Budrio – Bologna (INAIL)

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				Mechanical testing machines	
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- Assessment of the “distance-to-market” (TRL 5, 6, 7 or 8) and of the business potential for the own companies. Please list also the companies which would be expected to participate (including ‘lead users’).

See also Table 1 above. In the following, only the mono-material area is dealt with.

SECTOR	SUBSECTOR	TRL (see Annex 1)	RESEARCH Infrastructures	COMPANIES
Orthopedics; Physical Medicine and Rehabilitation; Neurology	Personalised Orthoses	8-9	UniBO, IOR, TPM, INAIL	
Orthopedics; Physical Medicine and Rehabilitation; Neurology	Personalised Exo-skeletons	7-9	UniBO, IOR, TPM, INAIL	
Orthopedics; Physical Medicine and Rehabilitation; Neurology	Personalised Exo-prostheses	7-9	UniBO, IOR, TPM, INAIL	

- Description of the key assets of the regions participating

<ul style="list-style-type: none"> Research/testing facilities Emilia-Romagna has important research centres working on modelling and 3D printing for the healthcare sector, as mentioned above: University of Bologna (UNIBO), Rizzoli Orthopaedic Institute (IOR), Mirandola Science and Technology Park for Medicine (TPM), University of Parma. These institutions have a large number of laboratories, which are involved also in

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many research collaborative projects with local, national and international industries. The collaboration can work in both directions, i.e. research findings from labs to be translated to industry, and also research facilities to be offered to industry and its research teams.

-
- Companies / manufacturers
 - Design companies:
 - Software producers:
 - Material producers:
 - 3DP producers:
 - Lead users:
 - Orthotics and prosthetic producers ()
 - Traditional biomedical companies ()
 - 3D printing services ()
 - Instruments and software ()
-
- Clinics
 - IOR – Rizzoli Orthopaedic Institute, Bologna
 - Bologna University Hospital Authority St. Orsola-Malpighi Polyclinic

- What is the added value of **joint** demonstration activities here?

Value chain is covered on process, design, post-process and leading applications in healthcare sector with leading players.

Beyond the feasibility of the envisaged production chain, the joint demonstration activities carried out in this project will demonstrate the possibility to go through full personalized healthcare assistance, changing the offer of products and services.

The execution of the entire chain, from the subject/patient to be treated to the validations tests of the best possible final products, will demonstrated not only the feasibility of this high performance production through 3D printing but also the efficacy, though preliminary, of the relevant products.

- Does the current group of participating regions still miss competencies / assets to further develop and implement joint-demonstration? If yes, which additional ones should be sought?

The present group of participating regions do not miss fundamental competencies / assets

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necessary to further develop and implement these joint-demonstrations.

- Description of a first set of common demonstration activities.

A first set of demonstration activities can be the following:

- Personalised insoles for better foot to shoe interface in the context of safety-shoes and sport;
- Personalised braces and orthosis for the human wrist and the ankle joints;
- Personalised sockets prostheses for total knee and total ankle joint replacement

A series of sawbones and specimens will be utilized to keep validating the present procedures. 3D scans, medical imaging and relevant modelling are first performed on these. Corresponding devices (orthotics and prosthetics) manufactured via 3DP, in various possible shapes and materials. Experiments for functional and mechanical validation to be performed eventually.

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Annex 1

Our consideration of TRL are based on the specific application into the Life Sciences sector where regulatory is mandatory for market access. See below a scheme of TRL modified with this principle.

Table Technology Readiness Levels based on those of the European Commission with modifications based on the US Army Technology Readiness Levels for a pharmaceutical product² [in blue]

Technology Readiness Level	Description
TRL 1.	Basic principles observed [scientific technical watch maintained]
TRL 2.	Technology concept formulated [research ideas and protocols are developed]
TRL 3.	Experimental proof of concept (PoC) [Hypothesis testing and initial proof of concept (PoC) is demonstrated in a limited number of <i>in vitro</i> & <i>in vivo</i> models]
TRL 4.	Technology validated in lab [PoC and safety of candidate formulation/device or system is demonstrated in a defined laboratory or animal model]
TRL 5.	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) [Pre-clinical studies, including GLP animal safety & toxicity, sufficient to support further trials]
TRL 6.	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) [Phase 1 clinical trials support proceeding to phase 2 clinical trials or Class III device safety is demonstrated and in line with predictions]
TRL 7.	System prototype demonstration in operational environment [Phase 2 clinical trial is completed. Phase 3 clinical trial plan is approved. For devices the final product design is validated and final prototypes are produced and tested]
TRL 8.	System complete and qualified [Phase 3 clinical trial is complete and licencing/authorisation given. For devices market approval given]
TRL 9.	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies) [Post marketing studies and surveillance]

5.2 Case for joint-demonstration “Hybrid materials 3D Printing for Automotive components”

Leader: Emilia Romagna; **Co-Leaders:** Aragon, Norte, Baden-Wurttemberg, Saxony, Rhône-Alpes.

Positioning Note

- Description of the application(s) envisaged, with detailed description of the combination ‘Technology-Material-Infrastructure-Services’ (TMIS)

The automotive sector is facing a most deep transformation in its manufacturing techniques and materials for the drastic reduction in overall car weight determined by the need to reduce CO2 emissions. Many lead car manufacturers agree that this weight reduction will be obtained by integrating different functions and different materials in complex hybrid components for many applications. At the same time, the increasing capability and reliability of additive manufacturing techniques, in particular for producing full density metal parts without shape limitations, gives the opportunity to develop in a very fast way, and without further machining, high resistant interfaces, thus overcoming typical limitations of conventionally produced metal components. This project is going to demonstrate innovative hybrid materials components based on 3DP metals – CFRP (Carbon Fiber Reinforced Plastics) combinations for different applications in the automotive sector such as hard trim interior products, structural elements, external components, and powertrain elements. Specifically, this Pilot “3D Printing of Hybrid Materials”, will exploit technological capabilities of such combinations in order to provide a basis for the next generation of ultra lightweight construction methodologies for mass production.

The concept of the project is based on 3D printed metal inserts, properly designed and treated, that will be used as inserts in CFRP forming processes in order to obtain higher functional characteristics of the final components owing to the integration, within the same components, of CFRP and metal specific advantages.

In addition, the project will develop the technology chain for the production of complex tooling for the automotive industry, where AM will be used in combination with conventional machining. This hybrid additive/subtracting technology will exploit the natural ability of the AM technology for complex and freeform fabrication with the requirements of high precision and surface aspect of tooling. Tools for investment casting, injection molding, sand casting and composite materials processing will be rapidly manufactured for the whole range of small to large production of components.

The project will then use specific advantages of the adopted technology chain:

- The 3D laser melting technology to create full density metal inserts with the highest mechanical properties and structural homogeneity;
- the 3D additive technology capability to create complex free-form geometries in order to increase the bonding resistance at the metal-CFRP interface;
- the availability of the 3DP laser melting source in order to provide a laser cladding treatment of the 3D printed insert interface, in order to provide best chemical and physical conditions for a strong and durable bond;
- the newest technology for CFRP mass production, based on in-mold cure of the resin preform.
- The fast production of tooling of high complexity, in combination with conventional machining, with freeform capability of conforming cooling channels

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The pilot line is going to develop the following activities:

HYBRID METALS-CFRP

- 1) Selection of some demonstrators in relation to typical applications for technology demonstration;
- 2) Develop materials and design strategies for inserts, as well as the relative interface geometry in relations to functional requirements for each component application
- 3) Develop materials and design strategies for CFRP part together with final component requirements
- 4) Develop adequate 3DP processing parameters for inserts
- 5) Develop adequate interface treatments for high bonding strength
- 6) Develop adequate CFRP molding technique for high productivity/high strength
- 7) Produce a number of components for testing phase
- 8) Develop a complete testing campaign: static, fatigue, thermal, corrosion...

The use of cutting-edge technology will be aimed at maximizing production rate and at the same time minimizing or avoiding subsequent machining or finishing needs, in the typical near-net or net shape condition.

HYBRID ADDITIVE - SUBTRACTING

- 1) Selection of demonstrators for different tooling applications
- 2) Part design optimization
- 3) Develop adequate 3DP processing parameters for tooling AM manufacture
- 4) Develop fast machining techniques of material allowances
- 5) Produce a number of components for testing phase
- 6) Develop a complete testing campaign: static, fatigue, thermal fatigue.

For both lines the reference market will be the automotive industry, with particular attention to improving the mechanical properties of the components, including specific strength and stiffness, while seeking to increase productivity of additive and hybrid-additive techniques.

- Assessment of the “distance-to-market” (TRL 5, 6, 7 or 8) and of the business potential for the own companies. Please list also the companies which would be expected to participate.

HYBRID METALS-CFRP

The distance-to-market of each technology involved in the project is TRL8-9. In particular:

- Laser melting-based additive manufacturing techniques are at TRL9; molds and tools with conform cooling channels are already produced for numerous industrial applications such as die casting of metals, injection molding of plastics, extrusion dies...

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- Laser cladding is a well-established coating technology that is particularly suited for high performance application in various industrial sectors; hard coatings and corrosion resistance coatings are built on almost any kind of substrate. TRL9 is proven.
- In-mold cure of CFRP is an increasingly used technique in the automotive sector for producing parts with high production rate; this process has already been adopted for structural parts. TRL8-9 is the current state of the technology, where the TRL8 is still related to the difficulty to assess surface appearance and dimensional tolerances on large size components.
- Metal-resin interfaces are already present in the automotive sector in the well-known “Carbon Wheels”, in which a CFRP wheel is inserted with a metal core.

HYBRIDE ADDITIVE-SUBTRACTING

The distance-to-market of each technology involved in the project is TRL8-9. In particular:

- AM by laser melting and laser sintering are well established manufacturing techniques for tooling, especially for investment casting and injection molding
- AM solution of several materials for tooling are present in the market, e.g. Binding Jet Sand AM for foundry or Wax AM for investment casting
- Machining of AM material allowances on tooling only needs standardization techniques to be fully integrated in the process chain

Thus, the full availability of each part of the technology chain is thus well established. On the other hand the Pilot line of this project will demonstrate the possibility to build a new concept of mechanical component in which a superior requirement of stiffness/weight ratio can be obtained without sacrifice of overall dimensional and geometric tolerances, extending the technology capability to a wide range of applications, not only in the automotive sector.

The aim of this project is proving the flexibility of this technique in relation to many possible final applications, to assess concerns about interface durability of construction, by deploying specific design and manufacturing strategies and, at the same time, developing an accurate testing campaign of the obtained products and setting reference standard for manufacturers.

Of particular interest will be also the possibility to concept mechanical components in which the designer has the possibility to use metals in those positions of the component where further machining and assembly is required, while adopting the lightest available material in all the rest, without detriments in other function or manufacturing aspect.

BUSINESS POTENTIAL OF COMPANIES

- High performance part
 - o TRL from 5 to 8
 - o Potential: New design and competitive products, higher performance, complementary existing post-process competences, Faster penetration of the

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<p>market, faster production, bridge production, new solutions, new design (thinking),</p> <ul style="list-style-type: none"> ○ Emilia Romagna companies: Ferrari, Maserati, Lamborghini, Dallara, Ducati. ○ Aragon Companies - Potential Users: AERA (Aragon Aeronautical Cluster), CAAR (Aragon Automotive cluster) companies and tooling producers and Aitiip Technological Centre: moulds and dyes producers, (interested in substituting parts that have to move at high speed or need fast cooling or complex shapes). Main names: Aernnova – NMF, Alumalsa, Moldes Cereza, MoMo, Brembo, MYPA, UMEC, Composites Aragón, Sallén Aviación, Celulosa Fabril, INYMON, Thermolympic, Algotec, Zatec, MRA, KDK,... ○ Norte companies: MCG, DISTRIM, INAPAL, SODECIA, FAURECIA, SUNVIAUTO <p>- Rapid tooling</p> <ul style="list-style-type: none"> ○ TRL from 7 to 8 ○ Potential: fast production of highly complex tooling, high performance, new solutions ○ Companies (other than automotive): Automatic machines for packaging and pharma. ○ Norte companies: SOCEM, IBEROMOLDES, SIMOLDES, DISTRIM, SET, DIMLASER, EROFIO
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• Description of the key assets of the regions participating

EMILIA ROMAGNA

Research

ER Region has a cluster of laboratories for industrial research participated by universities, public research institutes and private companies. Among them CIRI MAM www.mam.unibo.it , MUSP www.musp.it EN&TECH www.enetech.unimore.it IMAMOTER-CNR www.imamoter.cnr.it and others. By the network are actually available equipment for:

- Additive manufacturing of metals (SLM and SLS)
- Laser surface structuring (hardening, sculpturing)
- laser cladding and welding
- CFRP production (in autoclave and out of autoclave)
- Material testing and characterization (mechanical properties, tribology, microstructure evaluation, SEM analysis, conductivity, corrosion, fluid viscosity of resins)
- Design and simulation of structures, isotropic and non-isotropic;
- Advanced process simulation: heat transfer for lasers processing, microstructure evolution and phase transformation, foundry processes, metal forming, polymerization, cavity filling.

