Additive manufacturing roadmap: gaps and actions on market driven value chains

FoFAM

Industrial and regional valorization of FoF Additive Manufacturing projects.

This project has received funding from the European Union Horizon 2020 Programme (H2020) under grant agreement number 636882.

Table of Contents

Abbreviations

ABBREVIATIONS	
AM	Additive Manufacturing
CAD	Computer-Aided Design
CAM	Computer-Aided Manufacturing
CSA	Coordination and Support Action
CTE	Coefficient of Thermal Expansion
DED	Directed Energy Deposition
FDM	Fused Deposition Modelling
HE	Higher Education
HIP	Hot Isostatic Pressing
ICT	Information and Communications Technologies
IoT	Internet of Things
IP	Industrial Property
IPRs	Intellectual Property Rights
LDM	Laser Direct Manufacturing
LCA	Life-Cycle Assessment
LMD	Laser Metal Deposition
MMC	Metal Matrix Composite
NDT	Non-Destructive Testing
Ni	Nickel
OEM	Original Equipment Manufacturer
PEEK	PolyEther Ether Ketone
PIM	Powder Injection Moulding
P&P	Pick&Place
QA	Quality Assurance
SW	Software
Ti	Titanium
TRL	Technology Readiness Level
VC	Value Chain
VET	Vocational Education and Training

1 Introduction

This document aims at presenting the additive manufacturing (AM) implementation map on market driven value chains and constitutes an open working document, developed in the framework of FoFAM project "Industrial and regional valorization of FoF Additive Manufacturing projects" (Grant agreement no. 636882).

This roadmap was designed with the aim to offer a strategy for building the fundamental knowledge and actions necessary to accelerate the design, application and implementation in the market of AM.

It is fundamental for the value chain selection to originate from the investigation of sectors with the most potential to contribute to bridging the gap between current knowledge and the successful commercialisation of AM manufactured products or services.

The sectors and market addressed in this roadmap have been selected according to the FoFAM project need to be relevant to the technological advancements across Europe and their potential to positively influence societal and economic challenges. Therefore, this selection is based on the evidence collated from the sector surveillance activity and the growth and impact analysis performed within the project and the contribution of the experts attending the 1st FoFAM workshop held in Brussels on September 2015.

In light of this the following sectors have been identified:

- Medical and dental
- Aerospace
- Automotive
- Consumer goods (including electronics)
- Industrial equipment

These sectors were also the focus of a number of relevant documents i.e. the European Additive Manufacturing Strategic Research Agenda, which highlights priority areas for future development in AM.

Version: December 2016.

2 Gaps and actions on the value chains

For each of the selected sectors, a value chain (VC) approach was followed to find the gaps preventing complete market deployment and proposed the corresponding needed actions. The VC is defined as the activities from knowledge to market along a process to generate and add value. The analysis takes place at VC segment level (Fig 1).

Fig. 1 *Value Chains segments defined*

The timeline for the proposed actions is also indicated considering the following:

- Short term: 2017-2020
- Medium: 2020–2025
- Long: 2025-beyond

The actions proposed are classified in two groups:

- Cross-cutting actions relevant to all sectorial value chains, responding both to technological and non-technological gaps
- Actions specific to a particular value chain, addressing both technological and non-technological gaps

Moreover, technical gaps include the current Technology Readiness Level (TRL). TRLs are based on a scale from 1 to 9 with 9 being the most mature technology (fig. 2).

TECHNOLOGY READINESS LEVEL	DESCRIPTION
TRL 1.	Basic principles observed
TRL 2.	Technology concept formulated
TRL 3.	Experimental proof of concept
TRL4.	Technology validated in lab
TRL5.	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6.	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7.	System prototype demonstration in operational environment
TRL 8.	System complete and qualified
TRL 9.	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Fig. 2 *Value Chains segments defined*

2.1 Cross-cutting actions

2.1.1 Technological cross-cutting actions

A number of technical challenges were identified that cut across all sectors (fig. 3).

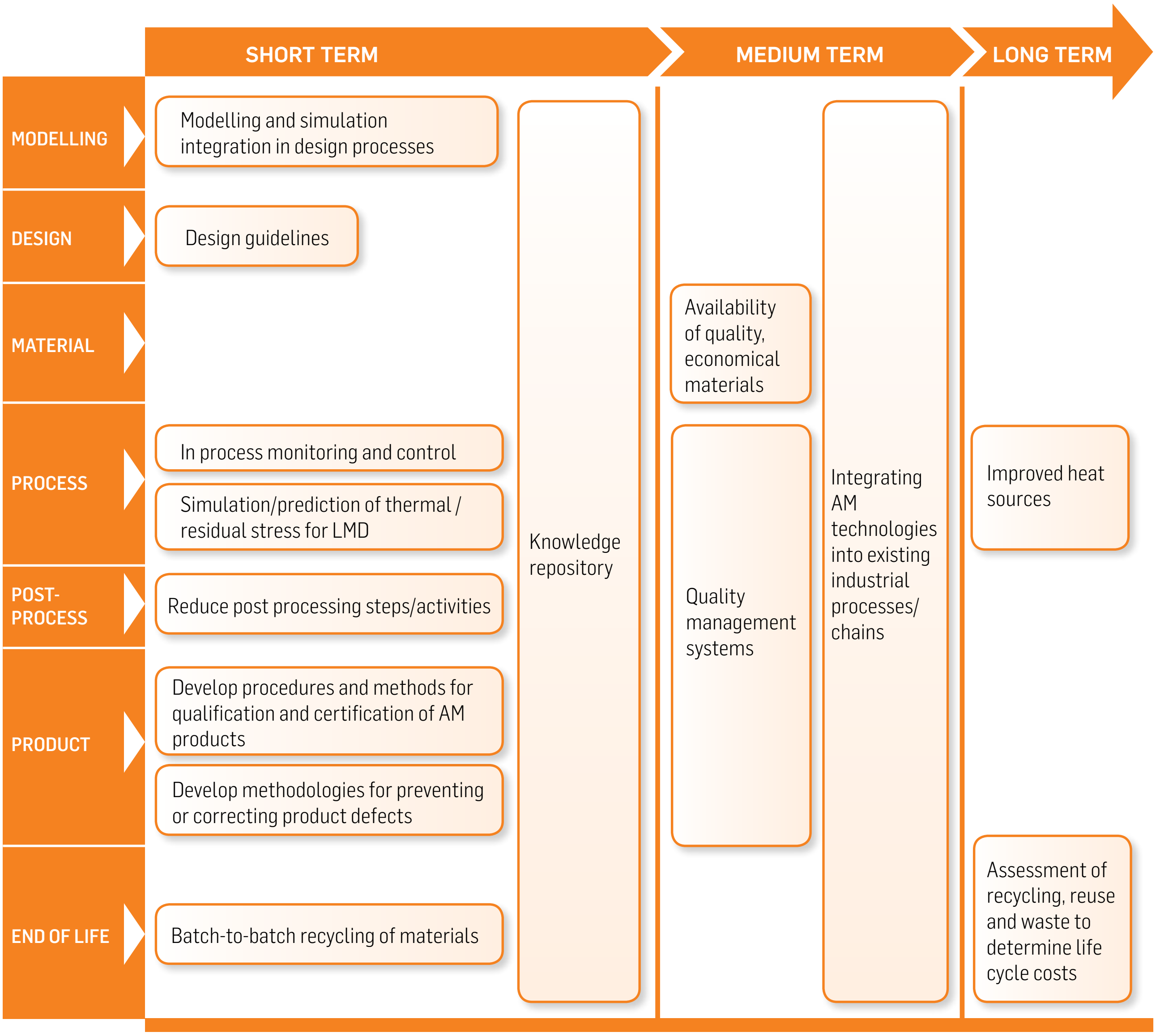

Fig. 3 *Summary of non-technological cross-cutting gaps*

SHORT TERM ACTIONS

VC SEGMENT	ACTION NAME	CONTEXT (GAP)	ACTIONS PROPOSED	CURRENT TRL
Modelling	**Modelling and simulation integration in design processes**	Development of accurate modelling and simulation tools is an important fundamental building block. Fast, economic modelling is required. Some individual and local action is ongoing, especially in universities and research centres, but not centralized. Thus, alignment of efforts is needed to progress in this matter and achieve higher TRLs.	• Complete realisation from design to part. Holistic modelling approaches using multi-physics, multiscale simulation and going from process parameters and simulation to product mechanical properties, via thermal mapping/history of the workpiece • Stochastic/empirical modelling techniques utilizing a large volume of data (knowledge repository) • Generation of material data is still needed: development of databases (material, properties and relation to surface condition) • Integration of modelling in the general process • Utilization of FP7/H2020 projects' outcomes in this field to build from	7-8
Design	**Design guidelines**	The engineering and design community requires much more knowledge in how to use AM technology. Design process should not be hampered by standard rules on how to design.	• Establishment of a set of generic AM design rules with guidelines integrated with design modelling tools • Design guidelines should not be limited to just the AM process but also include the entire manufacturing aspects of AM in combination with both preparations, pre- and post-processing • Development of topology optimization methodologies in the design phase to move from feature-based to function-based design with the aim to support the ongoing work of ISO TC/261 jointly with ASTM F42 on the subject • Creation of a central European data bank as base reference	7-8
Process	**In process monitoring and control**	Process monitoring is important for quality and production throughput. Improvement of control technologies are needed to enable effective in process measurement as current ones are not robust enough. Need for in-process monitoring and control to minimize defects and increase reproducibility and process reliability.	• Development of real-time in-process faster/cheaper measurement techniques to enable total control. Bring inspection techniques more developed in subtractive manufacturing to the world of AM • Definition of the parameters to be controlled • In-situ process monitoring of materials processing and allow for product defect detection • In-line non-destructive testing and/or in-situ analysis on the AM product • Knowledge of monitoring and NDT capabilities in AM situations and surface conditions • Implementation of existing AM manufacturing platforms to be fully integrated with the process • Automated conformity assessments, and its cross validation with existing standards; for example dynamic certification based on similar parts, processes, designs and material combinations, including big data, data safety and security	4-6
Process	**Simulation/ prediction of thermal / residual stress for LDM**	The selection of optimum process parameters for reducing structural distortion and residual stresses by simulation in laser direct manufacturing (LDM).	• Investigation of thermal distortion of thin walls and substrates to optimize tool paths and deposition strategies to either control or minimize distortion • Thermal field mapping (from machine sensors) in order to determine residual stresses and distortion. • Investigating how the process parameters affect thermal field, microstructure and mechanical properties to enable prediction of material properties	4-6

VC SEGMENT	ACTION NAME	CONTEXT (GAP)	ACTIONS PROPOSED	CURRENT TRL
Post-process	**Reduce post processing steps/activities**	Post-processing involves removal of the part from the platform and/or finishing the part. This segment of the manufacturing VC should be minimised, automated and integrated in the overall process as much as possible. Moreover, post-processing quality and reliability should be improved.	• Automation of post processing to minimise manual operations • Further investigation and evaluation of the effect of different post-processing operations (for example different heat treatments, Hot Isostatic Pressure (HIP) etc.) • Integration of the AM process in a single process/hybrid machine to reduce the need of post-processing activities • Models and datasets are needed to improve post-processing control of material properties and the final product • In-line process control • Development of intelligent fix and handling systems • Identifying a cost effective and adequate surface finishing method • Understanding how the removal of material from the surface impacts the oversize of the design • Investigate how post-processing can be supported via modelling providing a complete digital track of all steps	4-6
Product	**Develop procedures and methods for qualification and certification of AM products**	A quick and cost-effective certification should be developed. There is a need for qualification and certification methods that will increase the number of certified quality AM parts. The ability to certify and qualify parts to existing specifications (e.g. aerospace) is also important.	• Adaptive and flexible qualification for products • Experimental: development of a matrix of required mechanical tests and acceptance criteria (e.g. tension, bending, fatigue endurance, fatigue crack growth rate, fracture toughness) that comply with certification rules • Modelling and design: predictive models that develop and demonstrate the capability of prediction (of strength and fatigue life) to satisfy the certification requirements. These should take account of specific AM material characteristics, such as graded microstructures, residual stresses due to thermal load distribution and anisotropic properties of the final parts • Classification and categorization of defects in AM components and creation of an Atlas of defects. Defects nomenclature standardization • Development of a European wide system to certify companies that carry out AM (for example ISO3834). This is crucial to ensure the quality of the products that are produced	6-7
Product	**Develop methodologies for preventing or correcting product defects**	Preventing defects such evolution of micro structures, cracking or work-piece distortion. The real gap is linked with in-line control and in-process quality control activities.	• Use of a “knowledge repository” to improve process reliability • "Prevention of defects" module during the design process .To be linked/incorporated with product build preparation (build direction, nesting, maintenance etc.) • Monitor the process inside the component fabrication in order to anticipate defects • Investigate the consequence of defects/porosity/surface condition under service load conditions (fatigue loads), and identify the critical defect shape/size that could lead to premature failure • Explore effective post-processing methods (e.g. heat treatment, HIPing, laser peening) to reduce defect size • Identify the best manufacturing route for a product	6-7

VC SEGMENT	ACTION NAME	CONTEXT (GAP)	ACTIONS PROPOSED	CURRENT TRL
End of life	**Batch-to-batch recycling of materials**	Reusing feedstock for parts production.	• Develop guidelines for testing, reuse and recycling (for example per alloy/process) • Need for standard validation procedure for material properties in parts produced with feedstock that has been subjected to reuse or recycling, as well as guidelines for acceptable material properties and actions that restore the material properties to the original target values	4-6
Complete VC	**Knowledge repository**	Databases of process parameters and material properties need to be developed to enable determination of product design and establishment of material design allowances for specific processes.	• Knowledge generation for the effect of AM parameters (including waste streams), to the energy consumption and environmental footprint • Generation and availability of data regarding mechanical properties, dimensional accuracy, surface roughness etc. coupled with the respective machine characteristics and process parameters • AM material information database to enable the correct choice of AM materials • Investigations on effect of several protective gases/ mixtures on material characteristics	4-6

