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JRC FORESIGHT STUDY

How will standards facilitate new production systems in the context of EU innovation and competitiveness in 2025?

ANNEXES

Fabiana Scapolo, Peter Churchill, Vincent Viaud,
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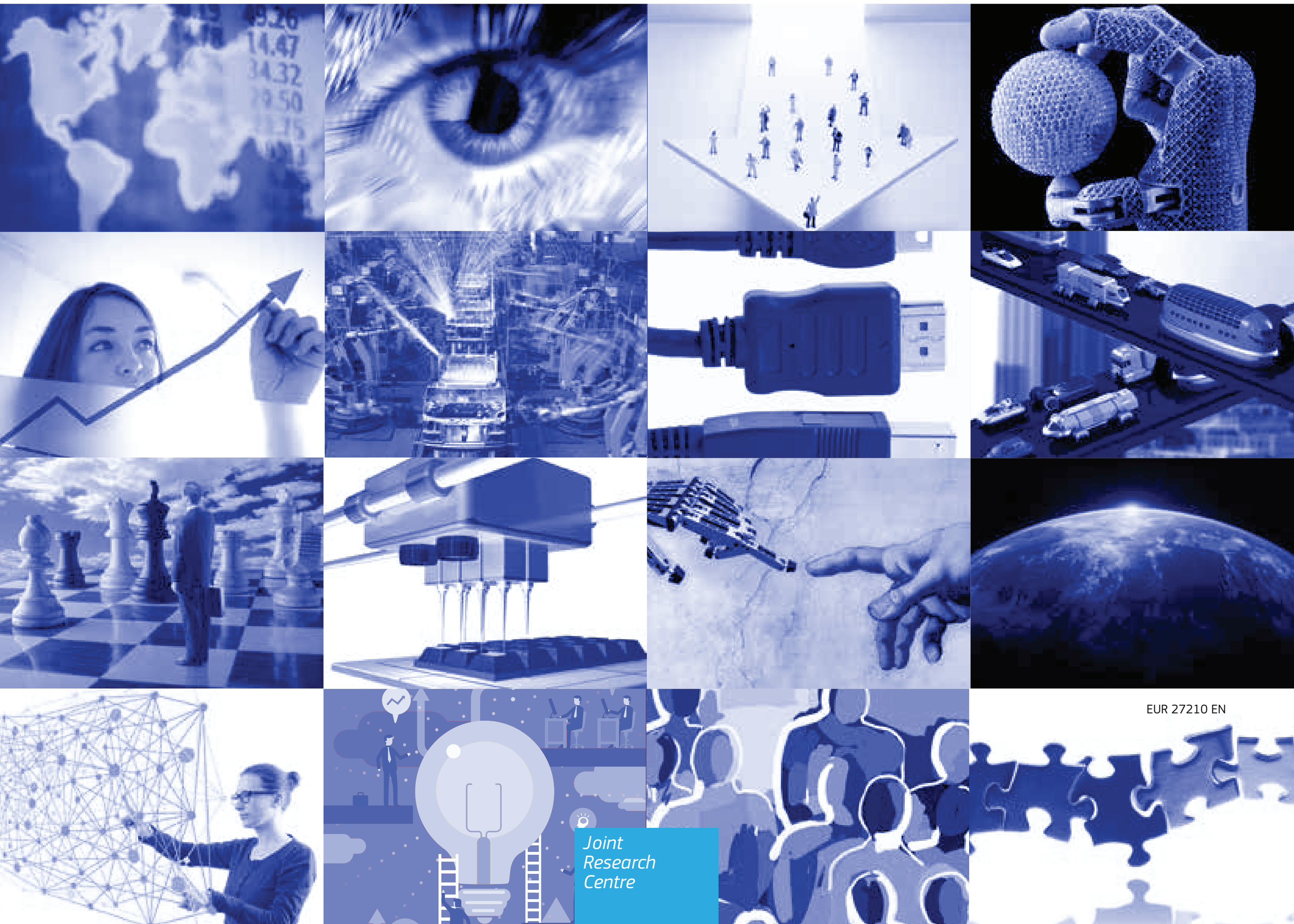
2014



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Abstract

Standards are very important as they provide requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose. They contribute to remove technical barriers to trade, leading to new markets and economic growth for industry. They also facilitate technology transfer and they contribute to ensure safety of products thereby affecting the daily life of citizens. This report 'How will standards facilitate new production systems in the context of EU innovation and competitiveness in 2025?' is the outcome of a foresight process looking at how standards and standardisation can become even more relevant policy tool supporting different European policies. The study has especially looked at the areas where Europe drives innovation, where the development of new products and processes could lead to new trade of goods, services and technologies. The foresight process has dealt with standardisation by using a holistic approach. It explored at how effective standards can be developed within a European industrial landscape vision able to contribute to jobs and growth in a sustainable manner. The report provides a clear overview of the evolution of the European production system and illustrates what are the drivers of change influencing the future production system. The Industrial Landscape Vision was used to identify the its implications on the European Standardisation System and it highlights priorities for the development of standards in the future.

FINAL REPORT
OF THE FORESIGHT STUDY

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Annex 3.

Overview of Standards and Standardisation

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1. The European Standardisation Policy

1.1 Overview

The European Commission standardisation policy started in the 1980s as an element of the completion of the Internal Market for goods. Since then, standardisation has increased its importance and scope in the political agenda. The latest landmark was in 2010 with "Europe 2020[1]", Europe's growth strategy for the next 10 years.

The seven flagship initiatives unfold this strategy for Europe, and the standardisation role is defined through four of them: (i) "Digital Agenda for Europe", (ii) "Innovation Union", (iii) "Resource-Efficient Europe" and (iv) "An Industrial Policy for the Globalisation Era". On this basis the European Commission has launched in 2011 the "Standardisation Package" to align its standardisation policy to the new strategy. The 25 October 2012, the legislation part of the proposal, Regulation (EU) No 1025/2012[2] has been published in the Official Journal, after adoption by the Parliament and the Council. It has entered into force on January 2013.

