

Opinion of the European Economic and Social Committee on 'Living tomorrow. 3D printing — a tool to empower the European economy'

(own-initiative opinion)

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On 10 July 2014, the European Economic and Social Committee, acting under Rule 29(2) of its Rules of Procedure, decided to draw up an own-initiative opinion on:

Living tomorrow. 3D printing — a tool to empower the European economy.

The Consultative Commission on Industrial Change (CCMI), which was responsible for preparing the Committee's work on the subject, adopted its opinion on 4 May 2015.

At its 508th plenary session, held on 27 and 28 May 2015 (meeting of 28 May), the European Economic and Social Committee adopted the following opinion unanimously.

1. Conclusions and recommendations

1.1 Additive Manufacturing (AM) is one of the key enabling technologies that will shape new approaching to manufacturing and the Products and Factories of the Future. The digital revolution, together with this fabrication revolution, will enable Europe to re-shore production from lower wage regions in order to spur on innovation and create sustainable growth at home;

1.2 The EESC believes that the EU can keep up its current position as a major global player in additive manufacturing, but in order to achieve this the following measures must be taken at European and national level;

1.3 Investments in ICT infrastructure should be given priority so that all members of the public and businesses have access to high speed internet networks, at the highest available standards of quality and security;

1.4 The European capacity for storage and transmission of large amounts of digital data must be strengthened and updated and the protection of these data guaranteed in accordance with the legitimate interests of EU citizens and businesses;

1.5 The EU institutions and national governments should prepare people for the challenges of the digital society and related disruptive technologies such as Additive Manufacturing, through investments in cultural, educational and training programmes that are in line with the dynamics and requirements of new job profiles associated with a new generation of production systems;

1.6 In order to reach the full potential of AM, research and creativity need to be encouraged (via financial and fiscal incentives) in companies and relevant educational and scientific institutions;

1.7 Additional research is needed to expand the range of materials and the number of applications, and to improve the robustness, speed, productivity and maturity of this technology. The steps towards a mature production process should be carried out in Europe, in order to secure our competitive position in the global markets and retain the economic benefits and high quality jobs involved inside the EU;

1.8 The European Innovation Partnerships must streamline efforts to develop new materials for AM. An extended range of materials and increased number of suppliers will promote more competitive pricing, open up new industrial sectors and create higher volumes of AM materials and more competitive supply markets;

1.9 The EU must facilitate investments in new AM equipment and should encourage the development of additive manufacturing technology in open production systems that are flexible and easy to integrate with other production and finishing technologies, in order to enhance the number of applications and increase the turnover;

1.10 The European and national regulatory framework was unable to keep up with the fast pace of change in additive manufacturing, which is why a specific regulation is needed to deal primarily with standards and certification, intellectual property, consumer protection, health and safety at work, and the environment;

1.11 The regulatory process concerning AM needs to be based on interdisciplinary and scientific research into the impact of this technology, with the full involvement of all stakeholders.

2. General comments

2.1 Manufacturing makes a significant contribution to the economy, particularly in terms of innovation, productivity and high quality jobs. However, Europe's industry has lost ground in the past two decades resulting in a **decline in industrial employment and added value** ⁽¹⁾. After decades of thinning out the manufacturing sector (due to outsourcing towards inexpensive labour), the focus is back on production in high-wage countries and the critical role that domestic manufacturing capabilities play in bringing the innovation to life and the ability to rapidly 'scale up' production of new products based on advanced technologies. Innovation, automation and sophisticated processes are at the root of industrial success strategies and have proven to be critical in maintaining a leading position ⁽²⁾. Using the right advanced manufacturing technology, Europe could **re-shore production** from lower wage regions **to spur on innovation and create sustainable growth at home**. Only in this way could Europe position itself as a leader in the new industrial revolution.

2.2 Additive Manufacturing (AM) is the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies. 'Additive manufacturing' is the official industry standard term (ASTM F2792), while '3D printing' is a commonly used synonym.

2.3 Additive Manufacturing is an umbrella term for a set of technologies and processes for different materials (metals, polymers, ceramics and others). These technologies have reached a level of maturity that increasingly allows for the existence of value-added commercial applications. Additive Manufacturing is regarded worldwide as one of the key enabling technologies that will shape new approaches to manufacturing and the Products and Factories of the Future. The so called FABLABs — laboratories for 3D-printing services and products — already exist.