MEDIUM TERM ACTIONS

TOPIC	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Material	**Availability of quality, economical materials**	AM community relies on a limited selection of conventional feedstock material. The availability of quality, economically feasible raw materials or feedstocks should be fostered. The range of available materials needs to be expanded.	• Dedicated topics on materials and chemistry for developing new polymers (and charge, where relevant). Nylon is emerging now, other polymers like PEEK or similar could be a new frontier. Polymers with low CTE • Ultra-high temperature materials (refractory, composite, others). New alloys with high temperature capability • Research into materials suitable for printing of multi-functional components/multi-material for multi-functional parts towards smart systems • Research on materials compatibility with current and novel AM processing technologies • Novel materials resulting in fewer undesirable by-products and less waste • Reinforce collaboration between designers, material producers and AM machine manufacturers	4-6
Process / Product	**Quality management systems**	Quality management system covering the whole AM-process chain from powder to the final product, as a basis for part qualification, and AM-process chain surveillance. This includes data gained from pre-process analysis (powder), process monitoring solutions as well as machine data etc.	• Development of AM-process chain monitoring solutions, protocols and data systems, which give indication about the conformance of the AM-process chain with existing standards and rules • Development of statistically based knowledge about the influence of AM-processing-chain parameters on the final part quality • Development of specific “AM-quality management” standards. Definition of quality on several levels: microstructure, mechanical properties and discontinuities • Setup of a qualification label for AM service providers	4-6

TOPIC	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Complete VC	**Integrating AM technologies into existing industrial processes/ chains**	Integration in the shop floor requires attention as AM machines do not stand alone in factories. Combination with other machinery (subtractive, metallization, inspection, assembly) allows complex process chains and highly functional products, thus higher value and possible sale prices.	• Integration of entire process chains, data management (single source) • Interfaces development • Evaluate/reconfigure CAD/CAM systems. CAD/CAM platforms to support the integration of AM processes and equipment • Fully automated AM processes connected via ERP and with the other machines in the production lines, to produce single parts in continuous production flow	4-6

LONG TERM ACTIONS

TOPIC	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Process	**Improved heat sources**	The heat or light source (in most) AM equipment is a bottle neck for improved production quantity and accuracy (resolution). This is a very important issue in terms of industries linked to glass manu-facturing (not only jewellery, but e.g. also optics).	• Development of improved heat transfer/control/distribution/strategy/new lasers/energy sources etc.	1-3
End of life	**Assessment of recycling, reuse and waste to determine life cycle costs**	There is a shortage of material recycling services and means for reusing AM materials.	• Environmental Impact Module/Evaluator will acquire real-time process data from measurement systems • Definition and quantification of environmental KPIs such as energy consumption, waste streams, heat emission and gaseous emissions • Connection with LCA databases will enable the application of LC methodologies for accurate analysis of the environmental impact of AM processes, incorporating an environmental perspective into decision-making processes for transitioning to AM • Development of effective feedstock recycling processes • Development of regulatory requirements for recycling metal powders and production of functional parts	1-3

2.1.2 Non-technological cross-cutting actions

Cross sectorial gaps related to non-technological areas such standardisation, education & training, communication, etc. have been identified (fig 4).

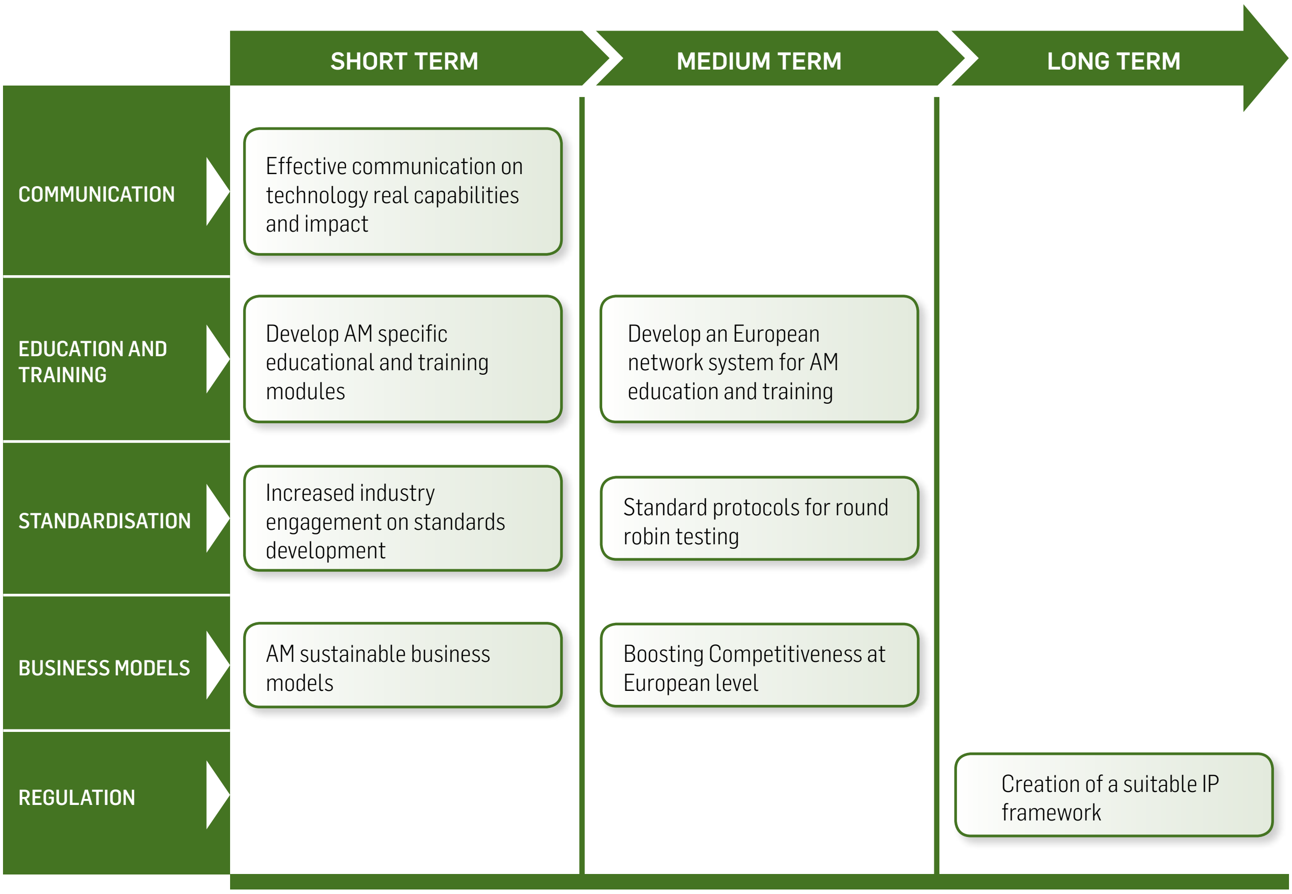

Fig. 4 *Summary of non-technological cross-cutting gaps*

SHORT TERM ACTIONS

TOPIC	GAP NAME	CONTEXT (GAP)	ACTION PROPOSED
Communication	**Effective communication of the technology for real applications and impact**	In some cases, the AM technology/term has been over-characterised and described by excessive media hype and expectations. This has brought serious damage to the credibility and development of the AM industry. To ensure rapid and effective guides, real benefits and impact need be communicated to industry.	• Use of existing communication networks of reference (e.g. platforms, industrial associations, standardisation committees…) to inform the different communities and foster dialogue between them. Moreover, to reach the general public and policy makers, sector magazines, newspapers and 2.0 tools (Twitter, You Tube) should be further exploited • Coordination with local industrial chambers and organisation, including umbrella organizations, of training days/seminars including practical workshops • Screening of existing/organisation of events, conferences to present the novelties, bringing examples of good collaborations, success stories in industrial implementation, and societal impact. This includes bringing together different stakeholders (policy makers, industry, end-users etc.) and adopting a 'correct' communication channel for each of them • Attention to the development of "use" cases where businesses in application sectors can have access to technology facilities and use AM equipment, thereby improving their practical understanding of this technology. This would tackle the problem related to overall conservative attitude towards AM in industry
Education and training	**Develop AM specific educational and training modules**	New jobs around AM will be created. Finding the workforce with the right competences is a challenge. Thus, knowledge gaps and educational needs for the AM workforce need to be identified and addressed. Training and education establishments need to preserve and develop the employability of workers. Industry and other employers (e.g. Standardisation bodies, IPR entities etc.) should be also engaged in the process in order to align their needs with regard to skills with the educational contents. AM education and training requires an integrated and interdisciplinary approach to prepare the current and future workforce to boost AM's real potential.	• Map existing educational programs and actors in Academic and Industry • Promote collaboration of educational bodies with industry and governments at regional, national and EU levels towards the inclusion of AM aspects on the educational curricula in an effective way • Ensure that AM curricula addresses employer's needs and includes both technical (AM and traditional manufacturing processes, materials, design for AM, safety, etc.) and business related aspects. They should target different levels: management, engineers, shop floor, etc. - from University level to the operator level, focusing not only in preparing a new workforce but also in re-skilling the existing one to work and implement AM • Introduce new means of teaching: for example practical modules held at industrial or specialized R&D centres • Provide AM training programs to gain AM knowledge and experience for workers seeking alternative em-ployment pathways • Initiation of learning technology related courses at school level • Use of standards as a base for all training materials and courses (certification by professional bodies) from industry training to higher education • Offer support for collaborative and community-oriented maker spaces/events that, as informal learning environments, promote awareness of AM among society

TOPIC	GAP NAME	CONTEXT (GAP)	ACTION PROPOSED
Standardisation	**Increased industry engagement on standards development**	To accelerate AM market take up, industry should be further engage in CEN, ASTM, and ISO standards development. Possible barriers concerning time and money to follow this activity should be minimized.	• Lower the barrier to engaging stakeholders by centralization of standardisation activities in specific key meetings/events etc. • Promote the ongoing activities on standardisation at a wider level. Continuous interaction with local, national, EU and international standards development bodies/activities should be pursued • Support further engagement via H2020 projects or other relevant projects with central focus on AM to evaluate possible use of results for standards elaboration. When suitable a Work Package dedicated to dealing/engaging with standardisation should be mandatory. Another alternative could be having a continuous standarisation project that interacts and coordinates with existing projects • Explore feasibility to evaluate which standards already approved and existing in non-AM sectors can be extended to AM
Business models	**AM sustainable business models**	Business cases and models are still needed to show decision makers what is possible with AM and how it could impact their business (for parts, for prototyping, for production processes).	• Evaluation of AM capabilities for new products and structures. Identification of appropriate use cases, right applications and markets, and development of practical solutions for the production and distribution of the products • Success models for business collaboration, realising current bottlenecks and best practices for transferability of novel technologies • Explore existing AM manufacturing platforms and materials to evaluate suitability as an alternative manufacturing solution • Business and economic model analysis. Cost estimation • Consideration of 3D parts models access and IPRs possible issues

MEDIUM TERM ACTIONS

TOPIC	GAP NAME	CONTEXT (GAP)	ACTION PROPOSED
Education and training	**Development of a European network system for AM education and training**	AM is a fast developing technology constantly changing, and educational contents and training guidelines need to be updated at the same speed and in a sustainable way to ensure the system tackles immediate and future needs. Moreover, a broad topic tackling a wide sector spectrum should be able to cover all aspects and increase dedicated resources, establish new educational partnerships to deliver broad education.	• Creation of a European network for AM education as a central reference hub for training and educational purposes, covering VET, HE etc. • Development of harmonized qualification and certification system for AM, covering all European Qualifications Framework (EQF) levels. The system would address the needs for training and qualification (and re-qualification) of personnel at all levels. Consideration also of different training needs of the different end-users sectors industrial, educational and consumers in order to generate suitable support material • Quality assurance system to guarantee the quality of the training provided along with standard best practices • Resource and facilities sharing, good quality course materials and other contents provided to create and sustain AM education across Europe • Promote students/workers/teachers exchange among educational establishments and practices in companies/R&D centres • Coordination with local industrial chambers and organisation of training days/seminars and practical workshops

TOPIC	GAP NAME	CONTEXT (GAP)	ACTION PROPOSED
Standardisation	**Standard protocols for round robin testing**	AM materials, equipment and process need to be qualified to repeatedly produce high-quality parts. The availability of several types of processes, machines and materials complicates this action. These protocols are needed to enable independent testing of processes and equipment and to establish trust on the technology.	• Test methods/standards for characteristics of raw materials (feedstock) for validation before manufacturing. Input from material providers to define the relevant ease of testing • Encourage/initiate interlaboratory comparisons • Develop conformity assessment protocols to allow for multiple manufacturing processes providing similar parts and tools • Inter-exchangeability of norms and standards, simulation and monitoring based certification process instead of final parts based testing
Business models	**Boosting Competitiveness at European level**	Leverage a rich knowledge base in AM to gain competitive advantage in Europe by accelerate the adoption of these technologies.	• To boost truly collaborative environments and networks among the regions and Member States following their capabilities (RIS3 strategy)/needs along the value chains segments • To analyse the need of the creation of an "EU Makes portal/platform" similar to USA model • To coordinate policy actions and incentives at the lo-cal/regional/national or EU level • AM marking/branding/labeling. "Made by AM" • Development of practical solutions for the production and distribution of the products

LONG TERM ACTIONS

TOPIC	GAP NAME	CONTEXT (GAP)	ACTION PROPOSED
Regulation	**Creation of a suitable IP framework**	Currently there is no case law about AM/3D-Printing. Knowing the real implications of AM will take some time and it will most likely happen that legislation comes after the act. IP law needs a great change to be able to deal with the threats that will be coming with 3D-Printed objects.	• Revision of the regulatory texts and the addition of specific categories for AM and 3D-Printing • To explore on who and what should be regulated, and liability aspects • To explore the need of regulating AM specifically and separately • To assess current protection tools: Copyright, Patents, Design Rights, Utility Models, Trade , Industrials Secrets