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Companies

Emilia-Romagna is a European leader region in the production of high performance vehicles including cars and motorbikes (Ferrari, Maserati, Lamborghini, Dallara, Toro Rosso, Ducati, Malaguti, Moto Morini), CFRP Industry (Riba, Reglass, CAM, Modelleria CPC and others), automotive components such as Magneti Marelli and VM Motori (FCA), as well as foundry and tooling companies.

ARAGON

Research

- From a short, medium and long term new applications, products, production system and high advance technological services. From low TRL to industrial serials.
 - AITIIP (Technological Centre www.aitip.com) – 3DP of metals and plastics including nanocomposites. Capacity of research, development and service bureau in 3DP from 15 years ago.
 - UNIZAR (University of Zaragoza www.unizar.com)
 - ITAINNOVA (Technological Institute of Aragon www.itainnova.com)

Companies

The automotive industry in our region Aragon, it is KEY, a huge concentration of industries is dedicated to this sector.

It was 2007 when, following a diagnostic study of the automotive sector in Aragon carried out by the Technological Institute of Aragon, it was found that the most innovative regions of our country with an automobile production plant all had an automotive cluster.

In 2013, our automotive companies employed over 6,800 people and had a turnover of more than EUR 1,400 million. Our clients were the leading Spanish car manufacturers – it must be remembered that most car manufacturing plants in our country are located within 300 miles from Zaragoza. But our products are not only sold to Spanish plants but also directly exported to various European plants, which account for approximately 35% of our turnover.

NORTE

The Norte region is characterized by SME companies working for the automotive industry spread by several sectors and a network of R&D entities that work in close collaboration. Following is a description of entities with interest for this project divided by organization type:

Research Centers

Universities and research institutes with expertise in AM holding rapid prototyping equipment. In addition to the AM equipment advanced skills exist in post processing related to conversion technics for metal (investment and sand casting) and composite materials processing. In this group we can find the University of Porto, Minho and Aveiro, with their Technological Institutes,

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INEGI, PIEP and CICECO among others. All these institutions also hold strong competences on characterization of AM parts and AM materials.

Car Components Manufacturers

The Automotive industry in Norte Region is characterized by some 1st tier companies and mainly 2nd tier manufacturers. Main fields of activity are sheet metal working (stamping, welding, painting, coating), foundry (sandcasting, high pressure die casting, ...) and plastic and composite materials (injection molding, sheet molding compound, hand lay-up, resin transfer molding, reaction injection molding, ...). These companies are suppliers of the main car makers like Renault, VW, PSA, Audi, Mercedes, etc.

Tool and Mold Makers

Portugal and Norte region in particular is well known for its Mold making capacity and competences for automotive production. The main final application typically are the manufacturing of injection mold parts, GFRP manufacturing, stamping, foundry for Car Components Manufacturers. These companies although potentially users and interested in this subject are still using AM (metal and polymer) technologies for product and engineering developments so must be strongly encouraged to change their AM referential to parts manufacturing.

- What is the added value of **joint** demonstration activities here?

Value chain is covered on AM process, Design, Post-process and leading applications in automotive sector with leading players

Beyond the feasibility of the envisaged production chain, the joint demonstration activities carried out in this project will demonstrate the possibility to build a new concept of mechanical component in which a superior requirement of stiffness/weight ratio can be obtained without sacrifice of component durability, structural safety and overall dimensional and geometric tolerances, thus allowing drastic weight reduction for the automotive industry and other industrial sectors.

The aim of this project is proving the flexibility of this technique in relation to many final applications, to assess concerns about interface durability of construction, by deploying specific design and manufacturing strategies and, at the same time, developing an accurate testing campaign of the obtained products and, also, setting reference standard for manufacturers.

Of particular interest will be also the possibility to concept mechanical components in which the designer has the possibility to use metals in those positions of the component where further machining and assembly is required, while adopting the lightest available material in all the rest, without detriments in other functional or manufacturing aspect.

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The complete integration of design-for-additive-manufacturing and high production CFRP manufacturing has, however, not been realized yet. The present project will be undertaken in a environment in which the synergy of specialist research institutes, complemented by the market and production knowledge of industrial partners, will create a European network for the construction of next-generation products and manufacturing techniques with higher efficiency and flexibility, greater mechanical performance and reduce time-to-market. The three key elements will be design, production and testing, all of which will be integrated to create a reliable process.

- The joint demonstration activities will be structured between the three regions as follows:
 - **Emilia Romagna**
- Early conception of new products for frame components and other structural elements, as well as drivetrain and powertrain components
- Development of new hybrid and flexible manufacturing processes for metal, plastics, composites and hybrid products. In particular these activities will be carried out:
 - a. Laser processing of inserts and metal parts
 - b. surface structuring
 - c. CFRP integration
 - d. machining
- Development of testing standards for hybrid products, in order to guarantee properties and performance capabilities of the demonstration automotive components. In particular fatigue tests, as well as corrosion resistance, interface integrity, impact resistance.
- **Aragon**
- Design of new product concepts in 3DP mainly the following products: Hard trim (interior products), Structural elements and external components, Drivetrain and Powertrain. In particular these activities will be carried out:
 - a. CAD and Design for Manufacturing
 - b. Simulation
 - c. FMEA and FMECA
- Preparing facilities for the development of new manufacturing automated, hybrid and flexible manufacturing processes for metal, plastics, composites and hybrid products
- Develop security testing of products, performance capabilities and properties of the automotive components, by specific Security Test facilities present in Alcañiz (Formula 1 circuit – Zaragoza)
- **Norte**
- New Design concepts with complex shapes, topology optimization, and light weight structures;

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- Sustainable design and Environmental impact of AM and Hybrid vs Conventional Technologies;
- Technical and Economic Assessment of AM and AM + Subtractive Process vs Conventional Technologies;
- Direct 3DP of Metal and Indirect Metal and composite materials parts manufacture by using AM or AM + Subtractive tooling;
- Post-processing methods to improve part characteristics;
- Closed loop monitoring (sensors techniques) and control of AM processes;
- Sample manufacture and Testing/Characterization (tensile, static, dynamic and fatigue, microstructure, x-ray, dimensional and geometrical, Digital image correlation, 3D measurement with structured light and photogrammetry).

INTEGRATION OF ACTIVITIES

Within this project, Emilia Romagna, Aragon and Norte have a very high grade of complementarity; in particular in Aragon, having a strong competence in design, will support the other two regions in the design concept of new components and also in design for manufacturing activities, FMEA and simulation. On the other hand, Emilia Romagna will be primarily focused on processing/manufacturing activities, by the strong capabilities on laser manufacturing and CFRP production, but also on final testing of hybrid components; finally, Norte will be more focused on design and manufacturing of Metal/Indirect Metal and composite materials, supporting the other two regions on Testing/Characterization of hybrid components.

PLANNING AND INFRASTRUCTURE LINKING

Once the demonstration components will have identified, specific tasks for the three Regions will be set, together with the activity/time general plan and scheduling of periodic meetings. In this phase, particular attention will be given to efficient linking the research infrastructures of the three Regions, in order to create fast tracks for information and products exchange. The linking process will in particular cover operational and physical activities, such as a unique environment for design and simulation, process methodologies, instruments and methods for testing.

DISSEMINATION

In order to facilitate access to larger community of lead users, a web site of the project will be created very soon, allowing the communication of the demonstration activities developed (in open area), as well as the gathering of all relevant technical information and deliverables (in restricted area).

EXTENDING SERVICES

During the development of the demonstration activities, the coverage of technologies and materials, as well as of the service provided, will be progressively increased to a larger number of

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companies (both components manufacturers and final users), also beyond the automotive sector.

- Does the current group of participating regions still miss competencies / assets to further develop and implement joint-demonstration? If yes, which additional ones should be sought?

No competencies or assets are lacking from the current group of participating regions.

- Description of a first set of common demonstration activities.

The project scope will include the optimization of design-for-additive-manufacturing, production and technological implementation and development of efficient testing techniques and associated common standards. The first set of common demonstration activities will include the design, manufacturing and testing of components with simple geometries where all processes can be optimized and refined.

Techniques of design for AM components will be developed, in particular including aspects for early cost estimation, effect slicing direction, conforming channels geometry and position, integration with numerical simulation, CAM of further machining.

In terms of production and technological implementation, the following will be performed:

- Establish component properties and characteristics (strength, stiffness, density, accuracy etc.) as functions of process parameters including laser specification, material characteristics and feed, process path etc.
- Optimize laser surface structuring procedures for optimization of bonding.
- Application of innovative high-production CRFP molding techniques to hybrid components.

The produced components will be tested in terms of mechanical properties (both static and dynamic), overall precision, surface appearance, durability.

In this way, the necessary knowledge required for the design, production and testing of more complex components will be acquired, including the necessary network links between the various regional partners. Following this first set of common demonstration activities, test samples will be produced in correspondence with mechanical components specified by industrial partners so as to demonstrate process effectiveness and feasibility. New materials and combination of materials will be evaluated, when required by the particular application developed; the process chain will be progressively improved by integrating sequences and optimizing process parameters. Finally, the pilot will focus on setting standards and certifications required for quality assurance of final products.

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5.3 Case for joint-demonstration “Creative industries: Customized Consumer Goods in Fashion, Furniture, Lighting and Visual Communication”

Leader: Catalonia; Co-Leaders: Flanders, South Netherlands

Positioning Note

- Description of the application(s) envisaged, with detailed description of the combination ‘Technology-Material-Infrastructure-Services’ (TMIS).

Creative industries is defined as those industries which have their origin in individual creativity, skill and talent and which have a potential for wealth and job creation through the generation and exploitation of intellectual property⁵⁵. One of the areas which today has more meaning and potential use of additive manufacturing / 3DPrinting belongs to this sector and it is concentrated on the production of customized consumer goods. This is because they meet most of the aspects that give meaning to use this type of manufacture: small series, complex geometries, customization, on demand production, etc. Besides that, another equally important aspect is that this market is mainly shared by small and medium enterprises for which the mass adoption of 3DP in their production requires capabilities that they cannot cope alone, capabilities ranging from design through production to product certification.

This Joint Demonstration initiative is intended to address **Customized consumer goods** in the domains of:

- **Fashion:** Jewellery, Footwear, Accessories, Wearables (Watches, Glasses, Sunglasses...), Props and costumes (Atrezzo, Masks...)
- **Furniture and lighting:** Small and medium furniture and lamps for homes, offices, public spaces and hotels.
- **Visual Communication:** Advertising, Promotional products, Fooding, Culture area, and Signage.

by providing technological and know-how capabilities covering the whole value chain:

- Novel Design tools and skills for Additive Manufacturing of customized consumer goods.
- 3DP of Metal / Polymer / Ceramic and Composite parts.
- Integration with conventional manufacturing and assembling technologies to achieve required tolerances and surface finishes.

⁵⁵ Creative Industries: Focus on Employment. June 2014. Department for Culture, Media & Sport (UK)

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- Testing equipment to assess durability, reliability, mechanical & chemical resistance, accuracy, security and safety, etc.
- Product certification.
- Education and training in additive manufacturing: Processes, materials, applications and economics.
- Support in developing appropriate business models for customized consumer goods.

- Assessment of the “distance-to-market” (TRL 5, 6, 7 or 8) and of the business potential for the own companies. Please list also the companies which would be expected to participate (including ‘lead users’).

The business potential is reflected in following data ⁵⁶:

- In 2011, the core creative industries in the 27 countries of the European Union generate €558 billion in value added to GDP, approximately 4.4% of total European GDP.
- The creative industries represent approximately 8.3 million full time equivalent jobs, or 3.8% of total European workforce.
- Employment in the total creative industries (core creative industries plus non-core creative industries) is approximately 14 million, or 6.5% of the total EU workforce.
- Only in the UK economy, the gross value added (GVA) of the creative industries increased by 9.4 per cent to £71.4bn in 2012, accounting for 5.2 per cent.

Creative industries are already using AM/3DP technologies and have been one of the early adopters for manufacturing customized consumer goods, but the sector could take much more advantage from the widely adoption of these technologies, the newly set up of value nets (instead of value chains) and the integration of AM/3DP with complementary conventional assembly and finishing technologies, in order to build more solid business, more enduring and with greater economic capacity.

The maturity of the technology to build geometries is high (TRL 6-7) but some important issues must be improved in order to deeply engage companies of this sector into the massive adoption of AM/3DP:

- In terms of design:

Generative algorithms to develop more innovative and complex geometries, software simulation tools and training and educational material to take profit of their potential.

- In terms of materials and processes:

⁵⁶ The economic contribution of the creative industries to EU GDP and employment. Evolution 2008-2011. TERA Consultants, Paris, September 2014.

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Increase of available materials, capacity to build directly coloured parts, capability to build with affordable costs –AM/3D Printed parts must be cheaper- that implies higher manufacturing sizes, quicker building processes and more automated cleaning and finishing processes like polishing and coating.

- In terms of product validation

Easy access to Testing, ageing and Certification facilities and services.

- In terms of business development:

Easy access to consultancy services for developing new strategies for market introduction and starting new businesses, based on AM/3DPrinting.

Companies which would be expected to participate:

Growthobjects is expected to take a leading role in design and training.

In Fashion:

Jewelry: Tous, **Mayoral**, Rabat.

Footwear: Louis Vuitton, Munich.

Accessories: Louis Vuitton, MadreMíaAmorHermoso.

Fuctionalized Textiles: Louis Vuitton, Desigual, Custo Barcelona, MadreMíaAmorHermoso.