Standards were historically a tool for engineers but they have broadened their scope becoming a tool for policy and legislation but also for consumers in their contractual relation with companies. Citizens are not often aware on the impact that standards have in their daily lives.

1.2 From the "New Approach" to a Wide European Standardisation Policy

The Information Directive[3] and the New Approach Council Resolution[4] and Directives[5] in 1985 were the starting points for the use of standards as a policy tool. The need to eliminate technical barriers to trade for the completion of the Internal Market for goods along with recognition that the old approach was not adequate drove the change. This resulted in a separation of the essential requirements or politically driven goals required to products which are set up in the legislation from the way to comply with those goals, defined by the stakeholders in the form of standards. This way of legislation, separating the goals from the means, has been called the "New Approach".

The "New Approach" initiated a new relationship between the European Commission (EC) and the European Standards Organisations (ESOs). Since then the ESOs[6] and the National Standards Organisations (NSOs) have a recognised status with respect to the EC. The European standardisation policy focuses on two main aspects.

The first is the European Standardisation System (ESS), which is an institutional infrastructure led by the three ESOs producing public goods (standards), mainly under private initiative. Here the EC contributes to their functioning by financially supporting the ESOs secretariats general, maintaining the information procedure that obliges NSOs to withdraw conflicting standards, as well as financing societal stakeholders and a SME association (NORMAPME) to ensure a balance of the system and keeping a role as observer of the ESOs. In return, the ESOs ensure harmonisation of technical standards produced by consensus in Europe and provide up-to-date technical specifications to comply with Directives.

Secondly the European Commission issues mandates requesting the ESOs to develop standards to support political and legislative targets. As a result there are two main types of mandates (but one mandating procedure): (i) to support legislation and (ii) to support policy.

i. Legislation mandates ask for the development of standards that comply with the essential requirements or other provisions of Directives or Regulations. Mandated standards provide a presumption of conformity to products facilitating internal trade and are mainly concerned with health and safety;

[1] COM(2010) 2020 Final

[2] Regulation (EU) No 1025/2012

[3] Directive 83/189/EEC

[4] Council Resolution of 7 May 1985 on a new approach to technical harmonization and standards

[5] More information on www.newapproach.org and on the webpage of DG Enterprise and industry

[6] CEN, CENELEC and ETSI are the three recognised European standardisation organisations

ii. Policy mandates do not provide any legal advantage to industry, but create market conditions in line with certain political goals and are mainly concerned with environmental protection, interoperability and compatibility.

In order to achieve a coherent standardisation policy the Commission has an Annual Union Work Programme for European Standardisation.

The system has major advantages:

- All conflicting national standards are withdrawn, eliminating barriers to trade;
- The purposes covered by *harmonised standards* are set up by the Directives, ensuring their legitimacy;
- The standards are developed by those who possess the state of the art, mostly industry, but the European Commission reserves the right to withdraw the presumption of conformity[7] if the political goals (mainly safety, environmental protection, consumer protection and quality) are not sufficiently addressed;
- Due to the open and consensual process of standardisation, standards are more likely to create overall benefits;
- The system is more innovation friendly as European standards tend not to be prescriptive;
- The standards are easier to update than Directives making the system more able to keep up with technological developments.

Standardisation has been increasingly used in other areas than the internal market for goods. A good example is the development of the GSM in 1990, which was a success of innovation policy. A more recent example is the Eco-design Directive[8] and its associated standards for environment protection. This marks an expansion of the role of standardisation as recognised in the 2008 European Commission Communication[9] linking standardisation and innovation. This path was extended further in 2010 in the Europe 2020 strategy through the accompanying flagship initiatives. Standardisation prominent role will continuously grow in EU policies targeting innovation, environment, global competitiveness, interoperability and services.

1.3 The "Standardisation Package"

In response to the Europe 2020 strategy and the flagship initiatives, in June 2011 the European Commission launched the "standardisation package". It consists of a Communication and a legislative proposal with its impact analysis. The Communication "on a strategic vision for European standards" has proposed the use of European standardisation as a broad based policy tool, addressing policies ranging from supporting European competitiveness, to protecting the consumer, improving accessibility of disabled and elderly people to tackling climate change and the resource efficiency challenge under sustainability perspective. The Communication also set out objectives related to improving the standardisation process; this includes an annual work programme; speeding up the standardisation process; the conditionality of the financing of the ESOs on performance criteria; a better integration of standardisation and research; and the need to raise standardisation awareness through education.

The standardisation regulation, which enters in force the 1st January 2014, consolidates the legal basis for European standardisation[10]; enhances European Commission cooperation with ESOs; improves support to consumers, encourages small business (SMEs), environmental and social organisation to participate in the standardisation process; recognises that Global ICT standards play a more prominent role in the EU; increases the number of European standards for services if there is a demand from business; and set up a committee for the approval of mandates.

2. Standards and Standardisation

It is important to separate the concepts of standards and standardisation. A formal definition of standards and standardisation can be found at the glossary section.

Standards are developed for products, processes, management and services. A standard is a voluntary formal agreement on doing something in the same way, repeatedly.

Standardisation is the process to create a standard, and includes all the supporting activities that ensure the proper functioning of the system; such as the infrastructure to gather the experts and stakeholders who create, approve and update standards, the distribution of standards, the financing of the activities, etc.

There are not only a considerable amount of types of standards but there are also a great variety of organisations developing standards. Standard organisations do not create standards themselves, they gather experts, mostly from industry, to develop, revise and amend standards. They also support the standards dissemination by publishing them, coordinating work items, conducting public consultation, undertaking lobbying, making agreements, etc.