2.2 Sectorial actions

2.2.1 Technological actions for health value chain

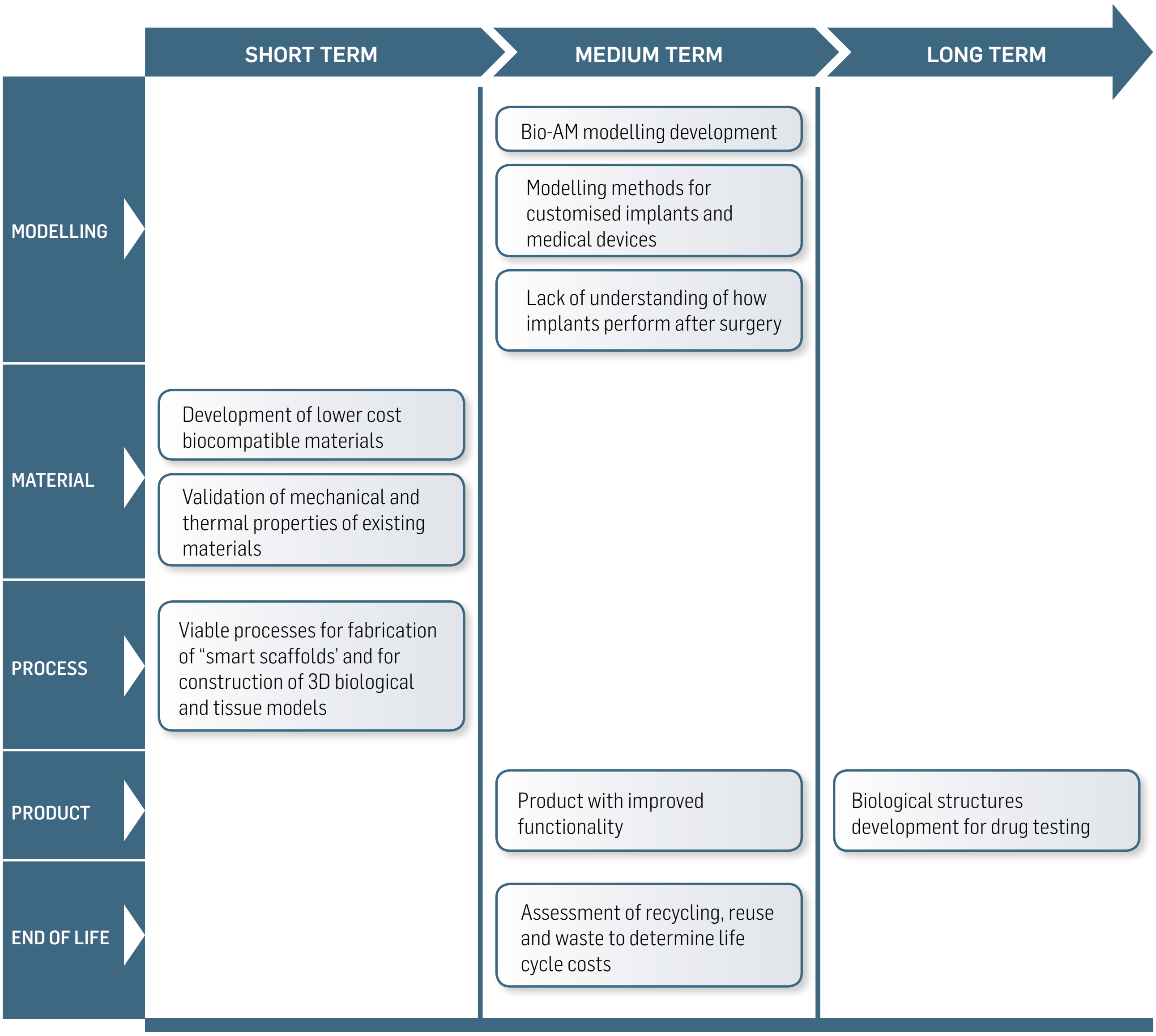

Fig. 5 *Summary of technological identified gaps in the health sector*

SHORT TERM ACTIONS

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Material	**Development of lower cost biocompatible materials**	Novel bio-functional materials capable of supporting the use of printing in current and novel human and diagnostic applications are needed. Materials for medical applications (e.g. implants, dental elements, chirurgical instruments) must meet high demands on biocompatibility and reliability. Linked with cross-cutting gap.	• New or adapted processes for bio-functional powder production • Adapted equipment for bio-functional powder use • Development of new machine concepts e.g. for graded material properties and multi material combinations • Development of new composites based on polymer/ ceramic and ceramics reinforced metal (metal matrix composites, i.e. MMCs) • New materials: e.g. magnesium, copper, bio-degradable polymers, etc. • Focus on biocompatibility and required performance properties • Mechanical characterisation comparison with traditional materials	4-6
Material	**Validation of mechanical and thermal properties of existing materials**	Material quality control and high reliability materials are key issues for medical applications that require validation.	• Significant experimental effort needed and population of corresponding databases • Improve process stability. Brittle fracture is a key property to be assessed, i.e. fracture toughness and effect of small defect on the fracture property • Implement methods to improve quality across batches of used and raw material • Develop best-practice for machine and feedstock handling, round-robin testing and mapping of process parameters vs. material properties • Research the effects of heat treatment and post processing operations	7-8
Process	**Viable processes for fabrication of 'smart scaffolds' and for construction of 3D biological and tissue models**	Production of parts for medical applications require special processes and equipment.	• Development to enable industrial fabrication and implementation for medical applications • Encourage synthesis of multi-material porous structure for impregnation • Novel equipment supporting printing of bio-compatible fabrication including multi-material and printing of living cells	4-6

MEDIUM TERM ACTIONS

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Modelling	**Bio-AM modelling development**	Fine mesh structures of AM promote osseointegration in implants or drug release of medicine. Therefore, analysis and simulation of cell responses and cell tissue growth behavior is required.	• Increase research and knowledge of bio-AM in cell response and tissue growth behaviour • Investigate the robustness of models including repeatability • Converging biotechnology, engineering and medical expertise • Material models for controlled drug release	3-4

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Modelling	**Modelling methods for customised implants and medical devices**	Advanced modelling tools combining various medical imaging methods with modelling and design to support AM production are needed for efficient use of AM.	• Compilation of specifications and identification of current capability gaps in available software • Development of scanning and surgical methods; for example the development of multi-physics, multiscale modelling tools to ensure functionality and safety of parts and increase the understanding of how it will perform after surgery (from grain size or molecule to component level) • Development of file compatibility between imaging and AM modelling software	3-4
Modelling	**Lack of understanding of how implants perform after surgery**	Knowledge of long term clinical performance of AM implants will help to optimise the effects. Long term clinical performance of AM implants improving the advantages of AM in medical sector.	• Development of modelling tools that recognise how implants will perform after surgery (from the tissue to the material and implant) • Long term clinical observations that aim to understand the health related performance. This should use a case approach in which the full financial impact on the value chain is detailed. To include participation of all stakeholders (medical, organisational, financial, insurance, patients supply etc.)	1-3
Product	**Product with improved functionality**	Materials for introducing new functionalities and/or producing integrated electronics to broaden the application of AM.	• Development of “smart” parts by embedding sensors and/or effectors • Use of nanomaterials and nanotechnologies to improve material properties	1-3
End of life	**Assessment of recycling, reuse and waste to determine life cycle costs**	Recovery and reuse of expensive AM materials without compromising reliability and safety of produced critical parts. Linked with cross-cutting gap.	• Demonstration of pilot line operating with closed loop-recycling and reuse of precious materials • Set up of exemplary processes through demonstration projects • Development of automated conformity assessment protocols/systems to secure entry status and in-process validation of the quality, safety and security of the designs, (recycled) material, differentiated for use categories in the medical arena • Use a case approach to estimate the full financial impact on the value chain when making use of recycled materials, including risk assessments and financial impact of those risks	1-3

LONG TERM ACTIONS

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Product	**Biological structures development for drug testing**	Biological structures that can mimic key biological functions can help improving drug's development and replacing animal testing.	• Exploration of materials and biological factors to create conditions similar to human physiology	1-3

2.2.2 Non-technological actions for health value chain

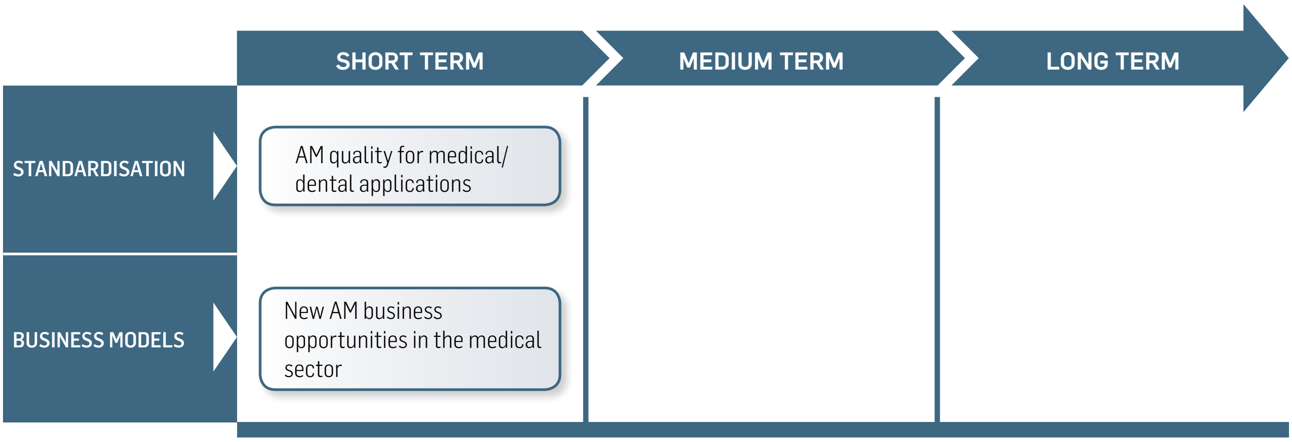

Fig. 6 *Summary of non-technological identified gaps in the health sector*

SHORT TERM ACTIONS

TOPIC	GAP NAME	CONTEXT	ACTION
Standardisation	**AM quality for medical/dental applications**	To boost the large market uptake of AM in the medical sector there is a need to develop standards and/or protocols which can be accepted by stakeholders. This is due to the existing rigorous restrictions in this sector to novel products/ processes.	• Development of standards and certifications that enlarge the number of stakeholders but also enables easier participation • Development of standard testing methods for AM based components • Development of concepts that ensure process robustness, equivalent to non-AM processes • Development of automated conformity assessment protocols/systems as to secure entry status and in-process validation of the quality, safety and security of the designs, (recycled) material, production method and build strategy, and end part validation, differentiated for use categories in the medical arena • Development of standards regarding intrinsically safe materials to be used for implants
Business models	**New AM business opportunities in the medical sector**	New business opportunities that deliver patient specific requirements, reduce the pill burden, drug testing etc. and enable simplification of the supply chain whilst accelerat-ing new developments. Linked with cross-cutting gap.	• Evaluation of AM capabilities for new products and structures. Identification of appropriate use cases • Explore existing AM manufacturing platforms and materials to evaluate suitability as an alternative manufacturing solution • Exploration of molecular AM processes and systems for tailored drug delivery • Business and economic model analysis • Research on the regulatory framework. Consideration of possible burdens of existing/new regulations (e.g., new European Medical device regulation on the way (MDR 2016 and MEDDEV 2.7/1) • Integrate AM into the regular toolkit of the Medical and Dental specialists' • Workflow development incorporating the full life cycle savings in healthcare, including the effects on investments, insurance, public healthcare, financing • CSA type project involving the medical, pharmaceutical, patients, AM community...

2.2.3 Enablers for health value chain

Further details on actor's capabilities and project's objectives and results can be found in the Annexes.

TYPE	MODELLING & SIMULATION	DESIGN	MATERIALS	PROCESS, EQUIPMENT, ITC	POST-PROCESSING	PRODUCT	END OF LIFE
RTOs	AITIIP Aragón (Spain) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) EURECAT Cataluña (Spain) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) KIMAB Stockholm (Sweden) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) CEA Rhône-Alpes (France) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) CTTC Limousin (France) EURECAT Cataluña (Spain) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) KIMAB Stockholm (Sweden) Lurederra (RTO) Navarra (Spain) TECNALIA País Vasco (Spain) TUKE Východné Slovensko (Slovakia) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) CEA Rhône-Alpes (France) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) CTTC Limousin (France) EURECAT Cataluña (Spain) IMR Southern and Eastern (Ireland) KIMAB Stockholm (Sweden) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TUKE Východné Slovensko (Slovakia) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) CETIM Rhône-Alpes (France) Coventry University West Midlands (United Kingdom) CTTC Limousin (France) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TUKE Východné Slovensko (Slovakia) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (United Kingdom	AITIIP Aragón (Spain) CETIM Rhône-Alpes (France) Coventry University West Midlands (United Kingdom) CTTC Limousin (France) EURECAT Cataluña (Spain)	AITIIP Aragón (Spain) CEA Rhône-Alpes (France) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) IMR Southern and East-ern (Ireland) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK)