Wearable: **Indo**, **Optim**, Woodys Barcelona, Etnia Barcelona, Rabat.

Props and costumes: La Fura dels Baus.

In Furniture and lighting: LedsC4, Vibia, Lamp, Estiluz, Metalarte, Santa&Cole, Marset, Roca, Magma design.

In Visual Communication:

Advertising: Morillas, Bassat Ogilvy.

Promotional products: Puig, Tatay, Moritz.

Fooding: Lekué, Bulli Foundation, Pere Gifré.

Culture area: Cosmocaixa

- Description of the key assets of the regions participating

- research/testing facilities

- Leitat: Industrial R+D+i Centre with demo platform for 3DP (3 technologies in house, design and whole process integration, finishing, coating, testing and certification)
- Fundació CIM: Industrial R+D+i Centre with demo platform for 3DP (4 technologies in house, design and whole process integration, finishing, coating)
- Eurecat: : Industrial R+D+i Centre with demo platform for 3DP (3 technologies in house, design and whole process integration, finishing, coating)

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- Cetecom, Industrial R+D+i Centre with demo platform for 3DP (1 technology in house, design and whole process integration, finishing, coating, testing in composite materials)
 - IAAC for fundamental and applied research on materials, design, processes and post processes in the field of Architecture.
 - IQS, CNM, CVC, UPC for fundamental research on material, design, post process and testing. Different AM/3DP technologies available at their facilities.
- companies
 - Design companies: Growthobjects, Milà, Cunicode...
 - Software producers: McNeil, I2Cat, CIMNE
 - Material producers: Oxolutia, Colorfila, Venair,...
 - 3DP producers: HP, RepRapBCN, Stalactite, Oxolutia, Venair, Ultrason, Natural Machines..
 - Lead users: (See list above-mentioned)
- What is the added value of **joint** demonstration activities here?

Assess and demonstrate the added value potentially consisting of :

 - exploiting existing complementarities
 - linking infrastructure and knowledge to create critical mass
 - getting access to larger community of lead users
 - increasing coverage of technologies and materials, expanding services to lead users
- Does the current group of participating regions still miss competencies / assets to further develop and implement joint-demonstration? If yes, which additional ones should be sought?

- Facilities with: Material Jetting, Lamination and Direct Energy Deposition technologies
 - Facilities with more production capacity: Large format systems (FDM, Material Jetting, Binder Jetting)
 - Facilities with capacities to provide AM/3D Printed parts made directly in colour.
 - Open facilities for surface finishing: polishing, painting, metal coatings...
 - Developers of new materials
 - Design software developers.
- Description of a first set of common demonstration activities.

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Further develop activities' program consisting of:

- Machine tuning for industrial production (metal, ceramic, polymer) under industrial parameters of quality, reliability, speed, repeatability, durability and costs.
- Investigating AM technology capability (in terms of roughness, dimensional and geometrical accuracy, internal defects).
- Demonstration for AM technology integration in industry
- Testing and validation of parts produced by AM.
- Testing/validating new design for creative products under parameters of Minimum viable product (MVP)
- Training for design adapted to AM process
- Improving test methods / certification processes

5.4 Case for joint-demonstration “Additive Subtractive platform” ”

Leader: region Flanders; Co-Leaders: regions Wallonia, South-Netherlands, Baden – Württemberg, Norte

Positioning Note

- Description of the application(s) envisaged, with detailed description of the combination ‘Technology-Material-Infrastructure-Services’ (TMIS)

An important challenge for the European manufacturing industry is to combine the potential benefits of 3DP with the ever increasing need for high precision, high finish products.

Future success will largely depend upon the smart, efficient combination of existing technologies (eg laser assisted milling of 3D printed ceramic wear resistant precision components). However, as it encompasses a complete production line, the needed investments are high and feedback on the economic viability of the chosen process combinations will only become visible after the investments have been done. This issue proves to be very challenging to large companies as well as SME’s in the manufacturing sectors. The foreseen demonstration action is thus oriented more specifically towards smart combinations of relevant existing additive-subtractive-measuring-transportation-automation-finishing technologies to enable a quick, professional analysis of possible production process set-ups by the participating companies.

The “Additive Subtractive high precision & high finish production” pilot line idea will focus on several, geographically dispersed physical hybrid machine flow set-ups from raw material to high precision, high finish products & components, thus creating a network of open, connected, flexible production innovation hubs.

Doing so, an environment can be created where (machine) technology providers from all over Europe can work together with lead users around new materials, new processes and new products.

The ultimate goal is to realise a (digitally) networked production platform able to produce in a cost effective way one piece or small product series with an extreme high precision, finish and added value, combining additive and subtractive technologies for non-market specific applications :

- Titanium **aerospace** component
 - Goal: re-design the component to arrive at a cost effective production process for small to medium sized series
 - Challenges: lightweight, complex shape, tight tolerances

Deliverable D2.2

- Functional prototype for validation of a tool design (eg hardened metal component of a metal **extrusion** tool)
 - Goal: replace a trial-and-error design proces of tool inserts with a functional piece to construct a 1st series product
 - Challenges: complex shapes, surface quality
- Personalized **medical** CoCr component
 - Goal: get surface quality under control (mirror surface at one side, rougher surface at other side)
 - Challenges: surface quality, flexible finishing (customized parts, one piece series)
- Functionalised component (eg moving mechanical part like a teathed **automotive** axes)
 - Goal: add additional functionality to a component, like applying mechanical functional texture protected by a covering layer.
 - Challenges: surface texturing, complex shapes
- -- To be completed with examples of polymer, powder bed fusion and potentially also ceramic material applications --

- Assessment of the “distance-to-market” (TRL 5, 6, 7 or 8) and of the business potential for the own companies. Please list also the main companies which would be expected to participate (including ‘lead users’).

Firstly, subcontractors and OEM-customers within the automotive, aerospace and medical markets will be approached. Later also other sectors will be added.

Aim is to approach several participants within several value chains, eg techspace + airbus, ZF Windpower + subcontractors, Caterpillar + SLS, VCST + VW, ...

Involvement of other regions/companies will be facilitated through easy, guaranteed and privileged access to the pilot line infrastructure and IPR valorization. Also participating companies will receive (parts of) proven process trial results.

Income will be generated through paid project based trial set-ups and production runs for participating companies.

- Description of the key assets of the regions participating

Deliverable D2.2

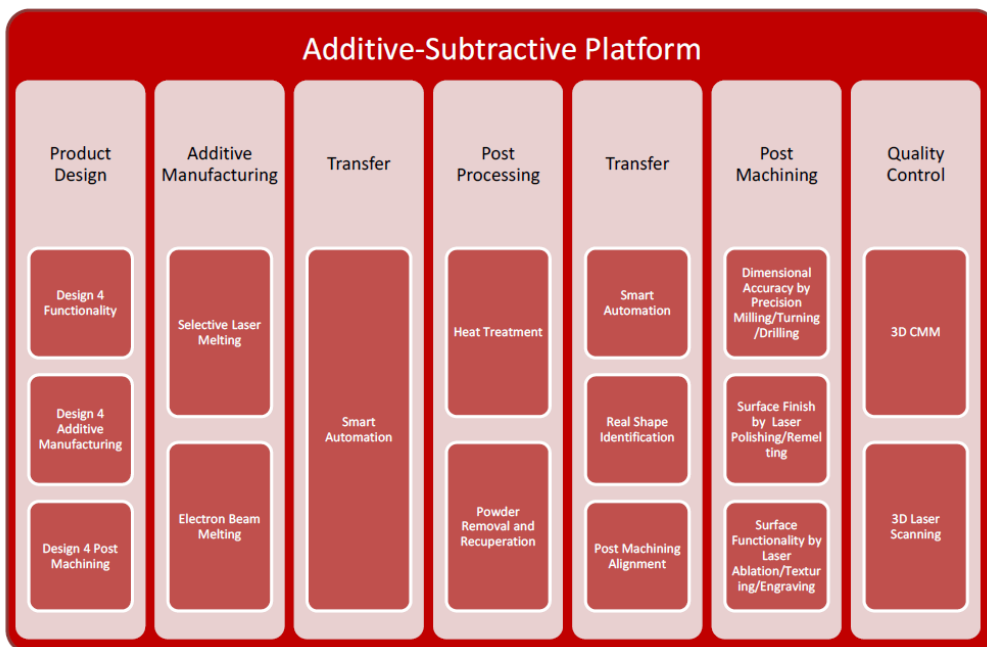
The “Additive Subtractive high precision & high finish production” platform includes all stages from raw material to quality control of the finished component.

The Flanders, Wallonia and ... regions combine a dense population of 3DP companies (Raytech, PowerDust, Vamac, LayerWise, Melotte, Aldema, ...) with a network of precision subtractive subcontractors (ASCO, CNH, Niko, Techspace Aero, AMOS, BMT Aerospace, Borit, Cassidian, Mockel, MSD Metalworking, Picanol, SABCA, Stubbe, ...)

All necessary hardware (additive technology, robots, scanners, precision milling, laser treatment, 3D CMM, ...), software (CAD, CAM, FEM, ...) & related expertise (design, programming, materials, ...) will be combined in one physical pilot line in Leuven (Belgium), and another in ... -- to be completed --.

This pilot lines will be closely linked to the additive and subtractive expertise areas of Flanders (Sirris Diepenbeek & Leuven), Walloon (Sirris Liège & Gosselies) and South Netherlands (Brainport Industries, precision expertise cluster around ASML, FEI, ...)

Metal based platform description:



A first set of needed investments will include :

Deliverable D2.2

Equipment	
Description	Estimated investment
Additive technology	
Selective Laser Machining	€ 500.000,00
Electron Beam Machining	€ 700.000,00
Powder removal and recuperation system	€ 100.000,00
Shot peening	€ 20.000,00
Oven for thermal treatments	€ 250.000,00
Subtractive technology	
High Precision 5 axis Milling	€ 750.000,00
High Precision Lathe	€ 500.000,00
Grinding machine	€ 650.000,00
Wire-EDM	€ 400.000,00
EDM	€ 450.000,00
Electrode milling machine	€ 400.000,00
Milling equipment & tooling	€ 60.000,00
EDM equipment & tooling	€ 45.000,00
Functionalization technology	
Laser texturing machine	€ 500.000,00
Spray coating system (robotic)	€ 750.000,00
Platform automation	
High precision clamping system(s)	€ 75.000,00
Mobile flexible robotic handling system(s)	€ 150.000,00
Automated loading stations	€ 150.000,00
CAM programming software	€ 25.000,00
Quality monitoring system	€ 35.000,00
3D Vision bin picking system	€ 75.000,00
Safety systems	€ 45.000,00
Tracking & tracing system	€ 50.000,00
Gripper technology	€ 50.000,00
Digital production planning system	€ 125.000,00
Quality inspection, monitoring & ensurance	
3D Coordinate Measurement machine	€ 100.000,00
3D Scanner	€ 40.000,00
Confocal microscope	€ 90.000,00
Interferometer	€ 110.000,00
Roughness measurement machine	€ 35.000,00
Coating quality measurement	€ 50.000,00
Environmental (climatization) system	€ 250.000,00
(Micro-) CT scanning	€ 400.000,00
Building and lab conditioning	
Air threathment installation (thermal stability)	€ 150.000,00
Air filtering system	€ 100.000,00
Clean room	€ 750.000,00
TOTAL	€ 8.930.000,00

Next to the hardware, following people support is being proposed :

Personnel	yearly cost
Manager (1 FTE)	€ 100.000,00
Engineering (4 FTE)	€ 320.000,00
Technician (6 FTE)	€ 360.000,00

- What is the added value of **joint** demonstration activities here?

The biggest added value will be the focused 'life demonstration' potential of metal, polymer

Deliverable D2.2

and/or ceramic material based pilot lines in helping production companies from all Vanguard regions assess the effect and opportunities of additive-subtractive combined production processes on their product and production portfolio.

A second added value could be that the pilot lines are 'connected' through digital connection models (e.g. digital design for 3DP, ...)

- Does the current group of participating regions still miss competencies / assets to further develop and implement joint-demonstration? If yes, which additional ones should be sought?

The 4 regions (3 countries) combined have all necessary competences needed.

- Description of a first set of common demonstration activities.

The "Additive Subtractive high precision & high finish production" platform will also be used to perform financial and technical capability studies on specific industrial components. These study results will provide a clear picture for production companies on :

- New additive design opportunities
- Possibilities and needs to get to the required end product spec's (post machining operations)
- Realistic production times and related costs
- Practical translation of pilot line idea to own product portfolio

5.5 Case for joint-demonstration “Machine, Tooling and Complex Parts”

Leader: region Wallonia; **Co-Leaders:** regions Lombardy, Aragon, Catalonia, Norte, Tampere, Rhone-Alpes.

Positioning Note

- Description of the application(s) envisaged, with detailed description of the combination ‘Technology-Material-Infrastructure-Services’ (TMIS)

An important challenge for the European manufacturing industrial sector is not only to be aware of the potential benefits of 3DP but also to minimize risks linked to the integration of 3DP in their products and production processes and maximize the potential economic benefit derived from this still bold move.

This issue is taken up with considerable effort by large companies, but proves still to be very challenging to SME’s in the manufacturing sectors. The foreseen demonstration action is thus oriented more specifically towards this type of companies.