⁽¹⁾ *Industry 4.0 — The new industrial revolution: How Europe will succeed*, Roland Berger Strategy Consultants 2014.

⁽²⁾ *Production in the Innovation Economy (PIE Study)*, MIT, 2013.

2.4 Additive Manufacturing is a **fast-growing sector**. Growth has accelerated over the past 4 years as an increasing number of organisations adopt Additive Manufacturing products and services. The compound annual growth rate (CAGR) of worldwide revenues produced by all products and services over the past 25 years is an impressive 27 %. The CAGR for the past 3 years (2011-2013) was 32,2 %, reaching a market of EUR 2,43 billion in 2013 ⁽³⁾. Wohlers Associates anticipates that the market will exceed EUR 5,5 billion by 2016 and EUR 10 billion by 2018. However, as an emerging technology, AM industry experts estimate that the current market penetration covers only a fraction of the potential applications identified. In 2011, experts estimated market penetration at less than 8 % (meaning a total market of approximately EUR 17 billion) ⁽⁴⁾. If AM grows to capture just 2 % of the global manufacturing market, the potential is 10 times bigger (approximately EUR 170 billion) ⁽⁵⁾.

2.5 The application domain evolved from prototyping in the early nineties to the production of functional parts. The expected growth is mainly driven by the fast, cost-efficient and larger scale serial **manufacturing of final, complex functional products** in various materials (plastic, metal or ceramic), rather than in design products and prototyping. AM is mature for prototyping, but is still in the 'innovator' phase for the production of final, functional products. Innovative AM-produced products are emerging but not viable, since there is a lack of robust AM machines and high-volume production systems.

2.6 Innovative additive processes will have a disruptive effect on the way things are designed and made. AM can improve the value delivery for current products within existing supply chains or can have a radical impact on products, supply chains and business models ⁽⁶⁾. Europe needs to be in pole position when the industrialisation of AM kicks off. Within European ecosystems for Additive Manufacturing, future growth is expected to be achieved by extending current activities (when the existing players move from prototyping to manufacturing) and by opening up new activities along the value chain.

2.7 Worldwide, AM is regarded as the key enabling technology for innovation in products and the supply chain. It is going mainstream and receiving substantial government funding to increase the maturity level (i.e. in the US, China and Singapore). Historically, the EU is in a good position, but if no action is taken it will lose this position and fall behind in the race for new markets.

3. Specific comments

3.1 Disruptive impact of Additive Manufacturing

3.1.1 At factory level, AM will shape new approaches to manufacturing and the Factory of the Future:

— AM allows for the production of multiple different end-products using the same equipment, materials and processes, and facilitates production approaches that are impractical or impossible using traditional manufacturing methods.

— One of AM's greatest assets will be its ability to combine with other high-value manufacturing solutions in the factory.

⁽³⁾ Wohlers Associates, *3D Printing and Additive Manufacturing: State of the Industry, Annual Worldwide Progress Report*, 2014.

⁽⁴⁾ Special Interest Group Additive Manufacturing for the Technology Strategy Board of the UK (2012), *Shaping our national competency in Additive Manufacturing, A technology innovation needs analysis*.

⁽⁵⁾ Wohlers Associates, *3D Printing and Additive Manufacturing: State of the Industry, Annual Worldwide Progress Report*, 2014.

⁽⁶⁾ *3D Opportunity Additive manufacturing paths to performance, innovation, and growth*, Deloitte Review 2014.

- AM is a key technology for digital fabrication in dynamic, decentralised supply chains. Global distribution of digital design (or engineering solutions) and specification files form the basis of local personalisation and production and replace the shipping of products from centralised factories. Digital fabrication leads to a distributed and diverse production base, with manufacturing closer to the customer (including small-scale production at home or in printshops for some products). Supply chains might combine capital-intensive factories producing complex products with customisation of components in a distributed and small-scale method (design-make workshops close to the customer/point of consumption).