7 The use of standards referenced in the European Union Official Journal allows producers to be given a presumption of conformity with the essential requirements of the CE marking Directives.

8 Directive 2009/125/EC

9 COM(2008) 133 final

10 It will replace Directive 98/34/EC (Standardisation part only), Decision 1673/2006/EC (Financing), Decision 87/95/EEC (ICT standardisation) and amends several Directives (objections to harmonised standards).

3. Types of Standards and Standardisation Bodies

Standardisation bodies are commonly classified as "formal" or "informal". Another classification distinguishes between formal, industrial and company standards[11]. The standardisation landscape is rapidly evolving and competition between emerging standardisation models are making classifications challenging. Given the importance of standards on the markets and ultimately on citizens lives, the question of legitimacy, democracy, market acceptance, legal recognition, openness, and the treatment to intellectual property rights are the points where differences among standards organisation are claimed.

Formal standard refers to a specification that has been recognized by the governmental authorities and that is made by a formal standardisation body or exceptionally standards development organisations (SDO). Formal standards should have the following characteristics:

- Established by all stakeholders to fulfil the market need;
- Open to representatives of any stakeholder group;
- Transparent processes;
- Published rules and procedures;
- Legally recognized by governmental authorities;
- Output can normally be followed/used without charge by any party;
- Approval procedures driven by consensus;
- Established specifically for the facilitation of standards development.

Industrial standards are those produced by SDOs or consortia, a group which is large and diverse and therefore difficult to characterise. The majority of them are in the ICT domain and many are recognised for their open and transparent processes. Nevertheless some may exhibit in practice at least one of the following characteristics:

- Established by a closed group, often for commercial advantage (consortium); they could, on the other hand be completely open;
- Produce standards as a by-product to their main activity (e.g. trade association);
- Output may not be publicly available or may be restricted in use by patents;
- Not specifically legally recognized as a standards developer;
- Not necessarily consensus-driven.

Company standards are developed by a company or trade association. As for industrial standards they can sometimes become a *de facto* standard because their widespread use and acceptance. In some cases they can receive formal approval as it was the case with PDF developed by Adobe and now adopted by ISO.

The strategic choice for a company to adopt company standards depends on a number of considerations:

- The choice between having more control on the output or reaching large acceptance of the result. Typically companies with market dominance prefer company standards. In this case internal processes can be imposed on suppliers;
- The time to the market of the service or product. Because the fast innovation pace of ICT the company standard approach may be preferred as it can produce a faster deliverable.

"*De facto*" and "*de jure*" standards are also referred to. The distinction between the categories is not clear[12]. The main issue of this classification is that in "*de facto*" standards the emphasis is put on market acceptance, whereas in "*de jure*" the emphasis is put on the organisation developing the standard.

De facto standards are those that have achieved a dominant position by public acceptance or market forces, and are usually developed by less formal procedures. The Microsoft word format .doc is an example of a "*de facto*" standard.

De jure means by right or by a lawful title, and *de jure* standards are those approved by formal standardisation bodies following formal procedures for their approval. It is not clear where standards developed by open consortia standardisation organisations belong to this category or not. On the other hand, non-full consensus deliverables made by formal organisations (e.g. CEN-CENELEC Workshop Agreements) should not be considered *de jure* standard.

[11] Based on CEN (2002) and Hesser W., Feilzer A., and De Vries H. (2006)

[12] Hesser W., Feilzer A., and De Vries H. (2006)

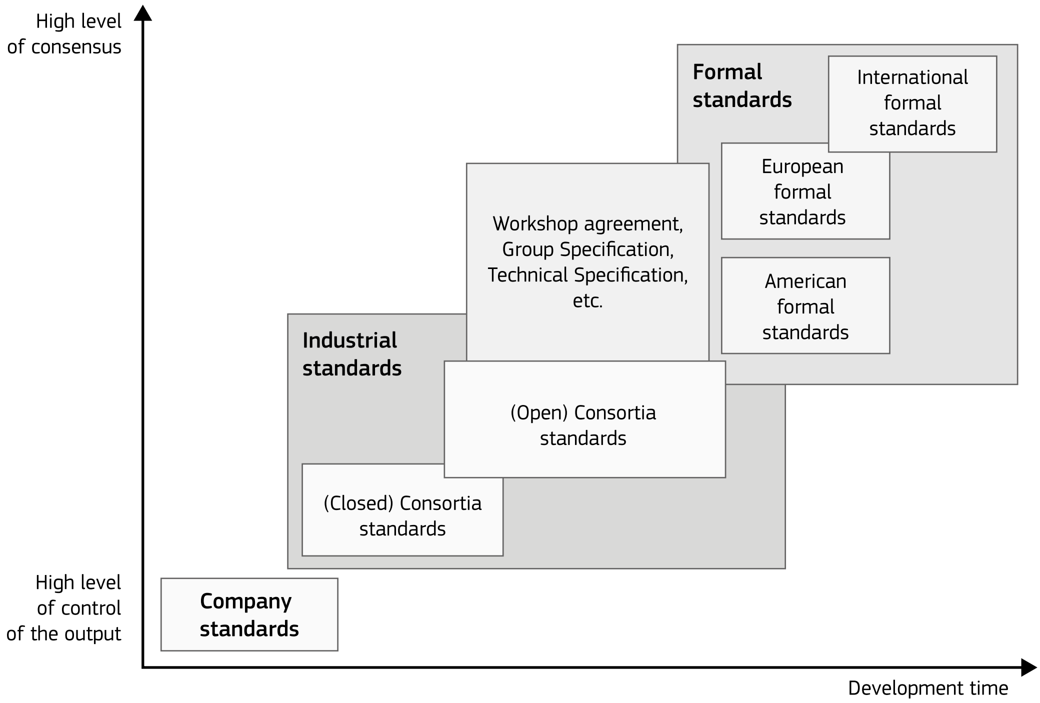


Fig 1. *Adapted from Ulrich Blum presentation in Porto, November 2007*

4. Formal International Standardisation System

The three formal international standards organisations are ISO[13], IEC[14] and ITU[15]. They establish the international standards on general, electro-technical and telecommunications issues respectively. Their members are representatives of the countries, normally their national standards organisations for ISO and IEC. ITU members include, in addition to the nation state members, industrial, commercial, scientific and financial organisations. All international standards are purely voluntarily in application. CEN and CENELEC are not direct members of ISO and IEC but the Vienna and Dresden agreement (respectively) allow the quick adoption of international standards as European standards if required by their members. ETSI has a Memorandum of Understanding with ITU for cooperation and reducing duplication, and ETSI is a sector member of the Telecommunication Standardisation Sector of ITU (ITU-T).