The aim of the acceleration platform is to tackle these challenges by providing complementary capabilities for SME’s where-ever in Europe, covering all development steps from product/parts/systems redesign to first 3DP components qualification (technical and economic)/certification with the maximal efficiency and objectivity.

Linking the existing and growing infrastructures amongst the partners will provide technological and know-how capabilities covering :

- Product redesign with complex internal shapes/technological optimization/ lattice structures
- 3DP of Metal / polymer / Ceramic high performance parts
- CAD-CAM to promote AM friendly product design and manufacturing
- In-line and off-line sensing and testing equipment: to inspect and monitor the quality of the final 3DP parts
- Post-processing capacities to improve part properties (surface coating, heat treatment, hip, vibration chemical grinding,...)
- Integration with traditional subtractive technologies to move towards hybrid manufacturing
- Costs vs performance trade-off: economical evaluation of 3DP as substitutive technology in different sectors
- Direct Plastic or Metal AM for Machinery/systems/products parts using several strategies as Like for like replacement, Like for unlike replacement, Component integration or functional intelligent parts.
- Using AM tooling for small series production of metallic or composite parts for machinery equipment e.g. free form bodywork accessories or foundry parts.

Deliverable D2.2

- Assessment of the “distance-to-market” (TRL 5, 6, 7 or 8) and of the business potential for the own companies. Please list also the companies which would be expected to participate (including lead users).

<ul style="list-style-type: none"> - Metal high performance part <ul style="list-style-type: none"> ○ Non-critical: TRL 7-8, Critical: TRL 5-6 ○ Potential: New design and competitive products, higher performance (combining improved resistance and lighter weight), complementary existing post-process competences ○ Sectors : <ul style="list-style-type: none"> ▪ Advanced system and components producers (complex parts with internal channels for Aerospace, medical, electromechanical systems) ▪ Tooling industry : moulds and fixtures manufacturers (rapid small series tools or specific inserts in tooling) ▪ Machine-tool builders (as integrators of technology in their product or as potential AM machines manufacturer) ▪ Process control and management systems providers (In-line sensing and noncontact systems producers, non-destructive control for AM processes and parts) ▪ Automation process providers (AM produced fixtures, jigs, for assembly line providers, robots integrators, ...) ▪ Material producers (evaluating opportunities of new market in AM materials) ▪ Service providers : consulting companies, AM products providers, design bureaus, Software developers, ... ▪ ... ○ Companies: <ul style="list-style-type: none"> ▪ See list in annex. - Custom part in technical ceramics for small and medium production: <ul style="list-style-type: none"> ○ Medical: TRL 7-8, Foundry: 5-6 ○ Potential: New design freedom and competitive products, higher performance, new materials, shorter time to market ○ Sectors <ul style="list-style-type: none"> • Medical supplier sector : <ul style="list-style-type: none"> • specific medical equipment from chirurgical tools to diagnostic machinery • bio resorbable implants

Deliverable D2.2

- Aerospace sector : SiC parts for thermostable applications
- Tooling sector : machining tools
- Machinery : wear and temperature resistant parts
- Foundry : cores and moulds for IC or conventional casting
- Companies implied in developments : see annex
-
- Plastic parts for demonstration and mass customization
 - TRL: 7-8
 - Potential: Faster penetration of the market, faster production, bridge production, new solutions, new design (thinking),
 - Sectors :
 - Injection moulding companies : production bridging techniques for small to medium series
 - Aerospace for non critical parts
 - Machine manufacturers for non critical or complex parts without major critical temperature or mechanical requirements
 - OEM's for specific components
 - Creative and commodities producers
 - Service providers
 - Software companies
 -
 - Companies: See Annex 1

- Description of the key assets of the regions participating

Walloon data :

- research/testing facilities collaborating in 3DP processes and materials development since more than 20 years
 - SIRRIS industrial research Centre with demo platform for 3DP (8 technologies in house, design and whole process integration, testing and certification)
 - CRM Group for metal material, post-process and testing facilities
 - Cenaero for mathematical modelling
 - ULg, ULB and UCL for fundamental research on material, design, post-process and testing
 - Strong industrial networks support : Competitvity poles (Mecatech, Skywin), sectorial organization (Agoria), industrial clusters (Plastiwin)

Deliverable D2.2

- An existing network of companies active or developing capabilities and applications in 3DP
 - design companies: Mitis, CITIUS, Wow,
 - Software producers: Topol, Geonx,
 - material producers: Hoganas, Magotteaux, Umicore, Total Petrochemical,
 - lead users: Techspace Aero, Sonaca, Kasios,

Lombardy data:

- research/testing facilities
 - AddMe Lab: laboratory for 3DP of metallic components –co-founded and led by one university (Mechanical Department of Politecnico di Milano) and five SME companies (having their own business in Titanium, gas system, inspection and sensing, tooling and laser systems production)
 - +Lab: Politecnico Milano Chemical department – 3DP of ceramics, nanocomposites, 3D mems
 - UniPV: FEM simulation and modeling with special attention on biomedical application
 - University of Brescia
- An existing network of companies active or developing capabilities and applications in AM:
 - Materials and powder companies: Gruppo Sapio, Titalia
 - Tools and moulds: BLM s.p.a., Fonderia Maspero Srl,, UCISAP (Italian association of Moulds&Die prooducers), AITA (Italian association of Additive manufacturing), UCIMU (Italian association of machine tools producers)

Aragón data:

- research/testing facilities
 - From a short, medium and long term new applications, products, production system and high advance technological services. From low TRL to industrial serials.
 - AITIIP (Technological Centre www.aitip.com) – 3DP of metals and plastics including nanocomposites. Capacity of research, development and service bureau in 3DP from 15 years ago.
 - UNIZAR (University of Zaragoza www.unizar.com)
 - ITAINNOVA (Technological Institute of Aragon www.itaipnova.com)
- companies
 - Metal, plastic and software development companies in the value chain mainly connected with the more active and key regional clusters: AERA, CAAR, TECNARA and ARAHEALTH

Norte data :

- research/testing facilities
 - INEGI / FEUP with long experience on 3DP technologies and several 3DP equipment. Large experience combining AM with conventional technologies (Foundry, composites

Deliverable D2.2

and sheet metal working) and post-processing. Testing and characterization know-how and equipment.

- IPL/CDRSP, one of the largest 3DP infrastructure
- University Aveiro, several 3DP technologies and equipment
- Other R&D infrastructure in 3DP
- companies
 - Machinery manufacturers: ADIRA, CEI, EFACEC, TECMACAL, AMOB, CHETO, RICO, FELINO, M.J.AMARAL, AZEVEDOS, SERI, METALOGALVA, ASGO, etc.
 - Tool and Moulds: SIMOLDES, IBEROMOLDES, DISTRIM, SOCEM, EROFIO, SIROCO, RICARDO&BARBOSA, SET
 - lead users: ADIRA, CEI, EFACEC
- other lead users:
 - SAKTI, SONAFI, AMORIM
- Catalonia data :
 - research/testing facilities
 - Leitat: Industrial R+D+i Centre with demo platform for 3DP (3 technologies in house, design and whole process integration, finishing, coating, testing and certification)
 - Fundació CIM: Industrial R+D+i Centre with demo platform for 3DP (4 technologies in house, design and whole process integration, finishing, coating)
 - Eurecat : Industrial R+D+i Centre with demo platform for 3DP (3 technologies in house, design and whole process integration, finishing, coating)
 - Cetecom, Industrial R+D+i Centre with demo platform for 3DP (1 technology in house, design and whole process integration, finishing, coating, testing in composite materials)
 - IAAC for fundamental and applied research on materials, design, processes and post processes in the field of Architecture.
 - IQS, CNM, CVC, UPC for fundamental research on material, design, post process and testing. Different AM/3DP technologies available at their facilities.
 - Tampere data :
 - research/testing facilities
 - Tampere University of Technology (TUT): fundamental research on material, design, post processing, characterization and testing. Different 3DP technologies available with demo platforms (4 technologies in house).
 - Tampere University of Applied Science (TAMK): Different 3DP technologies available (3 technologies in house)
 -
 - companies

Deliverable D2.2

- Machinery manufacturers: Agco, Ata, Bronto Skylift, Cargotec, Katsa, Konecranes, Metso, Sandvik, Tasowheel.
- Tool and Moulds: Logistics, Hetitec
- Automation: Fastems

Rhône-Alpes data

- Research/testing facilities:
 - CEA : technology infrastructures for 3D printing (SLS, DLP), 2D printing (ink-jet, screen printing, gravure printing, flexo printing, slot-die, aerosol jet, laser ablation, ...), 2D printing on non-planar surfaces, powder injection molding, nanomaterial synthesis
 - PEP : technology infrastructure for 3D printing (laser based systems, polymer layer-by-layer deposition), injection and coinjection molding, powder injection molding, polymer process modelling
- Companies :
 - Industrial 3DP Machine developer: **Phenix Systems** (part of **3D Systems group**), **Fives Michelin Additive Solutions**
 - Companies from the **Plastipolis cluster** (France's competitiveness cluster for the plastics industry sector)
 - Metal powder manufacturer: **Poudres Hermillon, LIFCO Industries**
 - Material jetting: **Jet Metal Technologies**
 - End users with interest in additive manufacturing: **Schneider** (electrical systems), **EFI** (sensors, automotive), **ARaymond** (automotive), **Anthogyr** (dental), + various companies specialized in injection molding (which need to fabricate molds by 3D printing) ...

- What is the added value of **joint** demonstration activities here?

Assess and demonstrate the added value potentially consisting of e.g.:

- exploiting existing complementarities:
 - Value chain is covered on AM process, Design, Post-process and leading applications in Aeronautic, spatial, medical, creative and machine component industries
 - Leading players in strategic markets: Aeronautic, Spatial, Medical and Machine components
- linking infrastructure and knowledge to create critical mass, exchange best practices, promote transdisciplinary collaboration, stimulate open creativity :
 - industrial Clusters and competitiveness poles : Mecatech (Mechanical engineering), Skywin (Aero and spatial), PlastWin (plastic industry), Wallonie Design (Design and

Deliverable D2.2

<p>creative), and BioWin (biotech and Health), AFIL (Associazione fabbrica Intelligente Lombardia - AFIL),</p> <ul style="list-style-type: none"> ○ AGORIA federation regroups all the Belgian “technology” industry <ul style="list-style-type: none"> ● Lombardi ○ AITA (Italian Association of additive technology) ○ UCIMU (Italian Association of machine-tool and systems producers) ○ AITEM (Italian Association of machining and manufacturing) <ul style="list-style-type: none"> ● Aragon ○ AITIIP Technological Centre (more than 3000 companies as customers) ○ CAAR (Aragon Automotive cluster) ○ AERA (Aragon Aeronautical cluster) ○ ARAHEALTH (Aragon Healthcare cluster) ○ TECNARA (Aragon Software development cluster) <ul style="list-style-type: none"> ● Norte ○ PRODUTECH (Production Technologies Cluster) ○ POOLNET (Engineering and Tooling Cluster) <ul style="list-style-type: none"> ● Catalonia ○ CEQUIP (Machinery producers Cluster) ○ AEI DirectMan (Advanced Manufacturing Industrial Association). ○ CIAC (Catalan Automotive Cluster) ○ FEMAC (Agricultural Machinery Cluster) ○ Cluster MAV (Advanced Materials Cluster)

- Does the current group of participating regions still miss competencies / assets to further develop and implement joint-demonstration? If yes, which additional ones should be sought?

In the different regions, common needs have been identified to support further projects and joint-developments :

- Industrial 3DP Machine developer
- Components for 3DP Machine developer
- Polymer and Resin producer (Aragon)
- In the development process but not yet on the market :
 - Developers of innovative materials
 - Common (Titanium and Aluminium) metal producers
 - Lead users in component (plane, logistic, satellite,...) assembly, ...
- Design software developers
- More Design experts / Business models consultancy

Deliverable D2.2

- More facilities with: Material Jetting, Lamination and Direct Energy Deposition technologies and with more production capacity and especially for 3DP of metal parts.
- Open specialized facilities for surface finishing: polishing, painting, metal coatings...

- Description of a first set of common demonstration activities.