3.1.2 At product level, AM will become the cornerstone for product innovation:

- Greater freedom of engineering leads to new generations of products: the almost **unlimited freedom in design** can yield a broad range of benefits in different sectors (i.e. automotive, aerospace, medical, machines and equipment, sport equipment and life-style): miniaturisation, function integration, lightweight, customised and personalised properties and geometry, etc.
- **Ultra short lead-times** will open up new windows of opportunities for functional prototypes or novel customised/personalised B2C and B2B products in all industrial sectors.
- **Application development is a huge economic opportunity for Europe.** The technological and market **development of advanced applications** kicks off by bringing an ecosystem together and digitising all steps. This leads to a centralised business concept. Scaling up market volume (within the region or abroad) involves a segmented decentralisation of blocks within the value chain. Franchising of product, design and production solutions makes it possible to capture value in Europe from global distribution of applications.

3.1.3 At business level, AM will lead to disruptive business models:

- **Digital production leads to disruptive** 'digital driven' business models — fast-changing with high levels of customisation. The internet enables user-generated content to be brought to the manufacturer of physical goods. Reconsidering the way companies produce and move products through their supply chains will lead to novel production chains and business models, i.e.: just-in-time, on-demand manufacturing near to the customer, repair of components, e-manufacturing, digital warehouses for long tail ⁽⁷⁾ spare parts or mass customisation. The current value chain can be replaced with a simpler and shorter value chain.
- Traditional AM service providers move into contract manufacturing and specialised services to serve OEM ⁽⁸⁾ customers. Supply chains are supported by engineering tools and digital e-manufacturing processes, 'democratising' design so that everyone can do it, with all the advantages and problems arising from such a business model.

⁽⁷⁾ Spare parts whose availability is scarce and so their price is high.

⁽⁸⁾ Original equipment manufacturer.

- AM enables the economic production of series by AM service providers, manufacturing companies or even at home based on a 3D model ('desktop factories'). New types of service providers are emerging: 3D print shops have opened their doors in European cities, 3D content and on-demand services link creators of 3D content, consumers who order parts from libraries and AM producers.

3.2 Technological impact of Additive Manufacturing

3.2.1 Need for a new generation of production systems

- International AM roadmaps ⁽⁹⁾, ⁽¹⁰⁾, ⁽¹¹⁾, ⁽¹²⁾, ⁽¹³⁾ highlight the need for significant technological steps in AM as a key factor in pushing forward the proposed added value and adoption of AM. Today's AM technology has been developed to make AM prototypes; machines are not yet ready for high volume production. AM companies face technological barriers in transforming AM into a serial production technology. AM machine architecture concepts still date back to the prototyping stage and too few innovations have been introduced (internally, today's machines look almost the same as their predecessors of 10-15 years ago). Disruptive 'machine' innovations are needed to bring this industry to the next level ⁽¹⁴⁾.
- To speed up development, AM companies and researchers need access to open platforms (in terms of both hardware and software) to overcome the limitations of commercial 'black box' machines.
- An increase in capabilities (cost efficiency, robustness and reliability) would extend the current potential of Additive Manufacturing towards larger-scale production for a wide range of applications. A shift in the technological limits and integration with other processes (hybrid production) will enable breakthrough applications ⁽¹⁵⁾. Take-up within the manufacturing industry requires an integration of AM in the factory environment and control systems.
- Alongside this strategic research, new disruptive production system concepts need to be invented, fundamentally re-thinking the way that products are built based on current AM technologies and the way these systems are integrated within the factory environment. This means that tomorrow's AM production will no longer be based on batch type AM machines placed one next to the other in a production hall; application needs demand the concept of continuous AM production systems, based on a chain of different production steps. These concepts are already known as the 'AM machine 2.0'; and they will drive future AM machine development.

3.2.2 Need for new processes, enabling certification of AM:

In order to be technically implemented in industry, AM technologies need to be certified. Certification will drive the industrialisation of the technology. Today, processes to enable certification of AM need to be developed, such as advanced in-process inspection and quality control techniques to ensure that standards are being maintained. At the very least, these processes need to detect when the product does not meet standards, and really a methodology should be developed to prevent non-conformity and correct defects.

⁽⁹⁾ European AM Platform initiated by Manufacture (2013), *Additive Manufacturing: Strategic Research Agenda (consultation document)*.

⁽¹⁰⁾ DMRC (Direct Manufacturing Research Centre, Paderborn Germany) (2012), *Thinking ahead the Future of Additive Manufacturing — Analysis of Promising Industries*.

⁽¹¹⁾ Innovatie Zuid (2013), *Hightech Systemen en materialen: Roadmap 3D-Printen*.