4.1 The US Standardisation System

Unlike Europe, the US does not have a centralised standardisation structure. There are over four hundred standards development organisations covering different sectors. Many of them are international such as ASTM[16] International, Underwriters Laboratories[17], NFPA[18] International, IEEE[19] or ASME[20] International. The system is overseen by ANSI (The American National Standards Institute) who accredits the standards development organisations, watches the system to ensure minimum of duplication and conflict standards and represents US interest in the formal international bodies.

4.2 The Japanese Standardisation System

Japan has opted for a more government controlled structure. The Japanese standardisation system has three bodies. JISC (Japanese Industrial Standards Committee), a part of the METI (The Ministry of Economy, Trade and Industry), represents Japan interest in the formal international bodies. JSA (Japanese Standards Association) has been progressively merging its activities with JISC. Together they develop and distribute Japanese standards. There is a third body dedicated to telecommunications, named TTA (Telecommunications Technology Association).

5. The European Standardisation System

The European Standardisation System (ESS) is quite unique. It is organised around two levels, a national level composed by the National Standards Organisations (NSOs) and a supranational level composed by the European Standard Organisations

[13] International Organisation for Standardisation (www.iso.org)

[14] International Electrotechnical Commission (www.iec.ch)

[15] International Telecommunications Union (www.itu.int)

[16] Formerly known as the American Society for Testing and Materials. (www.astm.org)

[17] UL is a global independent safety science company developing standards (www.ul.com)

[18] National Fire Protection Association – international (www.nfpa.org)

[19] IEEE: Institute of Electrical and Electronics Engineers (www.ieee.org)

[20] Formerly known as the American Society of Mechanical Engineers (www.asme.org)

(ESOs) namely CEN (European Committee for Standardisation), CENELEC (European Committee for Electrotechnical Standardisation) and ETSI (European Telecommunications Standards Institute).

CEN, CENELEC and ETSI are responsible for general, electro-technical and telecommunication standards respectively. They are independent not-for-profit organisations. The ESOs adhere to the basic principles of standardisation: openness; transparency; consensus; voluntary use of standards; technical coherence and primacy of international standardisation.

CEN and CENELEC share a common management centre (CEN-CENELEC Management Centre - CCMC) and have similar structures and functions, while ETSI has a different organisation and business model. Whereas the participation model of CEN and CENELEC is based on national representation (i.e. the National Standards Organisations), ETSI's model is based on direct participation of a wider scope of stakeholders (e.g. NSOs, universities, research bodies, industry and consumer organisations).

The NSOs plays an important role in CEN and CENELEC. They implement European Standards, translate, sell and distribute CEN and CENELEC publications (European standards, Workshop Agreements, CEN-CENELEC guides, CEN-CENELEC Technical Specifications, CEN-CENELEC Technical Reports…), dispatch delegations to Technical Committees, Subcommittees and Working Groups of CEN and CENELEC and participate in decision making on the technical, managerial and political level.

To support the preparation of European standards the NSOs set up mirror committees. They also provide secretaries to CEN/CENELEC Technical Committees and Subcommittees. This model provides indirect access to the individual stakeholders, which are members of their correspondent NSO.

The ETSI model is based on direct membership of organisations such as industry, academia, NSOs or any interested stakeholder which membership has been agreed by the General Assembly of ETSI. Their most common publications are ETSI Technical Specifications (TS); however they produce a limited number of European Standards. The latter are produced under request of the European Commission and follow a special procedure that matches the one used by CEN and CENELEC. ETSI also produced other deliverables such as ETSI standards (ES), ETSI Group Specifications (GSs), ETSI Guides, ETSI Technical Reports (TR) and ETSI Special Reports (SR).[21]

[21] See the glossary in Annex 2 for a definition of these deliverables.

5.1 The European Standard Setting Process

There is a portfolio of around 50.000 deliverables produced by the ESOs.[22] These deliverables consist of documents of different nature, not always comparable between the three organisations.

CEN and CENELEC produce mainly European Standards (1411 EN - 89% of total production during 2011); ETSI produces mainly Technical Specifications (2676 TS - 89% of total production during 2011) and only a small number of European Standards (81 EN – 3%). This difference is explained by the fact that ETSI deals mainly with interoperability standards in the ICT sector, where speed and time to the market is crucial for industry.

Each deliverable has its own development process. The European Standards are the most formal, requiring the higher level of consensus (and 71% of weighted vote). They are produced by the three ESOs. It takes an average of three years to be produced, with the approval phase accounting for a considerable part of that time.

When CEN or CENELEC elaborate a new European Standard, they set up a European technical committee under the responsibility of one of their national members. At the same time NSOs create the so-called "National Mirror Committees" (reflecting the European technical committee on the Member State level), which enable all interested parties (enterprises, consumers, public authorities, NGOs, etc.) to participate in the creation of the standard at national level and in their own language. These National Mirror Committees elaborate a national position for the drafting and voting of a European standard, which is then presented at the European technical committee.