Further develop activities' program consisting of:

- Machine tuning for industrial production (metal, ceramic, polymer)
- Investigating AM technology capability (in terms of roughness, dimensional and geometrical accuracy, internal defects)
- Demonstration for AM technology integration in industry, using experience built up with lead users to demonstrate to SME's
- Testing and validation of parts produced by AM
- developing and testing new ceramic materials
- testing/validating new design/concepts for high performance machines and tools parts.
- training for design adapted to AM process
- testing different in-line post-process sensors and tools to check and characterize product specifications
- improving test methods / certification processes

Deliverable D2.2

- ANNEX 1: List of companies

<ul style="list-style-type: none"> - High performance metal parts : <ul style="list-style-type: none"> ▪ Potential Users Wallonie : FN Herstal, TechSpace Aero, Sonaca, Thales, CMI, Capaul, Jtekt, moulds and tools manufacturers ... ▪ Potential Users Aragon : AERA (Aragon Aeronautical Cluster), CAAR (Aragon Automotive cluster). moulds and dies producers. Main names: Aernnova – NMF, Alumalsa, Moldes Cereza, MoMo, Brembo, MYPA, UMEC, Composites Aragón, Sallén Aviación... ▪ Potential users Catalunya : Metalquimia, Tesem - Ceramic parts <ul style="list-style-type: none"> ▪ in Medical: Wishbone, BoneTherapeutics, CERUM. ▪ In spatial: AMOS, Lambda X, ▪ In electrical devices manufacturing : FAE (Catalunya) ▪ In Foundry: CPP, WOIT, many foundry companies in Lombardy • Plastic parts <ul style="list-style-type: none"> ▪ WAL : Simonis Plastic, Ecoplast, Procoplast, Citius, Addiparts, Xtensys, Vigo Universal, Cadmes ▪ ARA : CAAR (Aragon Automotive cluster) companies and mainly plastic converters. Main names: Celulosa Fabril, INYMON, Thermolympic, Algontec, Zatec, MRA, KDK) ▪ Software development companies (TECNARA and IDIA clusters companies) ▪ Aitiip Technological Centre ▪ Catalunya : German Boada, Virutex <p>Material Producers :</p> <ul style="list-style-type: none"> ▪ Catalunya : Rovalma (high conductivity steel powders) ▪ WAL : Höganäs

Deliverable D2.2

5.6 Case for joint-demonstration “3DP smart bike”

Leader: Flanders; Co-Leader: Catalonia

Positioning Note

- Description of the application(s) envisaged, with detailed description of the combination ‘Technology-Material-Infrastructure-Services’ (TMIS)

The development of 3D-printing could benefit from marketable combinations of AM and other production techniques. This may particularly reduce the resistance of traditional production companies to incorporate AM into their production – rather than viewing AM as a replacement of “traditional” techniques, AM should be accepted as an additional option. In this sense, such combinations would further unlock the potential of AM.

The 3DP smart bike pilot has built a business case around the concept of 3D and other production techniques, specifically suited for the idea of interregional cooperation and decentralized production: “Any customer” could access an open-source platform, on the internet, and start assembling himself/herself “any bike”, out of different visualized 3D-printed and other parts. “Any designer/producer” worldwide could contribute to the online system, and the bike parts could be produced “on demand”, and assembled at “any” bike construction company.

Any European partner could easily “step in” with compatible parts at any time; there’s also no limit to the number of applications or versions of a certain item: the online platform could give the customer access to a myriad of different bike bells or handlebars.

This application concerns the bike as well as everything that is in its near surrounding of 1m. As such also the clothing of the biker, his shoes or helmet but also extra accessories on the bike can be concerned. Goal is to combine 3D printing (in polymers or metals) with electronics (possibly “printed-on”) to make the bike and its biker smarter, safer, better aerodynamic, reduced vibration and overall performing. Additionally, the concept of the open platform allows for profound customization and the integration with other production technologies would enhance a rapid implementation.

Smart means conscious, interpreting and acting upon captured data. High performing means making the bike or the accessories lighter, more efficient in its function thanks to fully customization as a result of the 3D printing process. Higher performing means also better aerodynamics and reduced vibrations during the use of the bike. Safer means automatic or semi-automatic connection with infrastructure and/or other vehicles to avoid collisions and dangerous situations.

Infrastructure used for this demonstrator will be 3D printers, electronics printers with a service to develop these new applications around the “3DP smart bike”. Materials can envision hybrid

Deliverable D2.2

materials combining plastics of different types or plastics and non-plastics combined to a digital produced part. Materials will involve also smart materials that act upon triggers outside the bike. In some cases, production technology may need to be developed to create answers.

The specific development would be set up as an “open-source” online platform: on one hand, there are customers interested in buying a (customized) bike, on the other hand there is a theoretically limitless number of suppliers of bike parts. They find each other through an online “configurator”. The client can compile his/her own bike by combining the compatible parts which have been posted by “any” designer in the world. The individual bike parts are consequently produced by theoretically “any” production company and assembled in one (new?) company or at the location of a partnering bike producer. This model would hence fully integrate Demand/Design/Delivery (...3D).

Similar platforms do exist, but so far a full integration from idea to delivery of a functional item has not been implemented yet.

Obviously the model could, once existing, easily be copied for the integrated production of totally different products.

This model also allows for numerous sub-cases, of which two have been identified so far:

- The combination AM for production of an inner mold, which is then wrapped with composite/carbon material (automated process – which can, once developed, be copied for numerous technologies). This technology would have an enormous potential in other production areas as well.
- The development of fiber-reinforced connectors – combining light-weight with strength, and integration in the project could mean the final breakthrough of this existing technology.

- Assessment of the “distance-to-market” (TRL 5, 6, 7 or 8) and of the business potential for the own companies. Please list also the companies that would be expected to participate (including ‘lead users’).

Flanders:

- Several bicycle production companies (TRL 6-7-8) (Race Productions N.V. (Ridley bikes), Eddy Merckx N.V. ,
- EC-IS is specialist in applying metrics and technology in critical operational environments TRL 6-7
- Several 3D printing specialist and 3D design/engineering specialist to make large structural shapes TRL 7; software specialists for 3D Printing (3Dee, Materialise, ...)
- (Potential) others: RS Print, Rein4ced, T&M Solutions, Twikit, Bio-Racer motion and others

Deliverable D2.2

- The needed IT-related and design expertise is also readily available. There is specific knowledge on online configurators and on 3D customization software packages (TRL 6 – 8).

Catalonia:

- Bicycle industry is growing in Catalonia due to the massive adoption of this transport in major urban areas and the increasing use of it in the leisure time sports (mountain bike...)
- The creation of the new Sport Cluster with an important contribution of bike sector will foster the use and the business potential for bike makers and ancillary equipment manufacturers. The massive adoption of AM/3DP could be of relevant benefit for them.

The TRL of AM/3DP technologies in order to serve the manufacturing for this sector is 7-8 for parts and components without critical mechanical requirements. And, similar to other sectors, at TRL 5-7 for critical parts.

The integration with “existing” bike parts would allow for quicker implementation of the technology.

The maturity of the technology to build geometries is high (TRL 6-7) but some important issues must be improved in order to deeply engage companies of this sector into the massive adoption of AM/3DP:

- In terms of design: Software simulation tools and training and educational material to take profit of their potential.
- In terms of materials and processes: Increase of available materials, capacity to build directly coloured parts, capability to build with affordable costs –AM/3D Printed parts must be cheaper- that implies higher manufacturing sizes, quicker building processes and more automated cleaning and finishing processes like polishing and coating.
- In terms of product validation: Easy access to Testing, ageing and Certification facilities and services.
- In terms of business development: Easy access to consultancy services for developing new strategies for market introduction and starting new businesses, based on AM/3DPrinting mainly devoted to bike ancillary customized equipment.

The set-up of the open-source Bike platform and the production of a few first parts, would require the following estimated investments:

	number	€ total
baseline study	1	25.000
platform design & architecture	1	100.000
cluster meetings	12	12.000

Deliverable D2.2

stakeholder management	1	100.000
development phase 1 & feedback (5 FTE, 3/4 yr)	1	562.500
development phase 2 & feedback (5 FTE, 1 yr)	1	750.000
hosting, hardware, ...	1	15.000
project management (1 FTE)	1	200.000
dissemination, follow-up	1	15.000
production costs print parts - trials and final parts	1	250.000
fitting & assembly	1	50.000
total estimated investment		€ 2.079.500

The estimated initial investment cost for machine development for continuous composite wrapping has not been calculated as yet; this would already require a separate feasibility study. Experts in the area of machine production make rapid estimated of in between 2 – 6 mio. €

- Description of the key assets of the regions participating

- research/testing facilities:
 - RTD's able to engineer and re-design components of the bike for 3D printing (Flanders, Catalonia)
 - Bike cluster that has sector specific knowledge (Flanders, Included into Sports Cluster in Catalonia)
 - Community of experts in 3D printing to upgrade, develop and beta-test new concepts of machines (Flanders, Catalonia)
 - RTD's able to improve aerodynamic performance of the bike (Flanders, Catalonia)
 - RTD's able to reduce the vibrations of the bike during use (Catalonia)
 - RTD's to create new concepts of bikes built up additively (Catalonia).
- companies (design companies, Software producers, material producers, 3DP producers, lead users etc)
 - Actors that design and build bikes and it accessories as a core activity and that could guide in the challenges (Flanders, Catalonia)
 - Actors with the expertise on open platform IT-development, customization software and configurator software (Flanders)
 - Actors with suited 3D print technology in-house to print the different components (Flanders)
 - Actors specialized in adaption of the shape of the bike and like this with the body of the driver (Flanders)
 - 3DPrinter producer in polymer materials (Flanders, Catalonia)

Deliverable D2.2

- CAR (Sportive High Performance Training and Research Center)
- Biking Barcelona and Smart Cities LightHouse Projects (Barcelona and follower cities)
- Living Labs
- Companies: Achilles Design, Twikit, Bioracer Motion, PinkOlive, 3Dee, Monty, Torrot, Urbikes, Berg Toys, etc...
- other lead users
 - (Bike) Fleet managers organizations and companies (Flanders, Catalonia)
 - Hire & share industries (Flanders, Catalonia)
 - Community of users to test the concepts (Flanders, Catalonia)

- What is the added value of **joint** demonstration activities here?

Assess and demonstrate the added value potentially consisting of e.g.:

- exploiting existing complementarities
 - Worldwide leaders/partners for bicycle and cycling technology in Flanders together with other regions (Catalonia)
 - Combine the added value of customized bikes together with the advantage of a smart product (Flanders and Catalonia)
 - Exploit and combine knowledge on smart textile materials (Flanders, Catalonia)
- linking infrastructure and knowledge to create critical mass
 - Integration of smart bicycle mobility solutions (Flanders, Catalonia)
 - Translation of selected solutions to be solved in other applications (Flanders)
 - Create knowledge on hybrid manufacturing of plastics (Flanders)
- getting access to larger community of lead users
 - Community of end users to test the concepts (Flanders, Catalonia)
- increasing coverage of technologies and materials, expanding services to lead users
 - Mobility solutions for commuters thanks to smart bicycle systems and infrastructure (Flanders, Catalonia)
 - Experience in processing hybrid materials (plastics/plastics or plastics/non-plastics) (Flanders, Catalonia)
 - Develop and share advanced knowledge on aerodynamics and vibration reduction (Catalonia)

- Does the current group of participating regions still miss competencies / assets to further develop and implement joint-demonstration? If yes, which additional ones should be sought?

No, but the open platform design allows for any “part” to be added – the platform would allow for an easy integration of newly proposed parts.

Deliverable D2.2

- Description of a first set of common demonstration activities.

Further develop activities' program consisting of e.g.:

- Software architecture
- Hardware (bike parts) dimensions, standardization
- Testing new combinations of materials (e.g. textile + polymers, polymers + carbon,...), hybrid manufacturing
- Integration of printed circuits for functional communication and safety systems on the bicycle (smart locks, smart light, smart communications)
- Creating smart materials, smart textiles
- Reducing post-processing steps for certain applications
- Rapid prototyping on aerodynamics, vibration reduction and quick response manufacturing
- improving / advancing certification and / or common standards
 - Safety standards on automated vehicle to vehicle communication in certain areas as School and environments where many young cyclists are on the road.
- Machine tuning for industrial production (metal, ceramic, polymer) under industrial parameters of quality, reliability, speed, repeatability, durability and costs.
- Investigating AM technology capability (in terms of roughness, dimensional and geometrical accuracy, internal defects).
- Demonstration for AM technology integration in industry
- Testing and validation of parts produced by AM.
- Testing/validating new design under parameters of Minimum viable product (MVP)
- Training for design adapted to AM process

Deliverable D2.2

5.7 Case for joint-demonstration “Adding a dimension to 2d printed textiles”

Leader: Lombardy; Co-Leaders: Flanders, South Netherlands, Catalonia, Nord Pas de Calais

Positioning Note

- Description of the application(s) envisaged, with detailed description of the combination ‘Technology-Material-Infrastructure-Services’ (TMIS).

Thanks to digital printing, textile sector regains ability to respond effectively to the new demands of a market requiring more and more flexibility, quality and reliable delivery time. In particular, innovation in the inks formulation and deposition on fabric by high production inkjet printing machines of new generation has contributed to obtaining very satisfactory results. Appreciable results are also due to the evolution of dedicated software, in particular for the drawing and the extreme freedom in the choice of colors. Advanced systems like CAD/CAM allow today to achieve results that would still have been unthinkable only a few years ago. Today, the traditional printing process sets the pace with the evolution of digital printing, also when applied to the dyes sublimation processes.

If this is the current state of the art, the near future consists of new technologies of digital production that may trigger a real new industrial revolution in textiles. Through the adoption of 3D Printing technologies, we imagine new aesthetic and functional effects in traditional sectors of clothing and furnishing, but radical innovations are announced in technical fabrics. These kind of technical textile have already been identified and classified at European level, and among others we can mention composites, geotextiles, packaging materials, protective textiles to UV radiation and high temperatures, textiles for military transport, for medical hospital, industrial textiles for filtration. Applications may encompass printing protective zones ‘shields’ on clothing with applications for sports, construction or others; printing filter elements on technical textiles; smart Patch seamlessly integrated in textile, for instance a heartrate or respiration monitor in a garment; direct printing of Ag and other functional inks on textile by screen printing and/or inkjet printing; assembly of electronic components on these conductive tracks by means of conductive adhesives, on existing pick and place infrastructure; etc..