⁽¹²⁾ EFFRA (2013), *Factories of the Future 2020: Factories of the Future Public-Private Partnership roadmap*.

⁽¹³⁾ Flanders MAKE, *Additive Manufacturing for Serial Production: Research Roadmap, 2014*.

⁽¹⁴⁾ Flanders MAKE, *Additive Manufacturing for Serial Production: Research Roadmap, 2014*.

⁽¹⁵⁾ EPSRC Centre for Innovative Manufacturing in Additive Manufacturing, <http://www.3dp-research.com/Home>

3.2.3 Need for development and accessibility to new materials:

- Those controlling distribution channels maintain a dominant position; e.g. machine manufacturers include in their maintenance and warranty contracts the obligation to use specific expensive raw materials, often only distributed by them, or they use the ‘razor-razorblade’ business model where a lock-in is created for consumables. The control of distribution channels, combined with what is still a limited volume ⁽¹⁶⁾, made it less attractive for material providers to invest large budgets in the development of new materials.
- The limited number of material supply sources leads to excessively high prices for raw materials and increases the supply guarantee risks for end customers. This market mechanism is curbing the potential of AM technology.
- Currently, the double-digit growth market creates economic opportunities and attracts more material providers. Materials development needs to be supported and encouraged. It is important to extend the range of materials and improve the properties of materials. Increasing the number of suppliers will promote more competitive pricing, making it more attractive to ignore machine warranties, and will create higher volumes and more competitive material markets.
- An extended range of materials will open up new industrial sectors and generate the demand for higher volumes of AM materials.

3.2.4 Main technical barriers — The main barriers to a large-scale breakthrough in industries such as aerospace, automotive, medical or consumer goods are mainly linked to boosting productivity and can be summarised as:

- process insufficiently robust and production speed inadequate (leading to excessive production costs),
- the need for next-generation AM production technology that can be integrated in a factory environment and hybrid production systems,
- insufficient and inconsistent material and product properties, an overly limited range of AM materials and slow material development,
- absence of technology for multi-disciplinary development of breakthrough novel applications.

3.2.5 Strategic research is required to:

- transform AM into a **serial production technology** with next-generation machines,
- **integrate AM** as a real production tool in the factory environment and systems,
- extend the **range of AM materials**,
- develop **novel applications** (and their development tools).

⁽¹⁶⁾ Wohlers Associates, *3D Printing and Additive Manufacturing: State of the Industry, Annual Worldwide Progress Report*, 2014.

3.2.6 Risk of technology drain from Europe:

- The AM technology and AM market has reached a certain level of maturity, resulting in the first consolidations within the field. Large US-based companies invest and acquire small (often EU-based) SMEs possessing knowledge, IP and patents for AM technology. The acquired knowledge is often put to use outside Europe as the EU's markets are diverse and difficult to access. It is in the interests of European SMEs to be acquired by large non-EU companies, as they open up large new markets for their applications. Both of these reasons represent a danger that European-based AM developments will leave the region.
- For EU-based AM companies, scaling up is not easy within Europe. Its high number of small and very different markets leads to high investment costs before reaching a certain level of viable market volume. Furthermore, switching to new markets is often slowed down by the lack of certain components of the value chain. Therefore, EU-based AM companies are eager to look for large non-EU-based markets to put their knowledge to use at an early stage.

3.3 The impact of Additive Manufacturing on legal issues ⁽¹⁷⁾:

- AM today is widely understood (by the media, press, public and politicians) to be a low-end 3D printing technology for smart 'home printing', rather than a future production technology. Although both will hold true in future, trends, barriers and research priorities differ fundamentally. Topics such as standardisation, intellectual property rights and liability must be considered completely differently depending on what technology and applications you look at.
- **Standards and certification:** It is generally recognised that a lack of standards has limited the uptake of AM in key industrial sectors e.g. aerospace and medical/dental. The availability of standards will help to increase the adoption of the technologies and open up extensive research and development opportunities. Professional markets are often demanding and require certification, which makes adoption of new technologies very difficult. The barriers to the widespread adoption of AM are both technical and legislative. Therefore, engaging the industry further in the ASTM F42, BSI and ISO working groups is essential for the future development of these technologies.
- **Intellectual Property (IP):** Experts raise concerns about the inevitable intellectual property issues that the increasing adoption of AM technologies will create ⁽¹⁸⁾.
- AM could have a major impact on intellectual property, as objects described in a digital file could be much easier to copy, distribute and pirate. The very same scenario that occurs with the music and film industry could play out, with the development of new non-commercial models and increasing tension between hampering innovation and encouraging piracy ⁽¹⁹⁾.
- Protecting IP of developers is a huge problem which is very similar with the protecting of rights in the music and film industry. AM industry should look for solution regarding IP protection that should be developed by the industry itself. A broadly shared IP protection technology will even overcome the concern that AM technology is controlled by just a few organisations through the protection of relevant Intellectual Property, thus restricting competition and the identification of new applications. This is slowing innovation and keeping system costs high.