TYPE	MODELLING & SIMULATION	DESIGN	MATERIALS	PROCESS, EQUIPMENT, ITC	POST-PROCESSING	PRODUCT	END OF LIFE
Industry including small and medium enterprises (SME) and large enterprises (LE)	AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) ESI Group (LE) Île de France (France) KMWE (LE) Noord-Brabant (Netherlands) MATERIALISE (LE) Vlaams-Brabant (Belgium) SIEMENS (LE) Berlin (Germany) TRIDITIVE (SME) Asturias (Spain)	+90 (SME) Turkey AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguri (Italy) EOS (LE) Oberbayern (Germany) ESI Group (LE) Île de France (France) KMWE (LE) Noord-Brabant (Netherlands) LCV (SME) Antwerpen (Belgium) MATERIALISE (LE) Vlaams-Brabant (Belgium) SIEMENS (LE) Berlin (Germany) TRIDITIVE (SME) Asturias (Spain	+90 (SME) Turkey AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) KMWE (LE) Noord-Brabant (Netherlands) LCV (SME) Antwerpen (Belgium) LINDE France Rhône-Alpes (France) MATERIALISE (LE) Vlaams-Brabant (Belgium) MBN (SME) Veneto (Italy) SIEMENS (LE) Berlin (Germany)	+90 (SME) Turkey AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) Granutools (SME) Liège (Belgium) KMWE (LE) Noord-Brabant (Netherlands) LVC (SME) Antwerpen (Belgium) LINDE France Rhône-Alpes (France) MATERIALISE (LE) Vlaams-Brabant (Belgium) SIEMENS (LE) Berlin (Germany) TRIDITIVE (SME) Asturias (Spain)	+90 (SME) Turkey AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) KMWE (LE) Noord-Brabant (Netherlands) LINDE France Rhône-Alpes (France) MATERIALISE (LE) Vlaams-Brabant (Belgium) SIEMENS (LE) Berlin (Germany) TRIDITIVE (SME) Asturias (Spain)	AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) KMWE (LE) Noord-Brabant (Netherlands) LINDE France Rhône-Alpes (France) LVC (SME) Antwerpen (Belgium) MATERIALISE (LE) Vlaams-Brabant (Belgium) SIEMENS (LE) Berlin (Germany) TRIDITIVE (SME) Asturias (Spain)	Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Ita-ly) EOS (LE) Oberbayern (Germany) KMWE (LE) Noord-Brabant (Netherlands) SIEMENS (LE) Berlin (Germany)
Others including consultancy services (CS), human resources (HR), associations, clusters...	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium) Mtikem (Cluster) Nord-Pas-de-Calais (France)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium) Matikem (Cluster) Nord-Pas-de-Calais (France)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium) Matikem (Cluster) Nord-Pas-de-Calais (France)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium) Matikem (Cluster) Nord-Pas-de-Calais (France)

TYPE	MODELLING & SIMULATION	DESIGN	MATERIALS	PROCESS, EQUIPMENT, ITC	POST-PROCESSING	PRODUCT	END OF LIFE
FoF Projects with applicable results to this sector	ADDFACTOR BOREALIS CAXMAN ENCOMPASS HI-MICRO HYPROLINE KRAKEN MANSYS NEXTFACTORY SMARTLAM SYMBIONICA TOMAX	ADDFACTOR BOREALIS CAXMAN ENCOMPASS HI-MICRO HYPROLINE KRAKEN MANSYS SMARTLAM SYMBIONICA	3D HIPMAS ADDFACTOR BOREALIS ENCOMPASS HYPROLINE KRAKEN MANSYS TOMAX	3D HIPMAS ADDFACTOR BOREALIS CASSAMOBILE CAXMAN ENCOMPASS HI-MICRO HYPROLINE KRAKEN MANSYS PHOCAM SMARTLAM SYMBIONICA TOMAX	ADDFACTOR BOREALIS CAXMAN ENCOMPASS HYPROLINE KRAKEN MANSYS	3D HIPMAS ADDFACTOR BOREALIS CAXMAN ENCOMPASS HI-MICRO HYPROLINE KRAKEN MANSYS NEXTFACTORY SMARTLAM SYMBIONICA	BOREALIS KRAKEN MANSYS

2.2.4 Technological actions for aerospace value chain

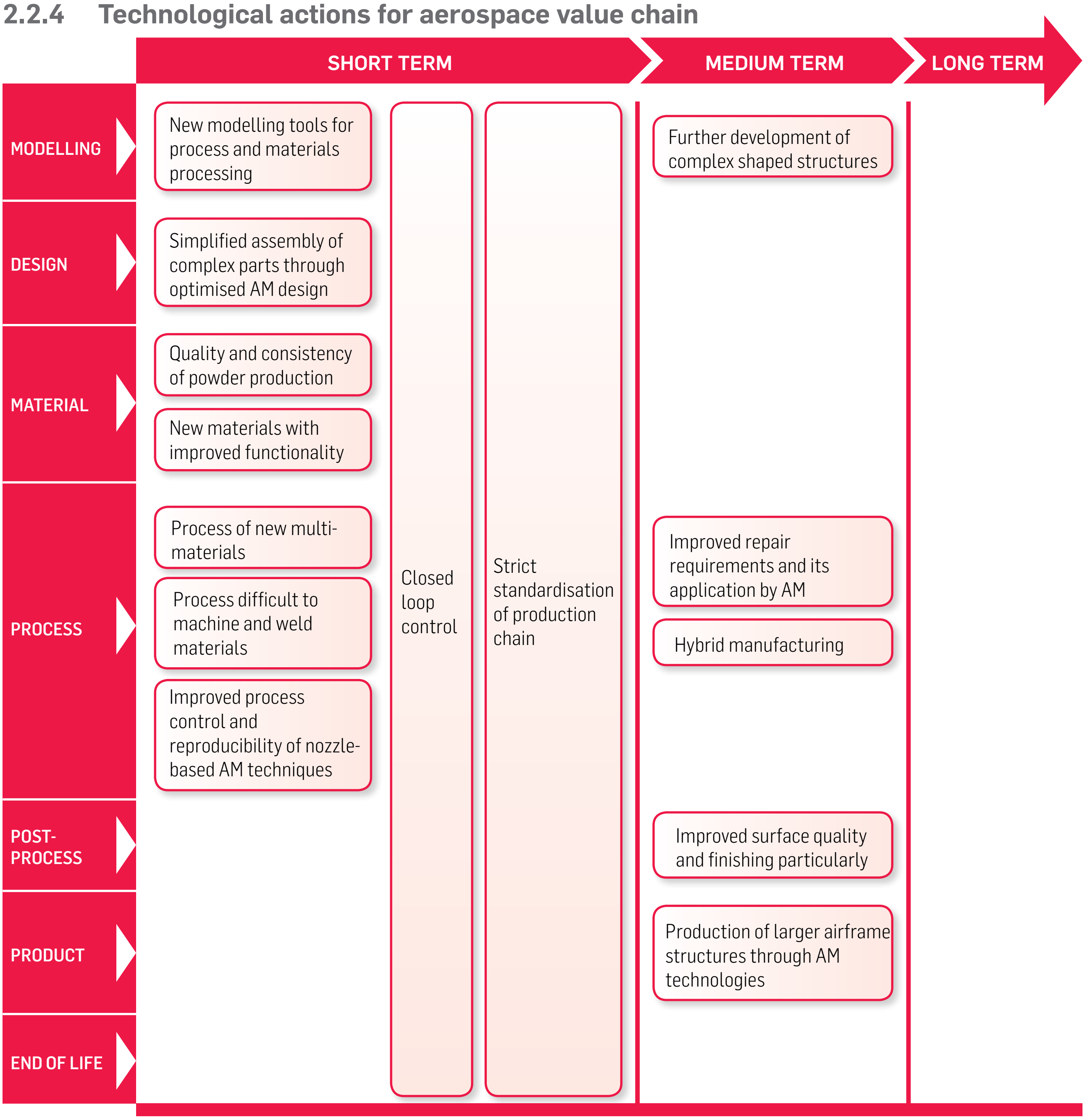

Fig. 7 *Summary of technological identified gaps in the aerospace sector*

SHORT TERM ACTIONS

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Modelling	**New modelling tools for process and materials processing**	Design optimization in combination with process reliability Fully integrate AM process modelling in state of the art software systems for efficient and optimized modelling. Linked with cross-cutting gap.	• Address simulation of the thermal conditions in the part in combination with topological optimization of the support structure and fixturing • Conduct a state-of-art literature survey of existing models and models that are currently being developed. Integration of state of the art tools emerging from FP7 programs • Deployment towards higher TRL • Encourage modelling using machine parameters as entry parameters, and establish links with mechanical properties	5-6
Design	**Simplified assembly of complex parts through optimised AM design**	Advanced design tools to help utilize the advantages of AM.	• Introduce topology optimization methodologies in the design phase to move from feature-based to function-based design • Topology optimization and CAD return	6-7
Material	**Quality and consistency of powder production**	Raw material quality control is key in aerospace business. Moreover, having the right requirement for powder batch acceptance is required for certification compliance. Connected to automotive sector gap.	• Work on material quality, shape for powder and size in order to have a well-controlled material for the 3D process • Quality and consistency of powder production. Improve processes for powder production with better distribution size control	6-7
Material	**New materials with improved functionality**	Reliability of AM produced parts during their life time is essential for aerospace applications. Reliable high performance materials (light weight, strong, high temperature, reliable) and special materials. Linked with cross-cutting gap.	• Development of shape memory alloys (thermal and magnetic) piezoelectric actuators and electro active polymers • Lightweight materials (e.g. titanium alloys) • Extreme operating temperatures superalloys for turbine components • Improved dynamic (fatigue) materials properties: Development of new alloys with improved dynamic properties and the development of advanced composites including high mechanical resistance ceramic particles in metal matrix • Development of materials with improved creep and oxidation resistance • Development of new routes for powder production to enable cheaper powders • Development of wire feedstock with chemistry tailored for AM applications	4-6
Process	**Process of new multi-materials**	Enabling the use of multi material, graded material including reliable modeling tools and optimized processes.	• Development of "smart" parts by embedding sensors and/or effectors • Development of new machine concepts e.g. for graded material properties and multi material combinations and the development of modelling tools to support this activity • Fatigue and fracture toughness properties; effect of defects • Residual stress in materials, caused by AM process and mismatch of different material properties (i.e. elastic modulus and coefficient of thermal expansion)	1-3

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Process	**Process difficult to machine and weld materials**	Machining and welding of super alloys produced by AM (Ni and Ti based) can be very difficult. Specific problems that occur should be solved to make more use of AM in combination with other processes.	• Establish methodology with machine parameters through defined design of experiments • New optimized cutting tools (in terms of materials and geometry) for AM parts • Use of ceramics • Development of appropriate modelling tools to support this activity	1-3
Process	**Improved process control and reproducibility of nozzle-based AM techniques**	It is required to demonstrate that the key process parameters are under control for certification in this sector. Repeatability, reproducibility and performance of AM processes can be improved using knowledge and tools, in order to get predictable outcome of the process. Lack of availability of suitable monitoring systems for AM; Incorporation into existing machines to control quality during building process. Linked with cross-cutting gap.	• Implement real thermal field mapping (from machine sensors) to determine residual stresses • Data regarding mechanical properties, dimensional accuracy, surface roughness etc. coupled with the respective machine characteristics and process parameters • Develop in-situ multiscale analysis methods by vision systems and image processing • In line control towards zero defects • Make use of established know-how in polymer FDM, injection moulding and PIM • Interaction with the "design" and "modelling" VC segments, i.e. design and process iterations • Structural integrity analysis: design against fatigue and design for damage (defect) tolerance	4-6
Complete VC	**Closed loop control**	Closed loop control for yield optimised processes. This is necessary for processing and equipment right performance, and the ability to qualify and certify parts and processes. Current building processes often perform the printing without recognizing errors during the fabrication.	• Create closed-loop and adaptive control systems with feedback capabilities • Directly identify errors in the process and try to repair them on the spot without losing the whole build job • Efficient modelling tools to provide intelligent feedback control	4-5
Complete VC	**Strict standardisation of Production chain**	Increased reliability by standardisation of all production steps and process control.	• Analysis of solidification/cooling rate + defects of the bulk material properties • Understanding of the influence coming from mass/size of product and predictions for scalability of AM processes • Assessment of final heat treatment	4-6

MEDIUM TERM ACTION

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Design	**Further development of complex shaped structures (e.g. lattice structures)**	The ability of AM to produce optimised complex shapes can only be utilised if these shapes can be designed.	• Develop algorithms to automatically generate stress optimized lattice structures (preliminary design) • Develop automated plausibility checks for structures under constraints (preliminary design). Integrate CAD packages with AM process (conceptual design) • Integration of simulation into the design phase (both in the preliminary and detail design) • Extension of topology optimization tools (concept design: optimisation for weight savings) • Structural Integrity & Durability assessment (detail design)	7-8
Process	**Improved repair requirements and its application by AM**	Repair of expensive parts (e.g. turbine blades) by adding new material at worn regions.	• Develop and adapt the process chain for repair approach in order to have an easy process and a final product with the best properties • Combine and specify with development of appropriated standards • More advanced repair operations through selective re-application of advanced alloy materials (e.g. IN718). Possibly in combination with some hybrid manufacturing solution, would and should be a part of industrial process development, evaluation and demonstration projects	6-7
Processx	**Hybrid manufacturing**	Hybrid manufacturing can support AM competiveness for particular aerospace applications. Connected to Automotive sector gap.	• Create advantage by combining small complex and functional AM parts with large volume parts with only stability as a function • Development of combined AM/subtracting with very good control of final product geometry and properties • Hybrid solutions should not necessarily be implemented within the same machine: develop techniques for AM integration in the industrial production system and/or Hybrid fabrication processes using multiple AM and other processes • Joining technologies, e.g. by welding, to join AM with AM or conventional materials to form a larger or complex geometry part	4-5
Post-process	**Improved surface quality and finishing particularly**	Complex lattice structures are difficult to reach for post process surface treatments. Surface finishing can improve the fatigue properties of a workpiece as cracks can start at the surface of the part.	• Research into the effect of post processing operations and automation of post processing • Development of materials (cermet/metcer) • Develop new cost-effective surface finishing processes for example combination of AM and subtractive manufacturing • Reduce and control particles size of powder • Optimisation of post-processing, e.g. on balance of cost (time, money) vs. material quality (residual stress, defect size, strength)	6-7

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Product	**Production of larger airframe structures through AM technologies**	Increasing the size envelopes and the productivity of the printers at a reasonable cost is needed.	• Development of new machines with larger build envelopes, higher productivity, and integrated post-processing • Assembly operations to be reduced towards the end of the production line • Address critical issues such as reliability of the process both over a large area, and over long building times. For example detection and elimination of faults with 100% certainty, achieve consistency of properties and minimize tension over a large build area and volume	5-6