Today, 3D printing is entering the world of fashion and the first examples of accessories. Products in small series that accompany the arrival of home textiles “bio” or disposable are shown on the web and at international fairs.

- Assessment of the “distance-to-market” (TRL 5, 6, 7 or 8) and of the business potential for the own companies. Please list also the companies which would be expected to participate (including ‘lead users’).

From **Lombardy Region**, the following companies in the fashion textiles chain are expected to participate to the initiative, with the main focus on fashion textiles: Tessitura Taiana, Stamperia di

Deliverable D2.2

Lipomo (textiles producers); Bottinelli informatica (software); J-teck (ink); in collaboration with Politecnico di Milano (Chemistry, Materials and Chemical Engineering Department)

From **Flanders** and **South Netherlands**, companies have to be identified.

Current TRL depend on the different envisaged applications. The printing of conductive structures on substrates like polyesters with screen printing is very mature and widely applied in industry. This also applies for the screen printing on textiles directly. For the combination, printing conductive structures directly on textile however, the level is much lower, TRL5 or 6. Applying components directly on textile has a highly exploratory character TRL<4.

- Description of the key assets of the regions participating

The skills and expertise available in **Lombardia** are related to the following research centers and universities: Politecnico di Milano, in particular the Istituto Nuovi Materiali, which has the demo-platform for the 3D printing; Stazione sperimentale della seta (an institute with a particular focus on silk-research); Centro Tessile Serico (testing lab for the textile related products analyses); Centro Cot. (research institute); Università di Bergamo (textile engineering).

In Flanders, TNO will participate to the activities Research offering competences on hybrid printed electronics including electronic modules in textile: process development, systems engineering, system integration, reliability. Existing facilities will allow the manufacturing of demonstrators (up to approx.. 10 pieces). Pilot line facilities are foreseen.

- What is the added value of joint demonstration activities here?

The potential added value will consist of:

- exploiting existing complementarities of the applications field such as protective customized clothing for as well cycling, motorbikes, others sports as professional clothing.
- linking infrastructure and knowledge to create critical mass, for example linking a 3Dprinter on a textile production machine to create directly textiles with added value.
- getting access to larger community of lead users (for example in the construction sector, cycling clusters, fashion industry).
- increasing coverage of technologies and materials, expanding services to lead users.

- Does the current group of participating regions still miss competencies / assets to further develop and implement joint-demonstration? If yes, which additional ones should be sought?

Competence to be strengthened regard the development of 3D printing dedicated software, of specific polymers for textile applications and of technologies for the extrusion of the identified polymers.

- Description of a first set of common demonstration activities

A first set of common demonstration activities is below reported:

Deliverable D2.2

Technical and economic demonstration of new possible coupling between textile supports (natural, artificial, synthetic) and some of the polymeric materials frequently used in 3D printing, especially for extrusion (e.g. FDM-Fused Deposition Modeling) and Inkjet .

Design and realization of the first textile 3D library, based on the collection of experiences of different regions. The textile 3D library will allow the use of physical samples, for example cataloged by type of material, printing technology, size, color, application sector, and any other technological parameter , commodity, functional or sensory impairment, useful to the pursuit of purposes of research , product development , commercial, or marketing. It will accommodate temporary exhibitions dedicated to specific topics, designers or brands, interested in sharing the new technology and it will be transferable in different locations through the easy downloading of STL files and the use of printers or print services available on site.

Reducing processing steps by integrating the production of the functionalities in one step on the production of the textile itself.

Improving / advancing certification on the possible applications of the technology.

Deliverable D2.2

5.8 Case for joint-demonstration “Metal products 3D Printing for Automotive components, tools and moulds”**Leader: Aragon (Spain);****Co-Leaders: Emilia Romagna (Italy), Norte (Portugal).****Other participants: Asturias (Spain), Lombardy (Italy), Baden-Wuerttemberg (Germany), Thuringia (Germany), Northrhine Westphalia (Germany)****Positioning Note**

- Description of the application(s) envisaged, with detailed description of the combination ‘Technology-Material-Infrastructure-Services’ (TMIS)

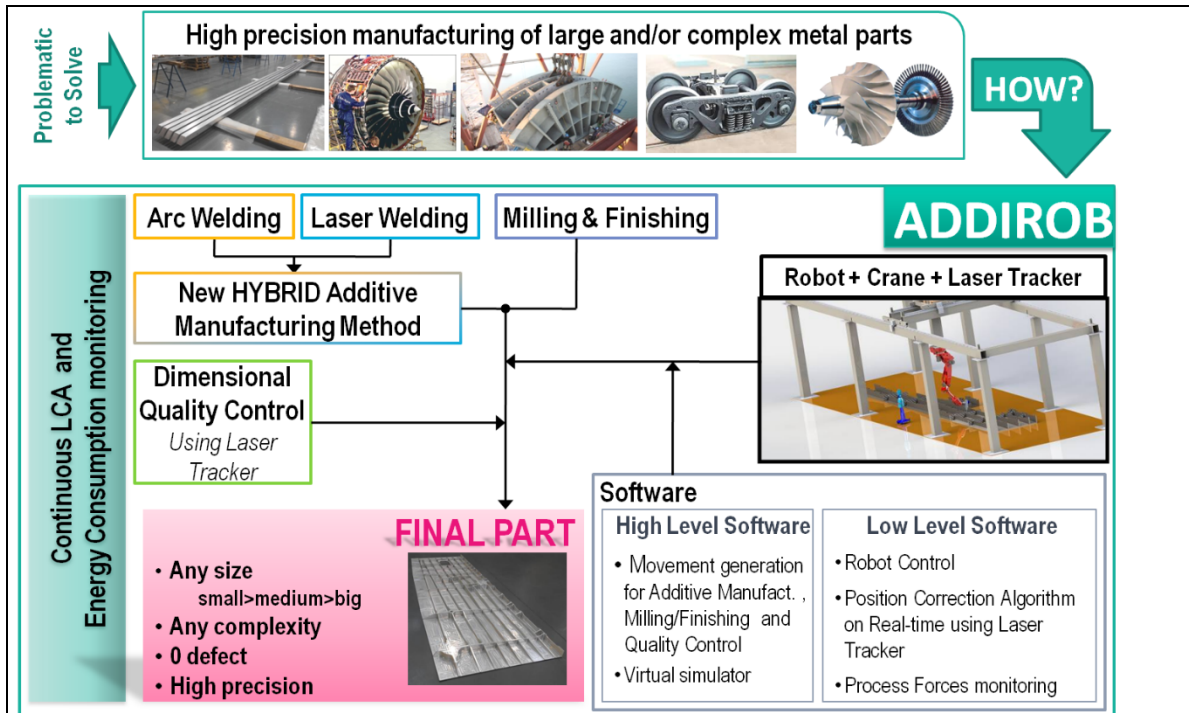
In order to optimize fuel consumption and reduce emissions, the automotive industry is always trying to find new solutions for saving vehicle weight. 3DP technologies can play an important role in this field as it enables the possibility to explore new design approaches *e.g.* topological optimization, graded materials and graded structures (possibility of hollowed parts).

AM processes generates much less raw material waste than traditional manufacturing processes thus increasing product manufacturing sustainability through more energy efficient production processes. These advantages apply both for medium to high volume productions and for general tooling.

AM manufacturing could be not only an alternative production process but also a complementary process for conventional technologies.

AM metal for automotive components demonstration activity aiming to prove the ability of these technologies to position themselves as an option against conventional technologies, taking into account the ability to obtain freeform morphologies and rely on the ability to have function graded materials with variable composition, adjustable internal structure, variable metallurgical condition and multi materials (Titanium, Metal matrix composites, Aluminum, Inconel, Titanium Aluminide, among others). Demonstration should focus on complex parts trying to follow the natural automotive flow from niche / motorsport vehicle parts to medium to high series production vehicles, *e.g.* exhaust manifold, suspension arms, steering knuckles. Besides these monolithic components, demonstrations may cover metallic inserts for carbon fiber reinforced thermoplastics, as this technology enables fast rate production of high performance components and for special tooling, (*e.g.* enhanced process to produce injection molding inserts with conformal cooling for the optical plastics). Direct Metal AM should be also considered Metal casted on AM molds, as well.

Deliverable D2.2



Source: Aitiip (Aragón)

Based on this concept, **the main objectives of this pilot – Automotive 2** are:

- Make the **additive manufacturing** of small, medium and **large (>2500mm) complex parts** a manufacturing industrial reality.
- Develop a completely new **Hybrid Additive manufacturing method based on Arc and Laser welding methods**, increasing the material deposition rate and, simultaneously, increasing the accuracy.
- **Combine in one process Additive manufacturing, Finishing and Dimensional Control tasks reducing the manufacturing time** and delivering high precision parts.
- **Integrate complete control software acting** on the (1) robot, (2) crane and (3) laser tracker **system** to enable:
 - generating the movements for the manufacturing tasks,
 - generating virtually the paths on the simulator,
 - providing direct control of the components,
 - a real time position correction algorithm and forces monitoring.

METAL PRODUCTS 3D PRINTING FOR AUTOMOTIVE COMPONENTS, TOOLS AND MOLDS

Action	Coordinator
7) Selection of demonstrators	Aragón

Deliverable D2.2

8)	Advanced products and tools design and characterization	Norte
9)	Process: Laser structure and machining	Emilia Romagna
10)	Process: manufacturing system and demonstrators	Aragón
11)	Testing	Norte

These demonstration activities implies to innovate on structural optimisation and economical efficient automated production (productive and flexible), keeping in mind requirements from resources and energy efficiency. The solution proposed by this consortium covers all this fields and even wants to make on step further, moving from solutions for complex parts to solutions for large complex parts also.

1) Innovative resource-efficient manufacturing processes through first-time-right approaches, innovative energy efficient machinery and developments in process control allowing both to cope with more recycling in the process and to increase output quality :

- Additive manufacturing process achieves the best **efficiency of material**, using only the exact quantity necessary to build up the part. Furthermore, the consequently reduced quantity of material removed on subsequent milling and finishing steps is **100% recyclable**. Using Laser tracker for positioning error compensating and for dimensional quality control tasks we will achieve a zero-defect part increasing the output quality and **achieving a first-time-right approach**. Compared to conventional manufacturing of large parts based only on subtractive processes, the **energy efficiency** of the system will be significantly better as the reduction of energy for removal is higher than the one used for welding additive manufacturing (20%). In addition to that, and compared with state of the art additive techniques, the **hybrid additive welding** (Arc+Laser) system achieves higher material deposition rate, that, together with the one-step integration of production and quality validation of the part, a reduction of the manufacturing time (40%) is achieved

2) Manufacturing process control and monitoring strategies based on integrated models of both processes and machines, with modules for resource and energy efficiency planning and monitoring, and with capability of selection of the best process and machine for the part to be manufactured: This system will be controlled by a software that will **optimise the manufacturing tasks** (additive and subtractive), and virtually simulate manufacturing before the operation and real time controlling of the process, taking into account energy efficiency on both stages, planning –virtual simulator- and monitoring –during process, allowing section of the **best strategy and plan** for the part manufacturing. It will develop a

Deliverable D2.2

CAD-CAM-CAE integrated system and designed specifically for the additive-subtractive concept proposed. An **adaptive system** will be implemented, based on **real-time force-feedback monitoring** that will permit smart behaviour of the control system to increment energy efficiency and reduce processing time.

- 3) ***Innovative process concepts and tools, including design supported by computational modelling, for resource efficiency in complex geometries manufacturing:*** The **real-time position correction** algorithm together force-feedback monitoring that will be implemented in the software and carried out by the control software over the robot movements and assured by the laser tracker measurements, achieves a maximum efficiency on large and/or complex geometries. We can achieve a **zero-defect manufacturing** with the most optimum process planning. CAD/CAM integration allows facing any complex size and defining the optimum robot path and process parameters from the technological database to be developed.
- 4) ***Innovative machinery improving resource efficiency from the current state of the art in complex geometries manufacturing:*** The current State of the Art for large complex parts is metal cutting, so the reduction on energy consumption using the developed system is expected to be up to 20%. Furthermore, the maximum improvement of the system will be the reduction of raw material used for the production of such large and complex parts (60-70% compared to traditional methods). Compared to the State of the Art for small and medium complex parts produced by Additive Manufacturing the energy efficiency can be increased with the lowering of the manufacturing time due to the higher deposition rate thanks to the innovative hybrid welding additive manufacturing proposed on these activities.
-
- 5) ***Remanufacturing and recycling, with novel or improved use of waste streams:*** Remanufacturing and repairing will be a reality with the proposed system and its additive manufacturing based on welding (a commonly used repairing process). Meanwhile, recycling the waste materials is also possible because the quantity of waste is minimal on the subtractive tasks due to the accuracy of the additive tasks. Moreover, these additive tasks are near to 100%-free of raw material waste. Other waste streams usual on machining (as coolant) are being minimized thanks to the developments during the activities to be developed

Concept description

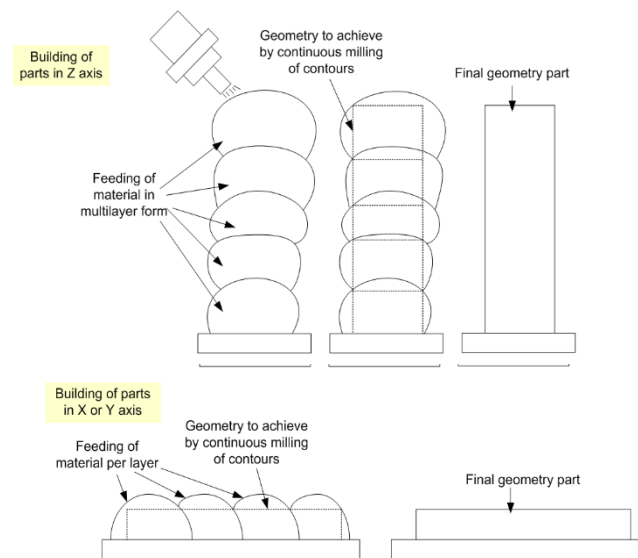
New Part Creation.