⁽¹⁷⁾ European AM Platform initiated by Manufacture (2013), *Additive Manufacturing: Strategic Research Agenda (consultation document)*.

⁽¹⁸⁾ *The National Law Journal*, 'Is intellectual property law ready for 3D printers? The distributed nature of Additive Manufacturing is likely to present a host of practical challenges for IP owners', February 4, 2013.

⁽¹⁹⁾ Scapolo, F., Churchill, P., Castillo, H. C. G. & Viaud, V., December 2012. Draft foresight study on: 'How will standards facilitate innovation and competitiveness in the European Union in the year 2025?', s.l.: European Commission.

- **Liability:** There are a number of implications concerning liability, especially for amateur or unknowledgeable designers, part manufacturers or distributors. Should a part fail, who is responsible? This is an area of increasing concern for the AM industry especially where flexibility, individuality and self-designing can introduce unfamiliar territory. New business models for the supply of parts made using AM technology and the associated business risks need to be developed.
- **AM qualification and certification**⁽²⁰⁾: Each element of Additive Manufacturing technology (i.e. materials, equipment, processes) must be qualified and certified to reproducibly manufacture high-quality parts. Non-standardisation makes the manufacturing of a high-quality part difficult on the first run. The development of AM standards for qualification and certification is complicated by the numerous permutations of machines, materials and processes and the absence of a central repository of AM data or authority on AM methodologies. Further deployment of AM technology will require standards development to facilitate quicker and more cost-effective certification of all materials, processes and products.

3.4 The impact of Additive Manufacturing on employment, training and education

- The deployment of AM technologies will have a direct impact on traditional production models, and especially internal workshop organisation. AM will ease the installation of mini-mills very close to customers, wherever there is demand. This will generate new jobs which cannot yet be measured because industrial deployment is too recent.
- The real impact on employment figures is very hard to identify because no studies have been carried out, and because it is very likely that there will be a substitution between actual jobs and future AM operators.
- Jobs in AM technologies will need new skills, such as machine operators able to deal with the process-specific software or engineers able to design parts with new systems: topological optimisation, re-engineering, etc.
- With the deployment of AM technologies, training and educational establishments will be needed to preserve and develop the employability of workers. Currently, European school curricula largely disregard AM, and the same applies in after-school training. Most training courses simply describe the technologies and their potential performances, and are not intended to help students acquire a real skill. Local governments should integrate AM in their learning plans, at least for vocational training. The attractiveness of 3D-printing, covering the whole innovation process (concept, design, computing, robotics and producing a final physical product) in a short period of time, could be used as an effective training method in school education focusing children's attention on technology and manufacturing.
- It is desirable that any training offer be designed following the cooperation between industry, local authorities, education institutions and workers' organisations, and is based on the real needs of the companies operating in this sector.

3.5 Health and safety at work

There are very few studies about AM from the perspective of health and safety at work, and there is a real need for them owing to:

- chemical risks, arising from volatile resins used in AM of polymer parts, and volatile metallic or non-metallic additives in metallic powders;

⁽²⁰⁾ *Measurement Science: Roadmap for metal-based Additive Manufacturing*, National Institute of Standards and Technology, May 2013.

- chemo-physical risks arising from the use of powders, especially when those powders contain nano-particles;
- risk of explosion, arising from the use of powders;
- specific risks, arising from the use of laser sources, electron beams, etc.

With the deployment of industrial AM applications, there is an urgent need for specific studies on risk assessment for workers, in order to develop protection systems and standards. Safety training also needs to be developed for workers dealing with AM machines. This could be part of the educational programme to be improved or set up.

Brussels, 28 May 2015.

The President
of the European Economic and Social Committee
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