2.2.5 Non-technological actions for aerospace value chain

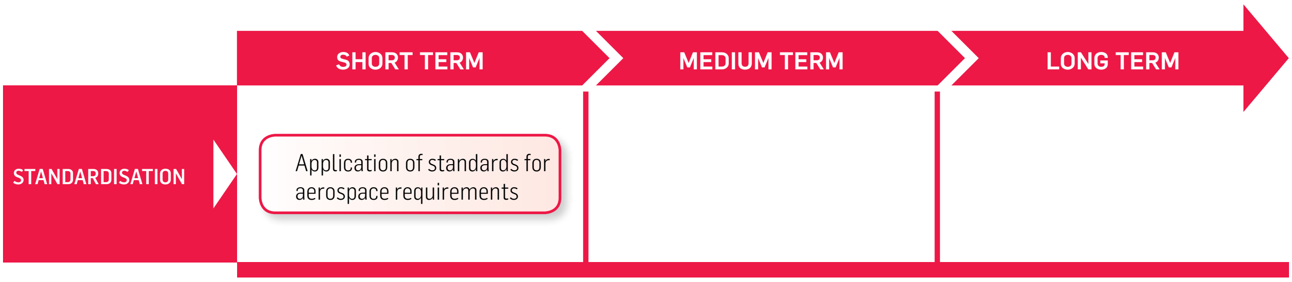

Fig. 8 *Summary of non-technological identified gap in the aerospace sector*

SHORT TERM ACTIONS

TOPIC	GAP NAME	CONTEXT	ACTION
Standardisation	**Application of standards for aerospace requirements**	The ability to certify and qualify parts to existing aerospace specifications is important for the deployment of these technologies in this sector. It is needed to show to the certification bodies that AM technical and industrial base could be in line with normal practices in the sector.	• Increase engagement of aerospace OEMs in AM Platform/community to contribute with AM specific requirements for aerospace applications • Have a clear technological and manufacturing readiness with plan in place to go further on more critical/complex parts to show to Air authorities • Develop/structure AM supply chain in Europe (from prototype world to serial production...) • Perform gap analysis for acceptance of AM structures to existing manufacturing standards and develop a clear route to acceptance

2.2.6 Enablers for aerospace value chain

TYPE	MODELLING & SIMULATION	DESIGN	MATERIALS	PROCESS, EQUIPMENT, ITC	POST-PROCESSING	PRODUCT	END OF LIFE
RTOs	AITIIP Aragón(Spain) Andaltec Andalucía (Spain) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland KIMAB Stockholm (Sweden) LMS Dytiki Ellada (Greece) M2i Zuid-Holland (Netherlands) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) Andaltec Andalucía (Spain) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland) LMS Dytiki Ellada (Greece) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) Andaltec Andalucía (Spain) CEA Rhône-Alpes (France) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) CTTC Limousin (France) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland KIMAB Stockholm (Sweden) Lurederra Navarra (Spain) M2i Zuid-Holland (Netherlands) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TUKE Východné Slovensko (Slovakia) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) CEA Rhône-Alpes (France) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) CTTC Limousin (France) IMR Southern and Eastern (Ireland) Inspire AG Switzerland KIMAB Stockholm (Sweden) LMS Dytiki Ellada (Greece) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TUKE Východné Slovensko (Slovakia) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) CTTC Limousin (France) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TUKE Východné Slovensko (Slovakia) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) Andaltec Andalucía (Spain) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) CTTC Limousin (France) IMR Southern and Eastern (Ireland) Inspire AG Switzerland LMS Dytiki Ellada (Greece) Lurederra Navarra (Spain) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) Andaltec Andalucía (Spain) CEA Rhône-Alpes (France) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) IMR Southern and Eastern (Ireland) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK)

TYPE	MODELLING & SIMULATION	DESIGN	MATERIALS	PROCESS, EQUIPMENT, ITC	POST-PROCESSING	PRODUCT	END OF LIFE
Industry including small and medium enterprises (SME) and large enterprises (LE)	AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) ESI Group (LE) Île de France (France) KMWE (LE) Noord-Brabant (Netherlands) MATERIALISE (LE) Vlaams-Brabant (Belgium) Safran (LE) Île de France (France) TRIDITIVE (SME) Asturias (Spain)	+90 (SME) Turkey AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) CRIT (SME) Emilia-Romagna (Italy) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) ESI Group (LE) Île de France (France) KMWE (LE) Noord-Brabant (Netherlands) LCV (SME) Antwerpen (Belgium) MATERIALISE (LE) Vlaams-Brabant (Belgium) Safran (LE) Île de France (France) TRIDITIVE (SME) Asturias (Spain)	+90 (SME) Turkey AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) CRIT (SME) Emilia-Romagna (Italy) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) KMWE (LE) Noord-Brabant (Netherlands) LCV (SME) Antwerpen (Belgium) LINDE France Rhône-Alpes (France) MATERIALISE (LE) Vlaams-Brabant (Belgium) Safran (LE) Île de France (France)	+90 (SME) Turkey AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) CRIT (SME) Emilia-Romagna (Italy) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) Granutools (SME) Liège (Belgium) KMWE (LE) Noord-Brabant (Netherlands) LVC (SME) Antwerpen (Belgium) LINDE France Rhône-Alpes (France) MATERIALISE (LE) Vlaams-Brabant (Belgium) Safran (LE) Île de France (France) TRIDITIVE (SME) Asturias (Spain)	+90 (SME) Turkey AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) KMWE (LE) Noord-Brabant (Netherlands) LINDE France Rhône-Alpes (France) MATERIALISE (LE) Vlaams-Brabant (Belgium) Safran (LE) Île de France (France) SIEMENS (LE) Berlin (Germany) TRIDITIVE (SME) Asturias (Spain)	AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) KMWE (LE) Noord-Brabant (Netherlands) LCV (SME) Antwrpen (Belgium) LINDE France Rhône-Alpes (France) MATERIALISE (LE) Vlaams-Brabant (Belgium) Safran (LE) Île de France (France) TRIDITIVE (SME) Asturias (Spain)	Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) KMWE (LE) Noord-Brabant (Netherlands) Safran (LE) Île de France (France) SIEMENS (LE) Berlin (Germany)

TYPE	MODELLING & SIMULATION	DESIGN	MATERIALS	PROCESS, EQUIPMENT, ITC	POST-PROCESSING	PRODUCT	END OF LIFE
Others including consultancy services (CS), human resources (HR), associations, clusters...	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) EWF (Association) Bruxelles-Capitale (Belgium) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) EWF (Association) Bruxelles-Capitale (Belgium) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)
FoF Projects with applicable results to this sector	AMAZE BOREALIS CAXMAN ENCOMPASS HYPROLINE KRAKEN LASIMM OPENHYBRID MANSYS PARADDISE STELLAR TOMAX	AMAZE BOREALIS CAXMAN ENCOMPASS HYPROLINE KRAKEN LASIMM OPENHYBRID MANSYS STELLAR	AMAZE BOREALIS ENCOMPASS HYPROLINE KRAKEN LASIMM OPENHYBRID MANSYS STELLAR TOMAX	AMAZE BOREALIS CASSAMOBILE CAXMAN ENCOMPASS HYPROLINE KRAKEN LASIMM MODULASE OPENHYBRID MANSYS PARADDISE STELLAR TOMAX	AMAZE BOREALIS CAXMAN ENCOMPASS HYPROLINE KRAKEN LASIMM OPENHYBRID MANSYS STELLAR	AMAZE BOREALIS CAXMAN ENCOMPASS HYPROLINE KRAKEN OPENHYBRID MANSYS LASIMM STELLAR	AMAZE BOREALIS KRAKEN MANSYS STELLAR

2.2.7 Technological actions for automotive value chain

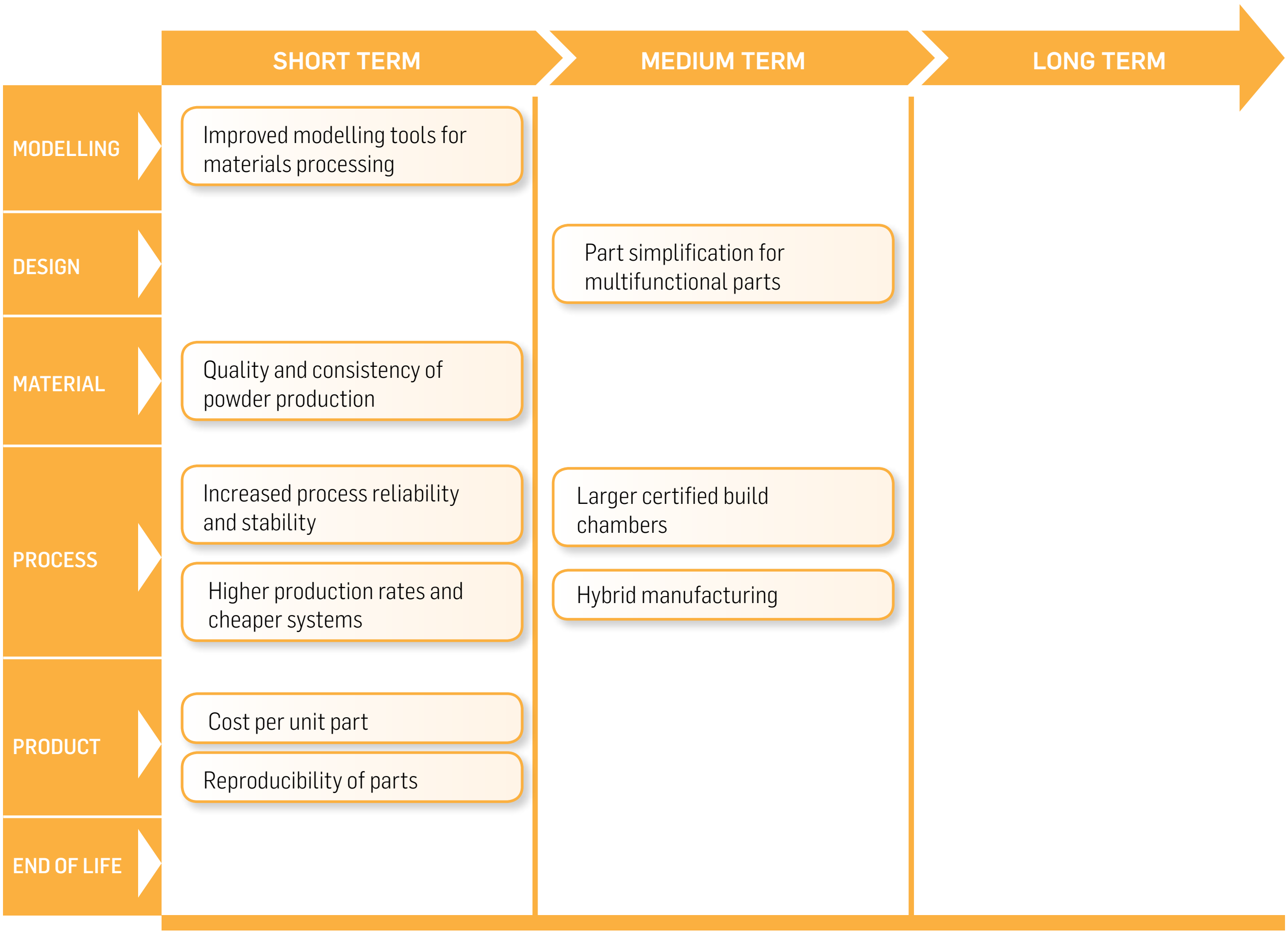

Fig. 9 *Summary of technological identified gaps in the automotive sector*

SHORT TERM ACTIONS

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Modelling	**Improved modelling tools for materials processing**	AM produced part simulation prior to production to enable first time right and minimal lightweight design (FEM, thermal history, porosity modelling, multiphysics, topology optimized, AM material properties table). Linked with cross-cutting gap.	• Increase understanding of the microstructure-material properties relationships. Foster the academic structure in the simulation of material microstructure (coarse-grained, montecarlo, random walk) • Develop mulitiphysics, multiscale modelling, from grain size or molecule towards components • Holistic modelling approaches using multiphysics simulation going from process parameters and simulation to product mechanical properties, via thermal mapping/history of the workpiece • Stochastic/empirical modelling techniques utilizing a large volume of data (knowledge repository)	6-7

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Material	**Quality and consistency of powder production**	Material quality and control is a key factor for a quality controlled AM manufacturing process. Implement new developments and benefit and encourage close links/cooperation with feedstock manufacturers. Connected to aerospace sector gap.	• Involvement of powder and resin manufacturers in AM Platform • Work on material quality, shape for powder and size in order to have a well-controlled material for the 3D process • Encourage developments based on nanotechnologies and nanomaterials texturing, coatings, spheroidization, etc.	5-6
Process	**Increased process reliability and stability**	Process reliability and stability are key for a successful industrial process. Improvement of control technologies are needed to enable effective in process measurement as current ones are not robust enough.	• Automation of the process, including loading/unloading, support removal and post processing • Develop in-situ multiscale analysis methods by vision systems and image processing • Insert sensors in the AM machine in order to monitor the quality of parts during the process • Study new solutions to improve the software that control the process • Standardization of all process steps • Methods to reduce the magnitude of residual stress • Reduce porosity and surface defects	6-7
Process	**Higher production rates and cheaper systems**	Economic use of AM requires lower cost per part, i.e. higher productivity or lower machine cost. One envisioned route is the hybridization, where more than one process is engaged in one machine. This development should be encouraged by market interests and competition.	• Process planning considerations. • Encourage machine and equipment manufacturers from outside the AM scene to engage and develop concepts/demo projects needed for studying feasibility • Process parameters optimization • Machine speed improvement • Users: learn how to design the part position into chambers • Software optimises deposition paths to minimise delays for cooling/curing and maintain stable thermal field • Machine producers: increase the numbers of laser sources/workheads	4-5
Product	**Cost per unit part**	Economic use of AM requires lower cost per part, i.e. higher productivity or lower machine cost.	• Higher throughput, by intelligent process management precision = slow, large structures = speed, design for better productivity, and cost efficient use of AM technology - All these will be encouraged by the development and demonstration of market ready AM processes • Development of low price materials	4-5
Product	**Reproducibility of parts**	Reproducibility is needed and must be (quality) secured by a consistent set of standards for the whole AM process and product cycle.	• Create standards and certifications • Definition of parameter exchange to get a higher reproducibility of the process • Development of best-practice in feedstock and machine handling • Round-Robin testing of materials and process parameters • Machine accuracy improvement	6-7