The additive manufacturing technology will permit building complex 3D shape parts, generating material layer by layer. In order to optimize efficiency and reduce the building time, an arc welding

Deliverable D2.2

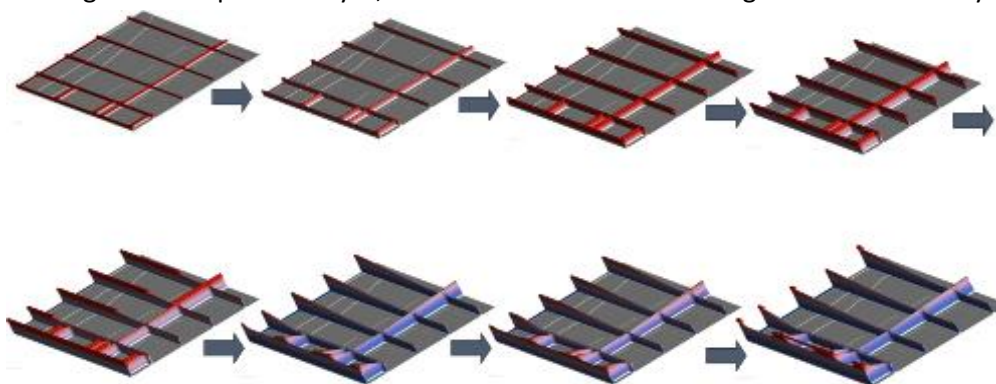
based technology will be used, and to improve quality of the layers itself, a laser-based additive system will help to stabilize the welded material, reducing stresses, deformation and typical welding problems.

The subtractive manufacturing technology, based on milling will describe the contour of the shape also layer by layer. Milling concept will be performed by a 6DOF industrial robot, making a perfect geometrical adaptation to the theoretical shape of the part. In performing the milling layer by layer as the part is built, access of the robot is assured to all areas of the part. This can even permit designer to conceive more complex parts than the ones currently being designed for the industry.

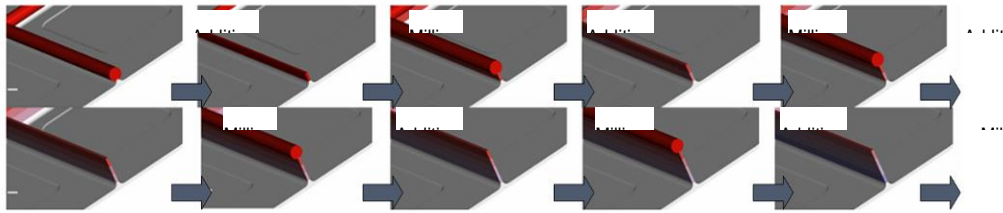


Manufacturing (additive-subtractive) Concept Diagram

Following images shows in detail a concept 3D simulation of the successive steps to build a part using this concept as described. Each image corresponds to a new step that alternates additive manufacturing to build up a new layer, and subtractive manufacturing to machine last layer.



Deliverable D2.2



step by step manufacturing concept scheme.

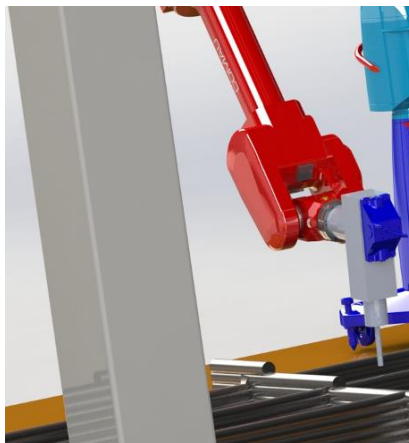
Additive + subtractive sequential alternating phases. In red, last added layer.

The use of this concept permits a clear decrease of the raw material to be used, in comparison with the traditional manufacturing methods that are used in the industry, based only on subtractive technologies. Depending of the complexity of the part, and the geometrical design, the reduction of the raw material can reach around 80%. In this system, only the final part volume is required, plus a slight excess of material to allow the milling finishing phase reproduce the desired shape. : remanufacturing and part reparation and ensuring part accuracy.

System Implementations.

Two prototype demonstration pilots are proposed to be develop :

- The first prototype will serve as a proof of concept and will permit the construction of small and medium 3D complex size parts using the concept described (one welding robot and one finishing robot working together on a small turning table). This will be a fully functional prototype, with the additive manufacturing process totally implemented, however without the package to monitor and control the force on the finishing processes.



Render Concept view of the first prototype. Additive manufacturing concept validation.

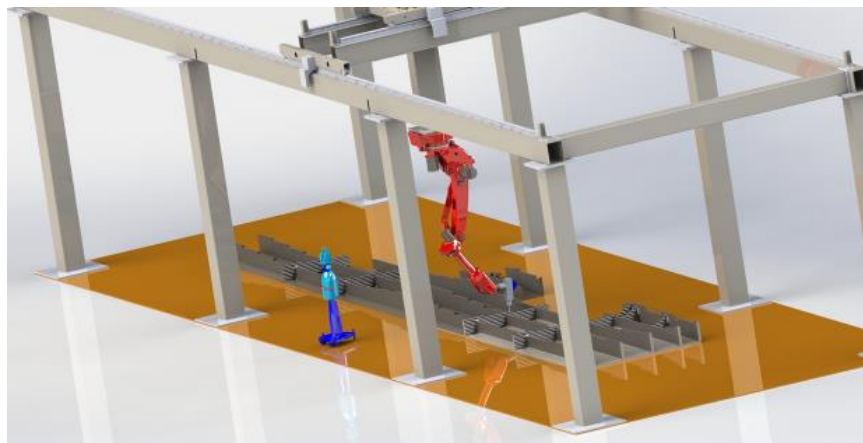
The second prototype will serve to extend the technology of the first prototype and apply it to large components (more than 2500mm). The technology concept of will be tested on a new hardware based on a crane (gantry system with 3 additional linear axes) that will increase the robot's reach to manage large parts. The workspace with the crane will be 18 m x 3,5m x 2,5m. This prototype

Deliverable D2.2

will include all the developments in the project, but with only one robot and with technology tool changer:

- Additive manufacturing
- Milling process to finish the part layer by layer in line with the additive manufacturing.
- Real time position tracking and correction.
- Force control assistance.
- High accuracy metrology.

This prototype will be able to build new large parts or to repair damaged existing ones. This second prototype will be used to perform the final large industrial demonstration cases



Render Concept view of second prototype.

All functionalities implemented. Additive +Subtractive, metrological validation. Large Components

In order to reduce the investment to develop this second large prototype, the main linkage of project is with the MEGAROB project in Aitiip.

1) Final list of participating

Please see attached the active list to be fulfilled by participants (.xls)

Some companies from Aragon have just confirmed their interest: FERSA BEARINGS, LINDE Y WIEMANN, UMEC, MANN HUMMEL, INYCOM, CAAR...

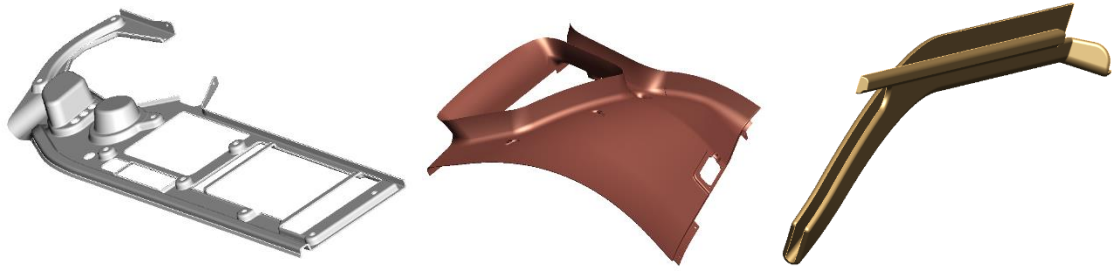
And NDA – non disclosure agreement must be signed by all partners involved.

2) Selection of at least two parts/ tools geometries as demonstrators and its materials

- ***One small / medium scale complex part or tool***

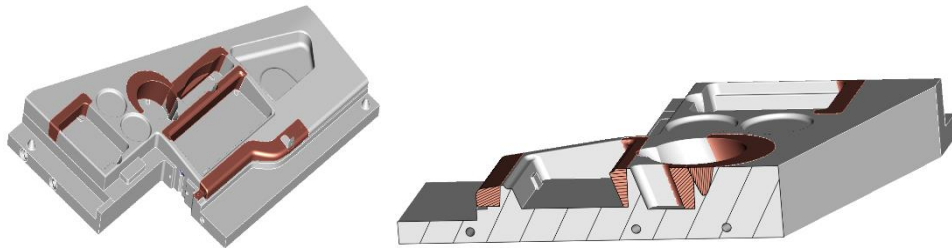
The general complexity of the geometry and shape, the need of metallic inserts and the fact that for each manufacturing process a metallic tool is required.

Deliverable D2.2



Example of small/medium complex parts

The complexity of the geometries makes the tools to be an important investment, that increases the part price, and reduce their competitiveness. Also the geometry of the tools makes it difficult to be built by traditional subtractive technologies, so they are cut in several parts, that have to be assembled and disassembled during each production cycle.



Example of moulds manufactured

To improve even more the part production process, the possibility to make the moulds in a high thermal conductor material is important. Several trials to make these tools by additive manufacturing systems (laser concept) were made and dismissed due to technological problems (size of the part required), and the small addition material rate, makes it too expensive and time consuming.

- ***One large complex part or tool***

Large and complex automotive part are often composed of tens (or even hundreds) of small metal parts riveted. Each of these parts are produced independently with their surface treatment and then assembled together. At the end of the process, the assembly is subjected to a new surface treatment of the overall surface. The production of a unique part by the proposed additive manufacturing concept would save huge industrial cycle and improve industrial precision. A unique part would also avoid the problems of corrosion and improve the fatigue strength at the connections between the parts. Finally, it could be considered a weight saving of about 25% to 30%.

Deliverable D2.2



Example of large part

3) Consortium agreement

Intellectual property rights and exploitation issues

4) Budget estimation and co-financial scheme

As soon as, all partners and activities will be defined must be develop a detailed budget and in parallel, different co-financial schemes must be evaluated.

- Assessment of the “distance-to-market” (TRL 5, 6, 7 or 8) and of the business potential for the own companies. Please list also the companies which would be expected to participate.

- High performance parts, tools and moulds
 - TRL from 5 to 8
 - Potential: New design and competitive products, higher performance, complementary existing post-process competences, Faster penetration of the market, faster production, bridge production, new solutions, new design (thinking),
 - Companies - Potential Users: CAAR (Aragon OPEL-GM and SEAT suppliers and CAAR – ARAGON automotive cluster (Brembo, Alumalsa, Thermolympic, Mypa, Fersa) and others as Aernnova, Sispra, EMILIA ROMAGNA (as Lamborghini, RIBA Composites and CRP) and NORTE companies (as Magneti Marelli, CACIA (Renault), Faurecia, Simoldes), ASTURIAS (as ARCELOR Mittal), BADEN-WUERTTEMBERG (as Daimler, Bosch) and THURINGIA (as Portec,...)
 - OEMs, large industries and SME.

Deliverable D2.2

- Description of the key assets of the regions participating

Aragon (Spain)

RESEARCH & DEVELOPMENT

- From a short, medium and long term new applications, products, production system and high advance technological services. From low TRL to industrial serials.
 - AITIIP (Technological Centre www.aitiip.com) – 3DP of metals and plastics including nanocomposites. Capacity of research, development and service bureau in 3DP from 15 years ago.
 - UNIZAR (University of Zaragoza www.unizar.com)
 - ITAINNOVA (Technological Institute of Aragon www.itaionnova.com)

COMPANIES

The automotive industry in our region Aragon, it is KEY, a huge concentration of industries is dedicated to this sector.

It was 2007 when, following a diagnostic study of the automotive sector in Aragon carried out by the Technological Institute of Aragon, it was found that the most innovative regions of our country with an automobile production plant all had an automotive cluster.

In 2013, our automotive companies employed over 6,800 people and had a turnover of more than EUR 1,400 million. Our clients were the leading Spanish car manufacturers – it must be remembered that most car manufacturing plants in our country are located within 300 miles from Zaragoza. But our products are not only sold to Spanish plants but also directly exported to various European plants, which account for approximately 35% of our turnover.