The work done by ETSI is carried out in committees and working groups composed of technical experts from the Institute's member companies and organizations. These committees are often referred to as "Technical Bodies". Where a ETSI deliverable is being converted without modifications into a EN, the technical bodies submit the draft document for the formal voting to the NSO. Otherwise there is an intermediate step where the NSO perform a Public Enquiry.

Other deliverables require less formal, limited consensus. The most common examples are the CEN and CENELEC Workshop Agreements (CWA) and the ETSI Technical Specifications (TS). They are different in nature but serve the same purpose of speeding up the standardisation process. A CWA is an agreement developed and approved in a CEN or CENELEC Workshop, which is open to the direct participation of anyone with an interest in the development of the agreement, and with no geographical limit. The development of a CWA is faster and more flexible than the European Standard process, and lasts on average between 10 and 12

[22] CEN, CENELEC and ETSI Annual Reports for 2012

months. ETSI produces mainly TS as a way to shorten the standardisation process duration. A TS is approved by the Technical Committee that drafted it, and not the whole ETSI membership as it is the case for a European Standards.

Other deliverables are produced by ETSI in a more flexible way, including the Group Specifications (GSs) produced by Industrial Specification Groups (ISGs) that are organised around a set of ETSI work items addressing a specific technology area, and following voting rules, work programme and deliverables that they self-define and approve. They are designed for quick establishment and delivery in order to fulfil urgent market needs.

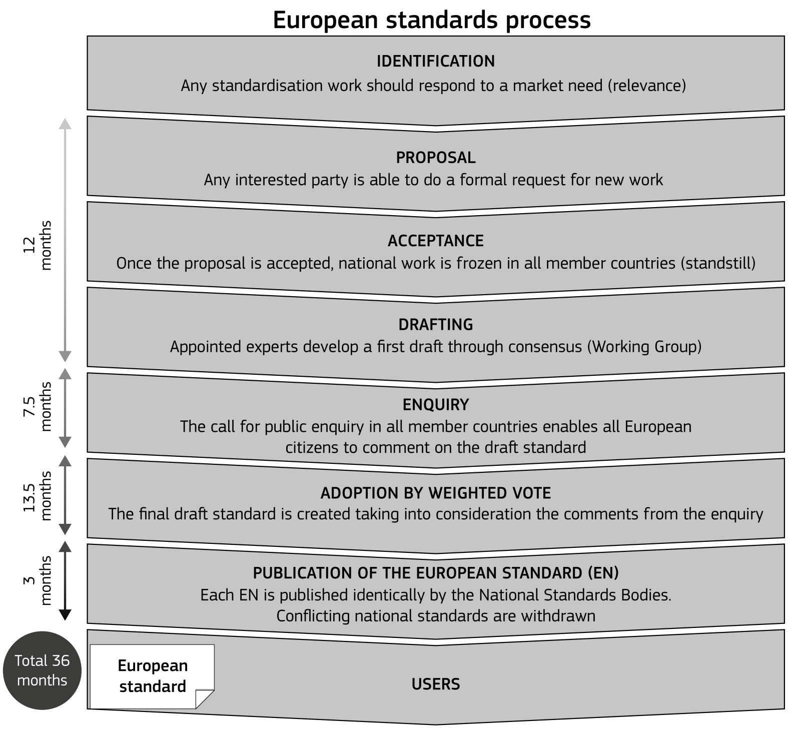
As an example of a standards drafting process, the scheme for the production of European Standards in CEN and CENELEC is reproduced below. As previously mentioned, the length and organisation of the standards drafting process vary among organisations and according to the kind of standards being developed.

More information on these specificities is available on the websites of CEN, CENELEC and ETSI.

The table below details the production of deliverables by CEN, CENELEC and ETSI in 2012[23].

Deliverables in 2012	CEN	CENELEC	ETSI
European Standards (EN)	**1014**	**438**	53
CEN and/or CENELEC Workshop Agreements (CWA)	17	0	-
CEN and/or CENELEC Technical Specifications (TS)	66	4	-
CEN and/or CENELEC Technical Reports (TR)	46	4	-
CEN and/or CENELEC Guides	5	6	-
ETSI Standard (ES)	-	-	19
ETSI Technical Specifications (TS)	-	-	**2427**
ETSI Group Specifications (GS)	-	-	8
ETSI Guides	-	-	4
ETSI Technical Reports (TR)	-	-	198
ETSI Special Reports (SR)	-	-	7
TOTAL	**1148**	**452**	**2716**

As an example, the following figure illustrates the European Standards process in CEN and CENELEC.



[23] CEN, CENELEC and ETSI Annual Reports for 2012

5.2 The Business Model of the European Standardisation System

The European Commission estimated[24] that the cost for the creation of all European standards produced in 2009 was approximately € 3,000 million extrapolating the results of a Roland Berger study in 2000[25]. According to the study, these costs result mainly from the expenses of industry experts participating in the process (around 82%), followed by the operational costs of National Standards Organisations and other national institutions (16%) and the costs of the management centres of European Standardisation Organisations (around 2%). On the basis of the related costs of experts, organisation of meetings, travel, etc., the EC estimated an approximate average cost for creation of a standard of around € 1 million.

The Berger study states that the system is financed primarily by industry (93-95%), followed by national governments (around 3-5%) and European Commission / EFTA contributions (around 2%). The fact that industry bears the bulk of the cost of the system, together with the voluntary character of standards, seems to indicate that, for industry, the benefit outweighs the cost.

Two generic distribution channels coexist in the ESS. ETSI provide access to their standards for free download at its website and sell them on DVDs, whereas CEN and CENELEC standards are sold through the NSOs. Membership fees and services are other sources of revenue for the ESS.