MEDIUM TERM ACTIONS

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Design	**Part simplification for multifunctional parts**	Alignment and rolling out of design methodologies, training (demonstration material) and certification of design methods is suggested.	• Development of new design strategies and tools, for the new material class, e.g. anisotropic properties and in-homogeneous microstructure, presence of residual stress • Think design before part shape and properties Identify parts that are suitable for AM production. • Need to train the approach of component fabrication • Benchmark costs (use expensive titanium fasteners vs. AM-driven one-piece design)	6-7
Process	**Larger certified build envelopes**	While AM processes are maturing, "conventional" machine manufacturers might come in and help to take current machines to the next level of machine design and engineering.	• Encourage machine and equipment manufacturers from outside the AM scene to engage and develop concepts. This development is already in progress • Collaboration with the AM industry and research community is highly recommended • Study and design new solutions for the use of more than one energy source in the build envelope	5-6
Process	**Hybrid manufacturing**	Exploiting the capability of AM by integrating or combining AM with other processes in the manufacturing stream Connected to aerospace sector gap.	• Create advantage by combining small complex and functional AM parts with large volume parts with only stability as a function • Development of combined AM/subtracting with very good control of final product geometry and properties • Hybrid solutions should not necessarily be implemented within the same machine: develop techniques for AM integration in the industrial production system and/or hybrid fabrication processes using multiple AM and other processes • Processing of inlays • Joining technologies, e.g. by welding, to join AM with AM or conventional materials to form a larger or complex geometry part. Attention should be paid to the interface of the joints and residual stress in the heat affected zones due to property mismatch and/or forced fitting	4-5

2.2.8 Enablers for automotive value chain

TYPE	MODELLING & SIMULATION	DESIGN	MATERIALS	PROCESS, EQUIPMENT, ITC	POST-PROCESSING	PRODUCT	END OF LIFE
RTOs	AITIIP Aragón (Spain) Andaltec Andalucía (Spain) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) EURECAT Cataluña (Spain) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland KIMAB Stockholm (Sweden) LMS Dytiki Ellada (Greece) M2i Zuid-Holland (Netherlands) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) Andaltec Andalucía (Spain) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland LMS Dytiki Ellada (Greece) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) Andaltec Andalucía (Spain) CEA Rhône-Alpes (France) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) EURECAT Cataluña (Spain) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland KIMAB Stockholm (Sweden) Lurederra Navarra (Spain) M2i Zuid-Holland (Netherlands) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TUKE Východné Slovensko (Slovakia) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) CEA Rhône-Alpes (France) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) EURECAT Cataluña (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland KIMAB Stockholm (Sweden) LMS Dytiki Ellada (Greece) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TUKE Východné Slovensko (Slovakia) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TUKE Východné Slovensko (Slovakia) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) Andaltec Andalucía (Spain) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) EURECAT Cataluña (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland LMS Dytiki Ellada (Greece) Lurederra Navarra (Spain) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) Andaltec Andalucía (Spain) CEA Rhône-Alpes (France) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) IMR Southern and Eastern (Ireland) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK)

TYPE	MODELLING & SIMULATION	DESIGN	MATERIALS	PROCESS, EQUIPMENT, ITC	POST-PROCESSING	PRODUCT	END OF LIFE
Industry including small and medium enterprises (SME) and large enterprises (LE)	AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) ESI Group (LE) Île de France (France) MATERIALISE (LE) Vlaams-Brabant (Belgium) TRIDITIVE (SME) Asturias (Spain)	+90 (SME) Turkey AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) CRIT (SME) Emilia-Romagna (Italy) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) ESI Group (LE) Île de France (France) LCV (SME) Antwerpen (Belgium) MATERIALISE (LE) Vlaams-Brabant (Belgium)	+90 (SME) Turkey AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) CRIT (SME) Emilia-Romagna (Italy) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) LCV (SME) Antewerpen (Belgium) LINDE France Rhône-Alpes (France) MATERIALISE (LE) Vlaams-Brabant (Belgium)	+90 (SME) Turkey AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) CRIT (SME) Emilia-Romagna (Italy) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) Granutools (SME) Liège (Belgium) LVC (SME) Antwerpen (Belgium) LINDE France Rhône-Alpes (France) MATERIALISE (LE) Vlaams-Brabant (Belgium) TRIDITIVE (SME) Asturias (Spain)	+90 (SME) Turkey AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) KMWE (LE) Noord-Brabant (Netherlands) LINDE France Rhône-Alpes (France) MATERIALISE (LE) Vlaams-Brabant (Belgium)	AIM Sweden (SME) Mellersta Norrland (Sweden) Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) KMWE (LE) Noord-Brabant (Netherlands) LCV (SME) Antwerpen (Belgium) LINDE France Rhône-Alpes (France) MATERIALISE (LE) Vlaams-Brabant (Belgium)	Altran (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) KMWE (LE) Noord-Brabant (Netherlands)
Others including consultancy services (CS), human resources (HR), associations, clusters...	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium) Matikem (Cluster) Nord-Pas-de-Calais (France)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) EWF (Association) Bruxelles-Capitale (Belgium) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium) Matikem (Cluster) Nord-Pas-de-Calais (France)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) EWF (Association) Bruxelles-Capitale (Belgium) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium) Matikem (Cluster) Nord-Pas-de-Calais (France)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)

TYPE	MODELLING & SIMULATION	DESIGN	MATERIALS	PROCESS, EQUIPMENT, ITC	POST-PROCESSING	PRODUCT	END OF LIFE
FoF Projects with applicable results to this sector	MAZE BOREALIS CAXMAN ENCOMPASS HiPR KRAKEN LASIMM OPENHYBRID PARADDISE STELLAR	AMAZE BOREALIS CAXMAN ENCOMPASS KRAKEN LASIMM OPENHYBRID STELLAR	3D HIPMAS AMAZE BOREALIS ENCOMPASS KRAKEN LASIMM OPENHYBRID STELLAR	3D HIPMAS AMAZE BOREALIS CASSAMOBILE CAXMAN ENCOMPASS HiPR KRAKEN LASIMM MODULASE OPENHYBRID PARADDISE STELLAR	AMAZE BOREALIS CAXMAN ENCOMPASS HiPR KRAKEN LASIMM OPENHYBRID STELLAR	3D HIPMAS AMAZE BOREALIS CAXMAN ENCOMPASS KRAKEN LASIMM OPENHYBRID STELLAR	AMAZE BOREALIS KRAKEN STELLAR

2.2.9 Technological actions for consumer (including electronics) value chain

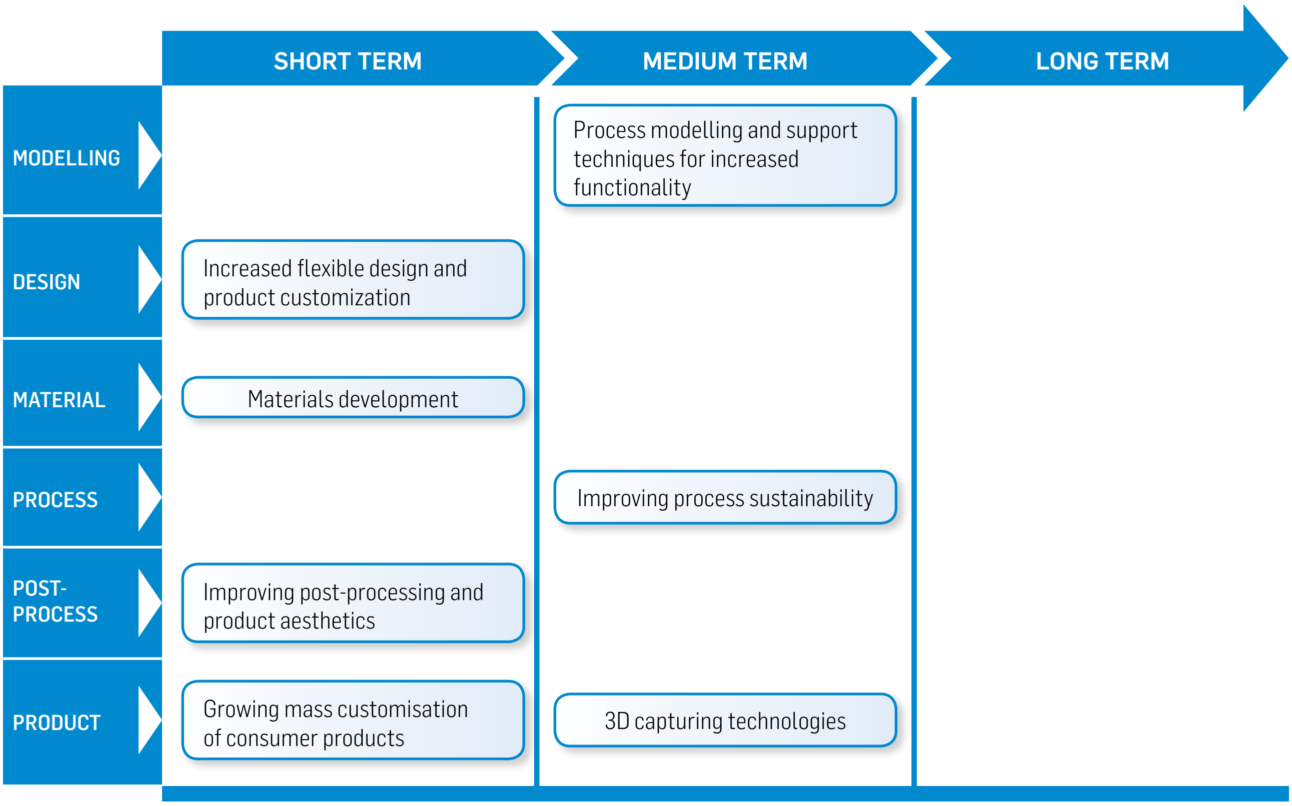

Fig. 10 *Summary of identified gaps in the consumer (including electronics) sector*

SHORT TERM ACTIONS

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Design	**Increased flexible design and product customization**	The use of design possibilities of AM in customization is not optimal. Actions needed to help implement this benefit for the sector(s). Also the link with intelligent AM parts (with embedded electronics) needs to be established. In order to allow for full-scale flexible electronics a stronger linkage between materials, design and advanced electronics is necessary as one of the key enablers in this segment.	• Use customization supported by automated software tools to bring AM into the products/parts • Drafted pre-CAD files depending on product families allowing further enhancement of design features. (Application independent) • Process chain modelling concepts • Improved topology optimisation tools • Establish linkages between electronics design and AM geometry design in one design system towards first time right production of intelligent (IoT) AM products • Establish linkages between materials, design and advanced electronics • Implementation of demonstration projects	7-8
Material	**Materials development**	New developments in this area should be made to enable AM of functional parts. Material properties such as optical, magnetic, conductive, fluidics, are not implemented in AM well enough today. Broader availability of multi-material parts could lead to higher demand from consumers. Linked with cross-cutting gap.	• Development of higher performance polymer material able to produce 3D components with the same or enhanced properties as injected parts e.g. metallic, high tech ceramics • Development of multi-materials e.g. coated coloured material or parts local properties • AM materials that are comparable to established materials: materials like metal, ceramics and glass, where still important gaps (apart from polymers) in terms of properties exist • Conductive materials in AM • Advanced materials with new material and atomistic models	5-6
Product	**Growing mass customisation of consumer products**	AM enables the involvement of the consumer in the design of their tailor made product. Tools should be developed/rolled out to unlock this capability. The perspective of the "creative industry sector" (fashion, art, sports, jewellery) has a strong focus on this aspect.	• Creation of an online platform able to manipulate CAD data, allowing both engineers and customers to interact with the final product geometry • Use customization supported by automated software tools (including multi-material, conductivity, electronic functionality) to bring AM into the products/parts. Not only for design, but also directly to relevant manufacturing & logistics processes as integrated approach • Mechanisms for modularisation of products • Analysis of process chains, allowing "configuration" of products in a detailed manner • The creation of good product databases • Demonstration project • Customisation perspectives should include both B2C, but also B2B perspectives (focus not only on consumer side)	7-8

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Post-process	**Improving post-processing and product aesthetics**	AM for consumer puts high requirements for surface quality. Mostly post processing is needed to achieve acceptable level of part quality. Use of the characteristics of materials and manufacturing processes to produce functional and aesthetically pleasing objects. Aesthetics play obviously a key role regarding clients and it is an important factor for product acceptance and commercialization.	• Development of parts with a specific "look and feel" • Introduction of new process concepts (like carbon 3D and Printvalley), continuous processes without layering • Improved topology optimization tools • Reduction of surface roughness (also for internal structures) • Utilizing products made by conventional technologies as inserts/basis for additive & subtractive tailoring • Colouring, nano-structuring to enhance surface properties wear, wettability, antifouling, dust free • Work on material and process with material ageing behaviour • Develop processes for post processing but also the AM process in such a way that post processing becomes more obsolete. Innovative support solutions. Role of automation and support infrastructure in this field (e.g. robotics)	6-7