Emilia Romagna (Italy)

RESEARCH & DEVELOPMENT

ER Region presently has equipment for:

- Additive manufacturing of metals (SLM and SLS)
- Laser surface structuring (hardening, sculpturing)
- laser cladding and welding
- CFRP production (in autoclave and out of autoclave)
- Material testing and characterization (mechanical properties: static, low and high cycle fatigue, room and high temperature conditioning, tension, compression, torsion, shear, monitored Charpy; cold and warm tribology, microstructure evaluation, SEM analysis, conductivity, corrosion, evaluation of fluid viscosity of resins)
- Design and simulation of structures, isotropic and non-isotropic;
- Advanced process simulation: heat transfer for lasers processing, microstructure evolution and phase transformation, foundry processes, metal forming, polymerization, cavity filling.

COMPANIES

Emilia-Romagna is a European leader region in the production of high performance vehicles

Deliverable D2.2

including cars and motorbikes (Ferrari, Maserati, Lamborghini, Dallara, Toro Rosso, Ducati, Malaguti, Moto Morini), automotive components such as Magneti Marelli and VM Motori (FCA), foundry and tooling companies as well as CFRP Industry (Riba, Reglass, CAM, Modelleria CPC and others)...

Norte (Italy)

RESEARCH & DEVELOPMENT

The Norte region is characterized by SME companies working for the automotive industry spread by several sectors and a network of R&D entities that work in close collaboration. Following is a description of entities with interest for this project divided by organization type:

Research Centers

Universities and research institutes with expertise in AM holding rapid prototyping equipment. In addition to the AM equipment advanced skills exist in post processing related to conversion technics for metal (investment and sand casting) and composite materials processing. In this group we can find the University of Porto and IPL with their Technological Institutes, INEGI, CDRSP, among others. All these institutions also hold strong competences on characterization of AM parts and AM materials.

COMPANIES

Car Components Manufacturers

The Automotive industry in Norte Region is characterized by some 1st tier companies and mainly 2nd tier manufacturers. Main fields of activity are sheet metal working (stamping, welding, painting, coating), foundry (sandcasting, high pressure die casting, ...). These companies are suppliers of the main car makers like Renault, VW, PSA, Audi, Mercedes, etc.

Tool and Mold Makers

Portugal and Norte region in particular is well known for its Mold making capacity and competences for automotive production. The main final application typically are the manufacturing of injection mold parts, GFRP manufacturing, stamping, foundry for Car Components Manufacturers. These companies although potentially users and interested in this subject are still using AM (metal and polymer) technologies for product and engineering developments so must be strongly encouraged to change their AM referential to parts manufacturing.

Asturias (Spain)

RESEARCH & DEVELOPMENT

The region is promoting and implementing R&D activities to improve different stages of the AM value chain such as product design, novel processes and materials development and integration of other conventional manufacturing technologies for post-processing. All the actors involved aim to select the main benefits that 3D printing technologies could improve the regional industrial fabric as well as to create novel business models around them. This strategy is implemented in a selective way in order to find market niches and to promote high technology specialization.

Deliverable D2.2

Main actors are:

-PRODINTEC (www.prodintec.com): technology center on advanced manufacturing and product design. PRODINTEC offers the following main services portfolio on 3D printing:

- Production of short series by using cutting-edge additive manufacturing technologies. PRODINTEC possesses in-house, technologies for manufacturing by Direct Metal Laser Sintering and Selective Laser Melting. Therefore, materials such as aluminium, titanium, stainless steel, polymer-based materials or specific metal alloys can be processed. Additionally, PRODINTEC have several technologies for prototyping such as 3D ink-jet printing, vacuum casting and jet binder
- High expertise on product design for additive manufacturing
- Post-processing of parts manufactured by 3D printing by adapting conventional manufacturing technologies such as high speed milling or thermal treatments
- Ad-hoc projects with customers to integrate 3D printing technologies in current manufacturing processes
- Development of periphery systems to improve 3D printing process such as vision systems for in-situ quality control or systems for powder handling
-

-ITMA (www.itma.es): technology centre on materials development. ITMA offers the following main services portfolio on 3D printing:

- Development of novel materials for 3D printing
- Integration of nanomaterials on 3D printing processes
-

-University of Oviedo (www.uniovi.es): It offers the following main services portfolio on 3D printing:

- Production of prototypes by 3D jet printing
- Process simulation and optimization of the production
- Development of novel 3D technologies

COMPANIES

Companies dealing with Materials development such as ARCELOR Mittal.

Other possible beneficiaries:

-TENNECO : world's leading designers, manufacturers and distributors of clean air and ride performance products and systems for the automotive, commercial truck and off-highway markets and the aftermarket.

-INMER: parts production for automotive, defense and construction sectors

Lombardy (Italy)

Baden-Wuerttemberg, (Germany) represented by the **German Aerospace Center (DLR), Institute of Vehicle Concepts**

RESEARCH & DEVELOPMENT

Deliverable D2.2

- Conception of automotive components (structural / non-structural) and complete vehicles, (and also drivetrain and powertrain components/ interface to drivetrain, powertrain, vehicle intelligence).
- CAD and FE-simulation, as well as crash-simulation.
- Testing: corrosion resistance, fatigue.
- Develop and provide a methodological approach to evaluate and determine automotive components with a high potential of an increase in value through the application of Additive Manufacturing (AM-) technologies.
- Implementation and development of an AM-specific design strategy for a fast concept generation of light weight structural parts in an early stage of product development.
- Final crash-testing of components (crash testing facility).
- Development of a research prototype (modules, components, e.g. front end, space-frame structure, etc.)

COMPANIES

- Daimler
- Bosch
- industrial partners within the meta-project “Active Research Environment for the Next Generation of Automobiles” – ARENA 2036⁵⁷
- Audi
- Porsche
- Trumpf
- EDAG
- ZF

Thuringia (Germany)

RESEARCH & DEVELOPMENT

Thuringia is a region where SMEs dominate. They belong mainly to the automotive and machinery/tooling sector. Beside a number of innovation-active SME and larger companies, the Thuringian industry and regional research centers are working hand in hand.

- Research institutions
- TU Ilmenau and ifw are involved in investigations to the technology optimization, such as processing parameters, (raw) material parameters, facility parameters while processing (and in preparation) as well as technology and product characterization. Special expertise exists for arc composition welding (for massive parts and components) and SLS (for small and delicate structures).
- Companies:
- The SMEs involved in AM and/or automotive topics are spread over several sectors. In the

⁵⁷ www.arena2036.de, English version is under development

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preprocessing exist competences for the indirect AM with design development and the processing of the manufacturing of moulds for tooling, metal parts/components. Although the AM processing has not reached the industrial sector, potential users are several mould design and construction companies and special purpose machinery builder involved in the automotive sector.

- In the field of post processing Thuringia holds besides suppliers for mechanical post processing several testing laboratories and hardening and chemical treatment suppliers.

COMPANIES

Portec GmbH, Opel Eisenach, H+ W Arnstadt, Lohnhärtereier Faulhaber, Autotest GmbH

Northrhine Westphalia (Germany)

RESEARCH & DEVELOPMENT

NRW and the DMRC

DMRC has the expertise to enhance the case in several topics, therefore you find attached some paper from my colleagues about the topic “fatigue” of different metallic materials, especially TiAl6V4.

COMPANIES

To be described

- What is the added value of **joint** demonstration activities here?

The joint demonstration activities will be structured between the three regions as follows:
Value chain is covered on AM process, Design, Post-process and leading applications in automotive sector with leading players

Aragon (Spain)

- design of new product concepts in 3DP mainly the following products and their manufacturing processes
 - Hard trim (interior products)
 - Structural elements and external components
 - Drivetrain
 - Powertrain
- development of new manufacturing automated, hybrid and flexible manufacturing processes for metal, plastics, composites and hybrid products
- Full equipped in security testing of automotive products and performance capabilities and properties of the automotive components.

• **Emilia Romagna (Italy)**

- Early conception and design of new products for frame components and other structural elements, as well as drivetrain and powertrain components

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- Development of new hybrid and flexible manufacturing processes for metal products. In particular these activities will be carried out:
 - a. Laser processing of inserts and metal parts
 - b. surface structuring
 - c. machining

Development of testing standards for metal products, in order to guarantee properties and performance capabilities of the demonstration automotive components. In particular fatigue tests, as well as corrosion resistance, interface integrity, impact resistance.

Norte (Portugal)

- New Design concepts with complex shapes, topology optimization, and light weight structures;
- Sustainable design and Environmental impact of Direct and Indirect Metal AM vs Conventional Technologies;
- Technical and Economic Assessment of Direct and Indirect Metal AM vs Conventional Technologies;
- Direct 3DP of Metal and Indirect Metal parts manufacture;
- Post-processing methods to improve part characteristics;
- Closed loop monitoring (sensors techniques) and control of AM processes;
- Testing/Characterization (tensile, static, dynamic and fatigue, microstructure, x-ray, dimensional and geometrical, Digital image correlation, 3D measurement with structured light and photogrammetry).

Asturias (Spain)

- 3D printing audits to identify and analyse what the 3D printing technology can bring to a particular SMEs/company
- Feasibility studies on the development of novel business models around AM technologies for the sector
- Assistance in the design for 3D printing of prototypes/complex parts/components
- Development and characterization of novel materials
- Prototypes manufacturing in different materials such as resins /plastics
- Parts/components manufactured by 3D printing in different materials: Plastics/metals
- Post processing methodology and equipment
- Development of methodologies for quality control and promotion of standardization issues
- Assistance in certification of parts manufactured by AM for critical sectors

Lombardy (Italy)

Baden – Wuerttemberg (Germany)

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- Conception of automotive components (structural / non-structural) and complete vehicles, (and also drivetrain and powertrain components/ interface to drivetrain, powertrain, vehicle intelligence).
- CAD and FE-simulation, as well as crash-simulation.
- Testing: corrosion resistance, fatigue.
- Develop and provide a methodological approach to evaluate and determine automotive components with a high potential of an increase in value through the application of Additive Manufacturing (AM-) technologies.
- Implementation and development of an AM-specific design strategy for a fast concept generation of light weight structural parts in an early stage of product development.
- Final crash-testing of components (crash testing facility).
- Development of a research prototype (modules, components, e.g. front end, space-frame structure, etc.)

Thuringia (Germany)

- maturing of optimization and specialization of new and AM-specific design approaches and their technological processing, widening technological borders with regard to design (complex, undercuts, freeform)
- investigation on the optimization of processing (initial state, process climatic, material, machinery) parameters and special properties with regard to postprocessing as well as adaption of optimized processing parameters involving academic and adopter company partners in order to reduce risk at technological commercialisation, to achieve sustainable production cycle and convince with high-quality products.
 -
- Potential 1: on basis of AM-oriented new design approaches, services in design development and commercialization of the technology processing, including technology adaption due to AM-specifics in special process stages, e.g. freeform mould manufacturing
- characterization of the product and material properties as a step following the AM metal part generation, these data as a basis for the analysis of AM-specific characteristics (material microstructure) and the subsequent development of AM-product specific postprocessing treatment, hardening and chemical refinement procedures including joint engagement in developing postprocessing and hardening treatment standards for AM-metal products in collaboration with the stakeholders of the cross-European metal-AM network within the vanguard pilot.
 - - Potential 2: Joint development of standards for hardening procedures and other chemical refinement with regard to the specific material characteristics of AM generated metal parts.
 - - Potential 3: the transfer in the commercial industrial application of these

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treatments.

Northrine Westphalia (Germany)

- Fatigue experts

- Does the current group of participating regions still miss competencies / assets to further develop and implement joint-demonstration? If yes, which additional ones should be sought?

No competencies or assets are lacking from the current group of participating regions.

- Description of a first set of common demonstration activities.

The project scope will include the optimization of design-for-additive-manufacturing, production and technological implementation and development of efficient testing techniques and associated common standards. The first set of common demonstration activities will include the design, manufacturing and testing of components with simple geometries where all processes can be optimized and refined.

In terms of design-for-additive-manufacturing, the following aspects will be developed:

- Application of new Design concepts with complex shapes, topology optimization, and light weight structures to take advantage of one of the strongest points of AM, the freeform ability in part design;
- Sustainable design and Environmental impact of Direct and Indirect Metal AM vs Conventional Technologies in order to verify the environmental footprint of these new processes.

In terms of production and technological implementation, the following will be performed:

- Establish component properties and characteristics (strength, stiffness, density, accuracy etc.) as functions of process parameters including laser specification, material characteristics and feed, process path etc.
- Optimise laser surface structuring procedures for optimization of bonding.
- Application of innovative high-production molding techniques to high advanced components.

In terms of testing techniques and development of standards, the following will be developed:

- Testing characterization of materials, light weight structures and parts, as manufactured and heat treated. Performing of destructive tests on coupons or samples like tensile, static, dynamic, fatigue, microstructure and x-ray, or NDT testing on parts e.g. dimensional and geometrical analysis, Digital image correlation, 3D measurement with structured light and photogrammetry.

In this way, the necessary knowledge required for the design, production and testing of more complex components will be acquired, including the necessary network links between the various regional partners. Following this first set of common demonstration activities, test samples will be produced in correspondence with mechanical components specified by industrial partners so as

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to demonstrate process effectiveness and feasibility.

Further develop activities' program consisting of e.g.:

- testing of new materials
- testing new combinations of materials (e.g. textile + polymers)
- reducing post-processing steps for certain applications
- improving / advancing certification and / or common standards