The figures below give a simplified view of revenue for the ESS:

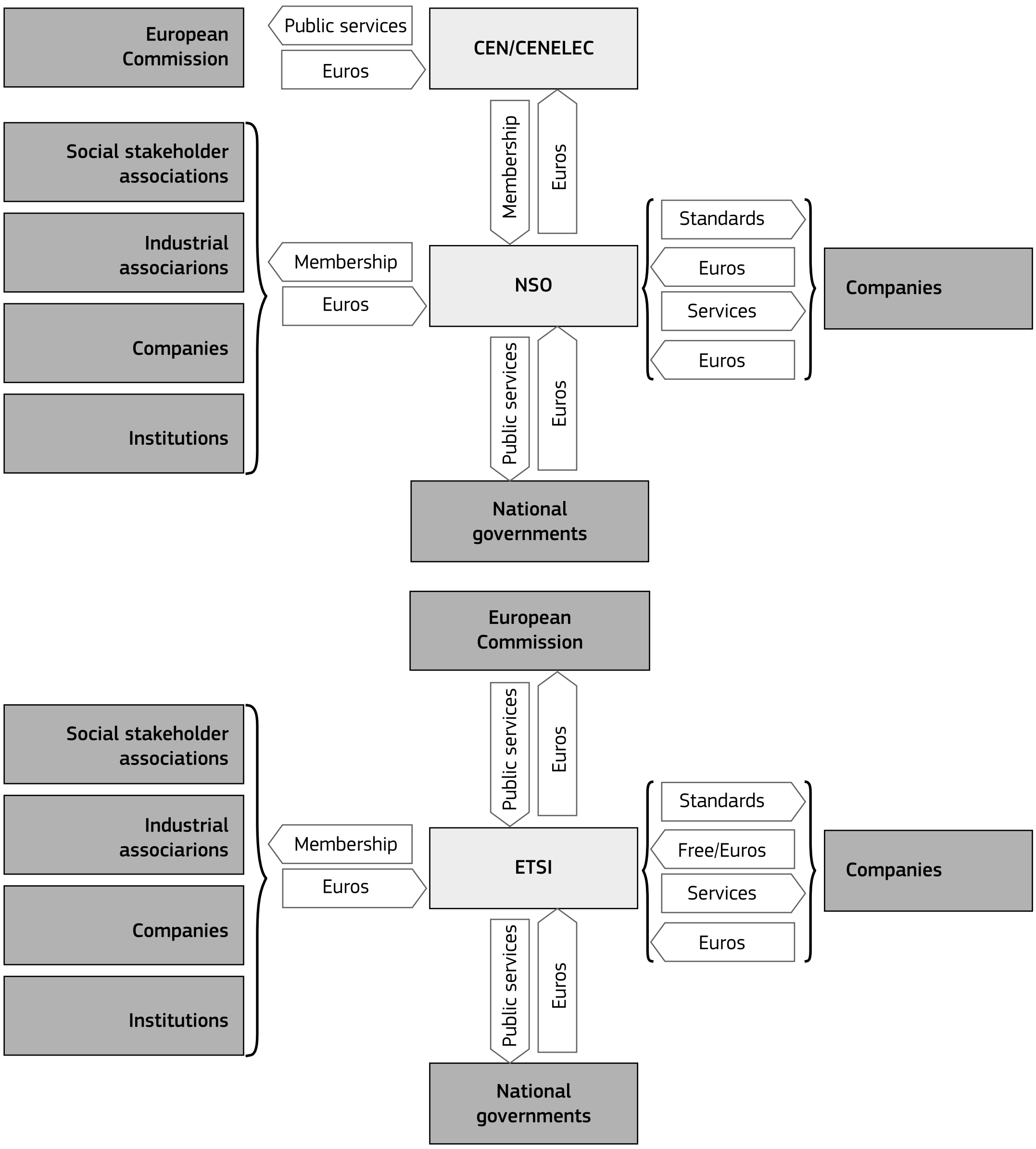


Fig 2. *Scheme of the financing of CEN, CENELEC and NSOS (up) and ETSI (down)*

[24] European Commission (2011). Commission Staff Working Paper. Impact Assessment on European Standardisation. SEC(2012) 671 final. 1 June 2011

[25] Roland Berger (2000). The future financing of the CEN system. Study commissioned by CEN. Roland Berger was commissioned to make a study on the cost of standardisation in 2000

The revenue structure is shown in the next table.

Type of revenue	CEN and CENELEC Management Centre [a]	ETSI [b]	EU + EFTA NSOs [c]
Public contribution	41%	21%	23%
Sale of standards	0%	0%	26%
Membership + Services	56%	67%	37%
Others	3%	12%	14%
Total revenue (€ millions)	**19,8**	**22,5**	**859**

Source: [a] *Annual report 2011;* [b] *Aggregate data from 2008 EC study;* [c] *Annual report 2011*

The pubic contribution to support the ESS amounts to € 210 million (23% of the total revenue) and the sales of standards generates € 223 million (25%). Most of the costs of the ESS is carried at national level[26].

Digitalisation has made it very difficult for the NSO to avoid the free circulation of copies of their deliverables, which jeopardises the current business model. How to adapt the business model to assure the continued financing of the ESS, while making it attractive for industry to continue to invest in the process and bear the major part of the cost is a challenge.

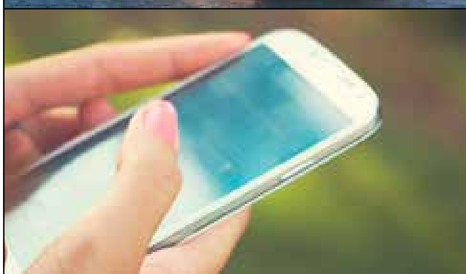
6. Overall Relevance of Standards

Standards are all around us making our life easier without even being noticed. Just imagine how our lives would be if light bulbs didn't fit into lamps, each ATM had its own incompatible credit card systems or there was not internet.

Standards are necessary and beneficial for the society as they can create economies of scale, facilitate and generate trade, enable innovation and raise the competition level. On the other hand they can be used in the opposite sense, by creating intentionally barriers to trade, preventing innovation and protecting monopolies.