MEDIUM TERM ACTIONS

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Modelling	**Process modelling and support techniques for increased functionality**	Part final properties are directly linked to material properties and part design. Predictive modelling. Guidelines & tools for first time right minimal design (including design history and FEM analysis) must be developed. Linked with cross-cutting gap.	• Develop models able to predict final properties and process parameters • Predictive modelling: model material, processes leading to first time right production of products. Self-learning models with iterative corrections will yield first time right products • Develop holistic modelling approaches using multi-physics simulation and going from process parameters and simulation to product mechanical properties, via thermal mapping/history of the workpiece • Implement stochastic/empirical modelling techniques utilizing a large volume of data (knowledge repository). • Electronics design and AM geometry design in one design software system	5-6
Process	**Improving process sustainability**	New developments including the manufacturing processes in this area should be made to enable AM of functional parts. Flexible and hybrid processes, including incorporation in existing production processes or adaptation to existing interfaces, are essential. Economic use of AM requires lower cost per part, i.e. higher productivity or lower machine cost.	• Development of more flexible/combination 3D processes • Develop hybrid process, including incorporation in existing production processes or adaptation to existing interfaces, with high throughput • Equipment for integration of conductive tracks, Pick and Place of electronic components • Process comprises: multi-material, conductive tracks, electronics • Intelligent/IoT AM parts drive the manufacturing cycle (which will be hybrid) themselves (4.0 approach) • Processes for thermally conductive & fire retardant, composite, Cermets, metal, carbon AM made products • Develop convergent processes towards smart devices with multi-functionalities • Increase production speed for 3D printers. Nowadays big pieces (20 cm x 20 cm x 20 cm) can take many hours (>10H)	4-5

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Product	**3D capturing technologies**	When personalised data is used in the AM design to provide tailored, personalised AM built products, (personal) 3D data capture (in an easy, accessible but safe way) needs to be established.	• Creation of algorithms/tools that will enable usage of low-cost commercially available equipment in order to capture 3D geometry e.g. SW/APP to 3Dscan / capture from mobile device and create the 3D cad model. Then further elaborate. Cheap/Easy to use for high market penetration	5-6

2.2.10 Non-technological actions for consumer (including electronics) value chain

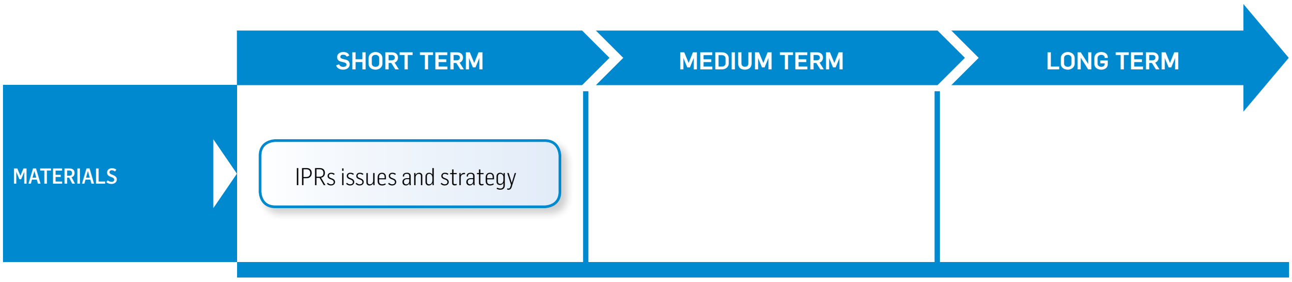

Fig. 11 *Summary of non-technological identified gap in the consumer (including electronics) sector*

MEDIUM TERM ACTIONS

TOPIC	GAP NAME	CONTEXT	ACTION
IPRs	**IPRs issues and strategy**	Intellectual property implications of AM should be reviewed to avoid that it hinders. Key IPR issues relate to AM designs and copyrights. Designs could be stolen and thus, reproduced.	• Development of a strategy to identify possible IP rights and issues that may arise taking into account the interests of all stakeholders • New forms of IPR mechanisms; clearer guidance on defining whether a CAD file could have copyright protection

2.2.11 Enablers for consumer value chain

TYPE	MODELLING & SIMULATION	DESIGN	MATERIALS	PROCESS, EQUIPMENT, ITC	POST-PROCESSING	PRODUCT	END OF LIFE
RTOs	AITIIP Aragón (Spain) Andaltec Andalucía (Spain) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) EURECAT Cataluña (Spain) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland KIMAB Stockholm (Sweden) LMS Dytiki Ellada (Greece) M2i Zuid-Holland (Netherlands) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK) VIVES Belgium	AITIIP Aragón (Spain) Andaltec Andalucía (Spain) Bangor University North Wales (UK) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) IMDEA Madrid (Spain) IMR Southern and East-ern (Ireland) Inspire AG Switzerland LMS Dytiki Ellada (Greece) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK) VIVES Belgium	AIJU Comunidad Valenciana (Spain) AITIIP Aragón (Spain) Andaltec Andalucía (Spain) Bangor University North Wales (UK) CEA Rhône-Alpes (France) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) CTTC Limousin (France) EURECAT Cataluña (Spain) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland Lurederra Navarra (Spain) KIMAB Stockholm (Sweden) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Neth-erlands) TUKE Východné Slovensko (Slovakia) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) Bangor University North Wales (UK) CEA Rhône-Alpes (France) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) CTTC Limousin (France) EURECAT Cataluña (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland KIMAB Stockholm (Sweden) LMS Dytiki Ellada (Greece) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TUKE Východné Slovensko (Slovakia) TWI South Yorkshire (UK)	AITIIP Aragón (Spain) Bangor University North Wales (UK) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) CTTC Limousin (France) IMDEA Madrid (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TUKE Východné Slovensko (Slovakia) TWI South Yorkshire (UK) VIVES Belgium	AIJU Comunidad Valenciana (Spain) AITIIP Aragón (Spain) Andaltec Andalucía (Spain) Bangor University North Wales (UK CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) CTTC Limousin (France) EURECAT Cataluña (Spain) IMR Southern and Eastern (Ireland) Inspire AG Switzerland LMS Δυτική Ελλάδα (Dytiki Ellada) (Greece) Lurederra Navarra (Spain) PRODINTEC Asturias (Spain) TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK) VIVES Belgium	AITIIP Aragón (Spain) Andaltec Andalucía (Spain) CEA Rhône-Alpes (France) CETIM Rhône-Alpes (France) Coventry University West Midlands (UK) IMR Southern and Eastern (Ireland) Inspire AG Switzerland TECNALIA País Vasco (Spain) TNO Noord-Brabant (Netherlands) TWI South Yorkshire (UK)

TYPE	MODELLING & SIMULATION	DESIGN	MATERIALS	PROCESS, EQUIPMENT, ITC	POST-PROCESSING	PRODUCT	END OF LIFE
Industry including small and medium enterprises (SME) and large enterprises (LE)	Altran Deutschland (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) ESI Group (LE) Île de France (France) MATERIALISE (LE) Vlaams-Brabant (Bel-gium) SIEMENS (LE) Berlin (Germany) TRIDITIVE (SME) Asturias (Spain)	+90 (SME) Turkey Altran Deutschland (LE) Hamburg (Germany) CRIT (SME) Emilia-Romagna (Italy) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) ESI Group (LE) Île de France (France) LCV (SME) Antwerpen (Belgium) MATERIALISE (LE) Vlaams-Brabant (Belgium) SIEMENS (LE) Berlin (Germany) TRIDITIVE (SME) Asturias (Spain)	+90 (SME) Turkey Altran Deutschland (LE) Hamburg (Germany) CRIT (SME) Emilia-Romagna (Italy) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) Kiwa (LE) Zuid-Holland (Netherlands) LCV (SME) Antwerpen (Belgium) MATERIALISE (LE) Vlaams-Brabant (Belgium) LINDE France Rhône-Alpes (France) SIEMENS (LE) Berlin (Germany)	+90 (SME) Turkey Altran Deutschland (LE) Hamburg (Germany) CRIT (SME) Emilia-Romagna (Italy) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) Granutools (SME) Liège (Belgium) LCV (SME) Antwerpen (Belgium) LINDE France Rhône-Alpes (France) MATERIALISE (LE) Vlaams-Brabant (Belgium) SIEMENS (LE) Berlin (Germany) TRIDITIVE (SME) Asturias (Spain)	+90 (SME) Turkey Altran Deutschland (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) Kiwa (LE) Zuid-Holland (Netherlands) LINDE France Rhône-Alpes (France) MATERIALISE (LE) Vlaams-Brabant (Belgium) SIEMENS (LE) Berlin (Germany) TRIDITIVE (SME) Asturias (Spain)	Altran Deutschland (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) Kiwa (LE) Zuid-Holland (Netherlands) LCV (SME) Antwerpen (Belgium) LINDE France Rhône-Alpes (France) MATERIALISE (LE) Vlaams-Brabant (Bel-gium) SIEMENS (LE) Berlin (Germany) TRIDITIVE (SME) Asturias (Spain)	Altran Deutsch-land (LE) Hamburg (Germany) D'Appolonia (LE) Lazio and Liguria (Italy) EOS (LE) Oberbayern (Germany) Kiwa (LE) Zuid-Holland (Netherlands) SIEMENS (LE) Berlin (Germany)

TYPE	MODELLING & SIMULATION	DESIGN	MATERIALS	PROCESS, EQUIPMENT, ITC	POST-PROCESSING	PRODUCT	END OF LIFE
Others including consultancy services (CS), human resources (HR), associations, clusters...	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium) Matikem (Cluster) Nord-Pas-de-Calais (France)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) EWF (Association) Bruxelles-Capitale (Belgium) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium) Matikem (Cluster) Nord-Pas-de-Calais (France)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) EWF (Association) Bruxelles-Capitale (Belgium) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium) Matikem (Cluster) Nord-Pas-de-Calais (France)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium) Matikem (Cluster) Nord-Pas-de-Calais (France)	AD Global (HR) (Cataluña-Spain/UK) Berenschot (CS) Utrecht (Netherlands) Flam3d (Association) Flanders (Belgium) IDEA (CS) Bruxelles-Capitale (Belgium) Matikem (Cluster) Nord-Pas-de-Calais (France)
FoF Projects with applicable results to this sector	ADDFACTOR CAXMAN HI-MICRO HIPR KRAKEN OPTICIAN2020 SMARTLAM TOMAX	ADDFACTOR CAXMAN HI-MICRO KRAKEN OPTICIAN2020 SMARTLAM	3D HIPMAS ADDFACTOR KRAKEN TOMAX	3D HIPMAS ADDFACTOR CASSAMOBILE CAXMAN HI-MICRO HIPR KRAKEN OPTICIAN2020 SMARTLAM TOMAX	ADDFACTOR CAXMAN HIPR KRAKEN OPTICIAN2020	D HIPMAS ADDFACTOR CAXMAN HI-MICRO KRAKEN OPTICIAN2020 SMARTLAM	KRAKEN

2.2.12 Technological actions for industrial equipment value chain

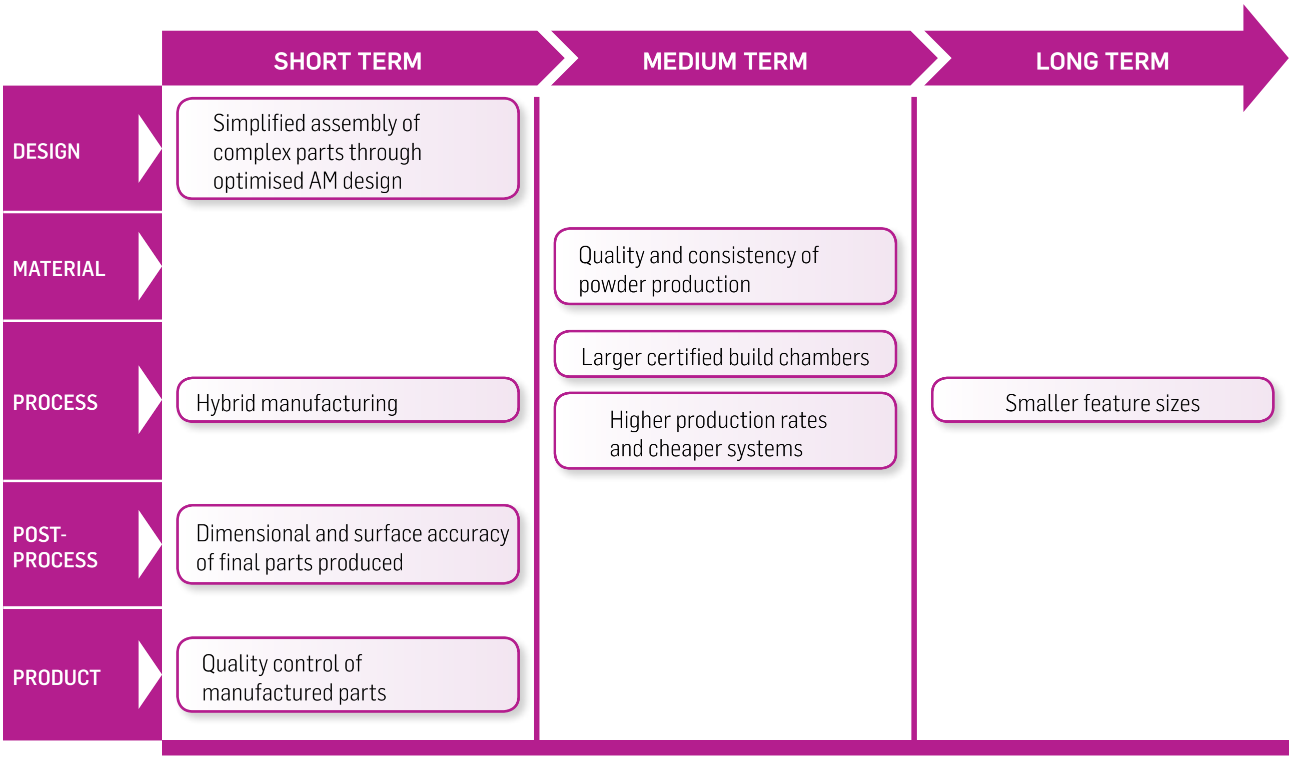

Fig. 12 *Summary of technological identified gaps in the industrial equipment sector*