Some examples of the impact of standardisation

The standardised container has radically affected the intermodal international trade. Created in 1968 it has reduced drastically the time to load and unload cargos, it has facilitated the switch between different transport systems (ship, truck and train) and has allowed the mechanisation of the ports. The result is that the transport of goods is much faster and cheaper.



The ICT industry is based on standards. GSM is a European standard that has revolutionised communications in the world. Nowadays smart phones rely on a multitude of standards for talking, making video conferences, surfing the internet, using the GPS system, paying for shopping, etc. They work as a technological platform upon which many innovative ideas in the form of applications are developed.

The first high-speed rail lines were built in the 1980s and 1990s as national infrastructure projects. Each system operated with his own rail lines, voltage and signalling standards. Locomotives operating internationally have to be equipped with a variety of expensive on-board systems. Sometimes the interoperability is even impossible and the trains have to stop at borders in order to change locomotive. As a result of the numerous signalling systems to be integrated into the Thalys, the cost of manufacturing each train is increased by 60%. The lack of European standards introduced these obstacles making the connection and integration of the different European networks problematic.

[26] Data from internal study made by the EC in 2008. ETSI sales of standards have not been included.

The prevailing standard is not always the most technical advanced solution. Several factors can produce all the users to be locked in to a certain standard. The QWERTY keyboard is a classic example of such a situation. Developed to avoid the jam of the keys on the mechanical typing machines, the layout is not optimized for speed of typing. Other keyboard layouts are believed to be more speed efficient, especially with computers, such as the one developed by Dvorak.

7. Benefits of Standards for EU Economy

From a macroeconomic perspective standardisation has today a positive impact on the economy, as it facilitates trade, increases efficiency and enables innovation. A recent study published by DIN[27], the German standardisation body, assesses that standards represent an economic benefit of € 16.77 billion a year in Germany; this is 0.72% of Germany's GDP. Similar studies carried in the UK[28], France[29], Australia[30] and Canada[31] corroborate this order of magnitude. A study commissioned by ISO to Roland Berger and published in 2010, estimates the benefits of standards for the automobile industry to be between € 23 and € 45 billion per year[32].

Standards provide technical functionalities to achieve economic and social benefits. The following categorisation[33] of functionalities and purposes of standards does not pretend to be exclusive, nor exhaustive. Some standards comply with several functionalities at the same time. They do however cover the vast majority of purposes for standards today. The text also describes some of the positive and negative economic effects from a microeconomic perspective.

Compatibility (or interoperability) standards define physical or virtual relationships between independent entities for the purpose of interoperability or communication. Most of a country's infrastructure uses compatibility standards to connect a number of disparate private and public entities, for example railway standards and network industries. Interoperability standards are the backbone of the ICT industry. Compatibility standards create *network effects*; and reduce *transaction cost* as costumers are ensured about the interoperability of software, hardware or products within their existing systems. Compatibility facilitates *division of labour* as it makes it easier to integrate different suppliers' sub products. Compatibility standards reduce barriers to trade for small entrants and permits innovation and the development of "add on" products to work alongside, or enhance well established products. On the other hand, closed standards can be used by incumbents to avoid competition.

Variety reduction standards limit the specifications for a service or product to a certain range. The majority of standards fall into this category. Variety reduction generates *economies of scale* and economies of learning in production as they allow specialisation and mass production. They reduce stockholding costs; they reduce the production risks faced by suppliers (but increase competition) and allow companies to concentrate their investments. In some cases they can hamper innovation and competition. The effect on transaction cost has a double effect; on one hand choices are easier but on the other not all customers are satisfied by the standardised varieties. There is a trade-off between choice and price. A well-known standard of this type is the international paper standard, ISO 216, which defines the A4 format used in most of the world except for North America. The widespread use of A4 paper has many advantages other than economies of scale in paper production itself. It avoids the need to rework documents to fit different formats and allows consumers to choose between competing paper brands, calculate shipping weights from the number of pages (most A4 sheets have the same weight), and fit papers from different sources into the same envelopes and binders.

Performance and minimum quality standards allow consumers to trust the quality or the performance of a product or a service before purchasing it, decreasing transaction costs and increasing trust. They reduce *adverse selection.* These standards are developed to specify acceptable product or service performance along one or more dimensions, such as functional levels, performance variation, service lifetime and efficiency. A standard that specifies a minimum level of performance often provides the point of departure for competition in an industry. As they give also some direction on how to achieve the targets, they contribute to knowledge dissemination. Unnecessary high levels of quality or performance standards can create barriers to entrants and to trade. An example of a performance standard is the minimum unleaded gasoline octane rating (called Euro Super) standard EN 228: 2008. The most known quality standards are

27 Blind, K. and Golucowicz, K. (2011)

28 DTI (2005)

29 Miotti, H. (2009)

30 CIE (2006)

31 Haimowitz, J. and Warren, J. (2007

32 Bryden, A. (2010)

33 Based on Guasch, J.L. and al. (2007), Hesser W., Feilzer A., and De Vries H. (2007)., Swann, P. (2000), Swann, P. (2010) and Temple P. and Williams G. (2002).

the ISO 9000 series which are for assessing and ensuring quality of management processes.

Measurement and test standards establish methods for describing, quantifying and evaluating product attributes such as materials, processes and functions. These standards allows for coherence between laboratories, manufacturers and public authorities establishing a common technical language in which to compare physical attributes and convey descriptive technical information. They enable precision manufacturing and help to demonstrate superior performance of products and services. Equally, measurement standards help to reduce transaction costs, reduce the risk by traders and enhance trust between them. Unit standards, such as the numbering system and weights and measures are the most typical and ancient examples.

Information and labelling standards are developed to help customers and consumers to make informed choices and to correctly use the products. They set up rules on how to communicate product characteristics, reducing transaction costs for buyers. Food packaging displays information about the nutritional value of the content, cloth labels inform about the textile material and give cleaning instructions and electrical appliances labels indicate their energy efficiency.