SHORT TERM ACTIONS

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Design	**Simplified assembly of complex parts through optimised AM design**	In order to help fast and successful implementation of AM, pragmatic actions are needed.	• Create a new design approach and tools that include every part of a sub-system and support the merging process of the components • Increase the chamber dimension in order to produce larger parts, which in turn will allow several components to be merged together without an assembly step	7-8
Process	**Hybrid manufacturing**	Industrial implementation of AM requires inclusion with and embedding with other technologies in a hybrid setting.	• Development of a higher number of solutions that cover different combination of AM processes and other technologies such as subtractive ones (i.e. laser cladding and milling processes and turning process, etc.)	5-6
Product	**Quality control of manufactured parts**	To cope with the hesitation of AM in this sector, a guideline/route for guaranteeing quality should be presented.	• Outline a series of standard tests, specific for AM able to evaluate the quality of the manufactured parts	6-7
Post-process	**Dimensional and surface accuracy of final parts produced**	To realise net shaped parts, most of the time post processing is required; how to optimize this?	• Try to understand if requests on surface finishing and dimensional tolerances are necessary • Consider these limits during the design phase, in order to better understand the parts and overcome the problem	6-7

MEDIUM TERM ACTIONS

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Material	**Quality and consistency of powder production**	Material quality and control is a key factor for a quality controlled AM manufacturing process.	• Optimization of the feedstock manufacturing process in order to narrow the properties range • Ceramic filled resins development for large size parts • Deepest monitoring of the quality control parameter during the manufacturing process	6-7
Process	**Larger certified build chambers**	AM processes building box quality and control is a key factor for a quality controlled AM manufacturing process.	• Study and design new solutions for the use of more than one energy source in the build envelope • Development of multi laser array light engine process and associated equipment • Equipment development for large size (filled) resin based materials	7-8
Process	**Higher production rates and cheaper systems**	Economic use of AM requires lower cost per part, i.e. higher productivity or lower machine cost.	• Teach users how to design the part position into the build envelope • Machine producer to increase the numbers of heat sources/workheads • EU Community to encourage investment in the second generation of AM Machines	5-6

LONG TERM ACTIONS

VC SEGMENT	GAP NAME	CONTEXT	ACTION	CURRENT TRL
Process	**Smaller feature sizes**	To expand the additive technology towards micro and nano-scale, processes and equipment serving that scale should be further developed.	• Development of equipment for nano-scale 3D structures • Technologies like two photon polymerisation deliver micro structures, to be expanded and extended	7-8

3 Enablers' details

LEGEND	
SECTORS:	H=health; AE=aerospace; AU=automotive; CG=consumer goods; E=electronics; O= other
VC SEGMENTS:	M&D=modelling and simulation; D=design; M=materials; P=process; PP=post-processing; PR=product; EL= end of life
PROCESS:	PBF=powder bed fusion; VP=vat photopolymerization; MJ=material jetting; ME=material extrusion; SL=sheet lamination; DED=direct energy deposition; BJ=binder jetting; O=other
NON TECHNOLOGY ACTIVITIES:	STD=standardisation; L=legislation; EDU=fducation/training; IE=business, commercialisation, industrial exploitation; IPR=intellectual property rights; TT=technology transfer

NAME	SUPPLY CHAIN	WEBSITE	COUNTRY/ Region	Sectors	VC segments	AM processes	AM Materials	Non technology activities
RTOs								
AITIIP	R&D Services bureau Materials provider Design End user	www.aitiip.com	SPAIN/ Aragón	All	All	PBF, VP, ME	Metal polymer, biomaterials	STD, EDU IE, IPR, TT
ANDALTEC	R&D Design Prototyping	www.andaltec.org/en/	SPAIN/ Andalucía	AE, AU, CG, E, O (food packaging)	M&D, D, M, PR, EL	VP, MJ, ME, BJ	Polymer, biomaterials	EDU, TT
CEA	R&D	www-liten.cea.fr	FRANCE/ Rhône-Alpes	All	M, P, EL	PBF, VP, MJ, DED	Metal, polymer, ceramic	TT
CETIM	R&D	www.cetim.fr/fr	FRANCE/ Rhône-Alpes	All	All	All, 3D printing metal	Metal, polymer, biomaterials	STD, EDU, IE, TT
Coventry University	R&D Design	www.coventry.ac.uk	UK/ West Midlands	All	All	PBD, DED	Metal, polymer	STD, EDU, IE, TT
CSM	R&D	www.c-s-m.it	ITALY/Lazio	AE, AU	M, PP, PR	PBD, VP	Metal, ceramic	EDU, TT
CTTC	R&D Materials provider	www.cttc.fr	FRANCE/ Limousin	H, AE, CG, E, O (energy)	M, P, PP, PR	VP, MJ, ME, SL, DED, BJ	Ceramic	EDU, TT
EURECAT	R&D Pilot and testing Training	www.eurecat.org	SPAIN/ Cataluña	H, AU, CG, O (machinery and tools)	M&S, M, P, PR	PBF, ME, SL	Metal, polymer, food	EDU, IE, IPR, TT
IMDEA	R&D Materials provider	www.materials.imdea.org/groups/pm	SPAIN/ Madrid	All	M&S, D, M, PP	ME, SL	Metal, polymer, biomaterials	EDU, TT

NAME	SUPPLY CHAIN	WEBSITE	COUNTRY/ Region	Sectors	VC segments	AM processes	AM Materials	Non technology activities
IMR	R&D Design	www.imr.ie	IRELAND/ Southern and Eastern	All	All	All	All	STD, L, EDU, IE, TT
INSPIRE AG	R&D Design	-	SWITZERLAND	All	M&D, D, M, P, PP, PR	PBF, DED	Metal, polymer, ceramic	STD, EDU, IE, TT
KIMAB	R&D	www.swerea.se/kimab	SWEDEN/ Stockholm	All	M&S, M, P	PBF	Metal	EDU, TT
KMWE	R&D Services bureau OEMs Design	www.kmwe.com/Capabilities/Additive-Manufacturing.htm	NETHERLANDS/ NoordBrabant	H, AE, O (semiconductors, industrial automation)	All	PBF, DED, EBAM	Metal	IE, TT
LMS	R&D Design Modelling and simulation Experimentation	http://lms.mech.upatras.gr/	GREECE/ Dytiki Ellada	AE, AU,CG	All	PBF, VP, ME, SL, DED	Metal, polymer	STD, EDU, TT
Lurederra	R&D, Materials provider	www.lurederra.es	SPAIN/ Navarra	All	M, PR	Materials technology, nanotechnology	Metal, polymer, ceramic, nanomaterials	STD, IPR, TT
M2i	R&D Services bureau	www.m2i.nl	NETHERLANDS/ ZuidHolland	AE, AU, O (maritime and offshore)	M&S, M	PBF, DED	Metal	IPR, TT
PRODINTEC	R&D Services bureau Design	www.prodintec.com	SPAIN/ Asturias	All	M&S, D, P, PP, PR	PBF, VP, SL	All	STD, EDU, IE, IPR, TT
IQS. Ramon Llull University	R&D	www.iqs.edu	SPAIN/ Cataluña	Own R&D	M&S, D, M, P	VP, ME	Polymer, ceramic, biomaterials	EDU, TT
TECNALIA	R&D	www.tecnalia.com	SPAIN/País Vasco	All	All	DED	Metal	L, IE, IPR
TNO	R&D Design	www.tno.nl	NETHERLANDS/ NoordBrabant	All	All	PBF, VP, MJ, ME, BJ, continuous SLS or material jetting in carousel	Metal, polymer, ceramic, food	STD, EDU, IE, IPR, TT
TUKE	End user	www.sjf.tuke.sk/kppt/	SLOVAKIA/ Východné Slovensko	All	M, P, PP	ME	Polymer	EDU, TT
TWI	R&D	www.twi.co.uk	UK/South Yorkshire	All	All	PBF, DED	Metal	STD, EDU, TT
TUKE	End user	www.sjf.tuke.sk/kppt/	SLOVAKIA/ Východné Slovensko	All	M, P, PP	ME	Polymer	EDU, TT
VIVES	Educational Establishment, R&D; design	www.vives.be/onderzoek-ontwerp-productie technologie	BELGIUM	CG, Mechanics	M, D, PP, Pr	PBF, ME,	Metal, Polymer	EDU, TT

NAME	SUPPLY CHAIN	WEBSITE	COUNTRY/ Region	Sectors	VC segments	AM processes	AM Materials	Non technology activities
Industry								
+90	R&D, Services Bureau, OEMs, Design, End User	www.arti90.com	TURKEY	All	D, M, P, PP, PR	PBF, MJ, ME	Polymer	STD
AIM Sweden	R&D, Services Bureau, OEMs, Design	www.aimsweden.com	SWEDEN/ Mellersta Norrland	H, AE, AU, O. Industrial	M&S, D, M, P, PP, PR	PBF, electron beam melting	Metal	EDU, IE, TT
AIRBUS	R&D, Design, End user	www.airbus.com	SPAIN	AE	M&S, D, M, PP, PR	PBF, MJ; DED	Metal, polymer	STD, LE, EDU, IE, IPR, TT
ALTRAN Deutschland	R&D, OEM, Software provider, design	www.altran.com	GERMANY/ Hamburg	All	All	PBF, ME	Metal, Polymer, Biomaterials	STD, EDU, IE, IPR, TT
ATLAS COPCO	OEMs	www.atlascopco.com	BELGIUM/ Antwerpen	O (industrial applications)	M&S, D, P, PP, PR	PBF, ME, BJ	Metal, polymer	L, EDU
CRIT	R&D	www.crit-research.it	ITALY/ Emilia-Romagna	AE, AU, E	D, M, P	PBF	Metal, polymer	EDU, IE, TT
D'Appolonia	R&D Engineering consultancy Operation and maintenance	www.dappolonia.it	ITALY/Lazio	All	All	All	Metal, polymer	STD, EDU, IE, IPR, TT, roadmapping, safety
EOS	R&D OEMs Materials & software provider End user	www.eos.info	GERMANY/ Oberbayern	All	All	PBF	Metal, polymer	STD, IE, IPR
ESI Group	R&D Software provider Design	www.esi-group.com	FRANCE/Île de France	All	M&S, D	PBF, DED	Metal	STD, EDU, TT, IPR, IE
Granutools	R&D, OEMs, Materials provider, End user	www.granutools.com	BELGIUM/ Liège	All	P	PBF	Metal, polymer, ceramic	STD, EDU, IE, TT
Kiwa	R&D	www.swerea.se/kimab	SWEDEN	All	M&S, M, P	BPF	Metal	EDU, TT
LCV	R&D Services Bureau Design	www.lcv.be	BELGIUM/ Antwerpen	All	D, M, P, PR	DED	Metal	STD, TT

NAME	SUPPLY CHAIN	WEBSITE	COUNTRY/ Region	Sectors	VC segments	AM processes	AM Materials	Non technology activities
LINDE France	Materials provider Process gases for AM + powder production + post-treatment	www.linde-gas.fr	FRANCE/ Rhône-Alpes	All	M, P, PP, PR	PBF, MJ, SL, DED, BJ, cladding, metal deposition (by laser or arc)	Metal	-
MATERIALISE NV	R&D Services bureau Software provider Design End user	www.materialise.com	BELGIUM/ Vlaams-Brabant	H, AE, AU, CG	M, D, M, P, PP, PR	PBF, VP, MJ, ME	Metal, polymer, ceramic, biomaterials	STD, L, IE, IPR, TT
MBN	R&D Materials provider	www.mbn.it	ITALY/ Veneto	H, O (cutting tools)	M	PBF, DED, O	Metal, polymer, composite, intermetallic	-
Safran	R&D OEMs End user	www.safran-group.com	FRANCE/Île de France	AE	All	PBF, DED	Metal, polymer, ceramic	IE
SCHUNK	R&D Design	www.schunk.com	GERMANY/ Stuttgart	O (mechanical engineering, automation)	M, D, PR	PBF, O (laser sintering plastics)	Polymer	IE, IPR
SIEMENS	R&D Software provider Design End user	www.siemens.com	GERMANY/ Berlin	H, E	All	PBF, VP, ME, DED	Metal, polymer, ceramic	STD, L, EDU, IE, IPR, TT
TRIDITIVE	R&D Services bureau Design	http://dynamics.triditive.com/	SPAIN/ Asturias	All	M&S, D, P, PP, PR	VP, ME	Polymer	EDU, IE, TT

NAME	SUPPLY CHAIN	WEBSITE	COUNTRY/ Region	Sectors	VC segments	AM processes	AM Materials	Non technology activities
Other								
AD Global	Human Resources	www. alexander danielsglobal. com	SPAIN & UK/ Barcelona & Birmingham	All	All	All L	All	EDU, Hiring AM talent
Berenschot	Consulting company	www. berenschot. com	NETHERLANDS / Utrecht	All	All	All	All	STD, EDI, IE, IPR, TT
IDEA	Consulting company	www. ideaconsult. be	BELGIUM/ Bruxelles-Capitale	All	All	All	All	L, IE, TT
Clusters/networks/associations								
EPMA	All Metal AM supply Chain	www.epma. com	BELGIUM/ Bruxelles-Capitale	Powder metallurgy	All	PBF	Metal	EDU, TT, networking, synergy
ERRIN	Network supporting regional Innovation and implementation of Smart Specialisation Strategies.	www.errin.eu	BELGIUM/ Bruxelles-Capitale	O (AM and nanotechnologies)	-	-	-	EDU, TT, networking
EWF	Education & Training Standardization	www.ewf.be	BELGIUM/ Bruxelles-Capitale	AE, AU, CG, E, manufacturing	M, P	PBD, DED	Metal, polymer	STD, EDU, IE, IPR, TT
Flam3d	Cluster Network Association	www.flam3d. be	BELGIUM/ Flanders	All	All	-	All	All
MATIKEM	R&D Services bureau Materials provider Design End user	en.matikem. com	FRANCE/ Nord-Pas-de-Calais	H, AU, CG	D, M, P, PR, EL	VP, ME	Polymer, ceramic, food, biomaterials	STD, EDU, IE, IPR, TT

FUNDACIÓN PRODINTEC
FACTORY OF FUTURE

TNO

ERRIN European Regions Research and Innovation Network

TWI

AM PLATFORM