Usability standards facilitate the use of products and software. They enhance the interaction of humans with objects and systems. They include ergonomic standards, design for all standards (e.g. for disabled and elderly people) or software interface standards.

Health, safety and environment standards aim to ensure a minimum level of protection for people and the environment. A group of those standards are focused on workers' conditions and processes, others on consumers or users, and a third group is focused on the environment. They reduce risk, increase trust for the buyers and reduce transaction costs. If the requirement levels are unnecessarily high they could introduce *barriers to entry* and trade. Hazardous waste operations, noise levels, personal protection equipment, toy safety or low voltage installations are examples of the scope of these standards.

Security standards are designed to prevent malicious acts such as sabotage, theft, unauthorised access or illegal transfer. One of the most used security standards is ISO/IEC 27002:2005 Information technology -- Security techniques -- Code of practice for information security management. Security standards apply mainly to cyber security, data protection and cryptology, but they can be found as well in nuclear or border control domains.

Type of standards on your mp3 player

Variety reduction: the "jack connexions" for the headphones come in three sizes: 6.3m 3.5mm and 2.5mm. Mp3 players use 3.5mm. The dimensions and characteristics of the plugs are fixed in the international standard IEC 60603-11 Connectors for frequencies below 3 MHz for use with printed boards Part 11: Detail specification for concentric connectors.

Quality and performance: Sound quality parameters such as signal-to-noise ratio, frequency response or distortion are defined by the standard IEC 61606- 2 Audio and audiovisual equipment – Digital audio parts – Basic measurement methods of audio characteristics – Part 2: Consumer use.

Measurement and test: The technical specifications of the mp3 player must be measured following standardised methods and units. The latest are defined at ISO 80000-1:2009 Quantities and units -- Part 1: General.

Information and labelling: Mp3 players have information engraved in their body such as the CE marking or the electric current required for charging the batteries.

Compatibility & interoperability: The music is encoded in MP3 standard which allows different devices to read the same music files. The mp3 codec is part of the MPEG-1 standard set by ISO/IEC 11172-3:1993 Information technology -- Coding of moving pictures and associated audio for digital storage media at up to about 1,5 Mbit/s -- Part 3: Audio.

Usability: The mechanical pressure of the headphones on the ears can be a source of discomfort. DIN Standard 45500 Part 10 limits the maximum permissible contact force for headphones aimed at limiting this parameter.

Safety, health and environment: Default settings on personal music players set at safe exposure levels, as well as clear warnings on the adverse effects of excessive exposure to high sound levels. The European standard EN 60065:2002/A12:2011 Audio, video and similar electronic apparatus – Safety requirements

Security: Apple online music store iTunes introduces a proprietary standard on the files, preventing them to be played by unauthorized computers and raising criticism for their lock in effect.

8. The Participation in Standardisation

Standards clearly produce economic benefits for the society in general and for their users in particular. Standards are considered by some economists as a quasi-public good as their use by one company does not reduce its availability to others, and it is difficult to exclude any company from using them. Nevertheless to develop a standard is a resource costly activity. It requires a considerable investment of time of experts, travelling cost, venue cost, etc.

Moreover, firms investing in standards development cannot capture all the value generated. This is known as the "free rider" effect and means that there is a risk of some standards not being developed, despite the common benefits generated, if the developers are not able to recover their investment. In many cases, capturing the value of participating on standardisation activities is even more difficult for SMEs which could explain their relative low participation compared with their market share. Actually, the lack of experts willing to participate on standardisation work is a recurrent mentioned problem of the system.

The value of standards is not reduced to their technical content. Their development by an open process to which all stakeholders have participated to reach consensus provides the standards with a large *market acceptance* and certain social legitimacy. Therefore, it is important to have an appropriate participation of all stakeholders. However some companies will have more at stake in the development of a certain standard, encouraging them to invest more into their development to drive the result in their favour. Inversely, citizens cannot justify the cost of participating at the individual level as the cost overwhelms the benefits.

To meet this issue, standardisation societal stakeholder organisations have been created. In Europe they represent the consumers (ANEC[34]), the environment (ECOS[35]) and the workers (TUTB[36]). Besides that, there is an association to represent the interests of the SMEs (NORMAPME). These associations introduce balance in the standardisation process. These associations receive public subsidies from the European.

Nevertheless the major cost for developing standards is covered by the industry. Beside the general benefits discussed in the previous section there are other strategic motivations at the company level to be involved actively on standardisation. These include:

- Push for standards that would avoid changes in their production process.
- Push for standards upon which industry can exploit their own advanced products or services.
- Drive the application of certain legislation (see New Approach Directives below).
- Push for standards that would contain their own patents.
- Anticipate the market demand by observing new standards development.
- Prevent harmful standards, e.g. standards that imply costly process changers or with third part patents.

9. Innovation and Standardisation

Standards play an important role in innovation because[37] they:

- Encode the *state of the art* providing a minimum level playfield, contributing to the push for competition, serving as a basis for technology watch and enabling *technology transfer*;
- Create common understanding, allowing cooperation among the scientific and industrial communities;
- Enable interoperability between new and existing products and services and contributes to the technology convergence;
- Provide a platform for further innovation (like 3GGP or internet);
- Reassure customers and consumers about safety and quality increasing the market acceptance.

Standards have demonstrated a stronger effect on innovations supported by network effects (IT, electric cars, etc).

34 European consumer voice in standardisation (www.anec.eu)

35 European Environmental Citizens Organisation for Standardisation (www.ecostandard.org)

36 European Trade Union Confederation (www.etuc.org/tutb)

37 Blind, K. and Gauch, S. (2009).; Anvret, M., Granieri, M. and Renda, A. (2010) and European Commission presentation

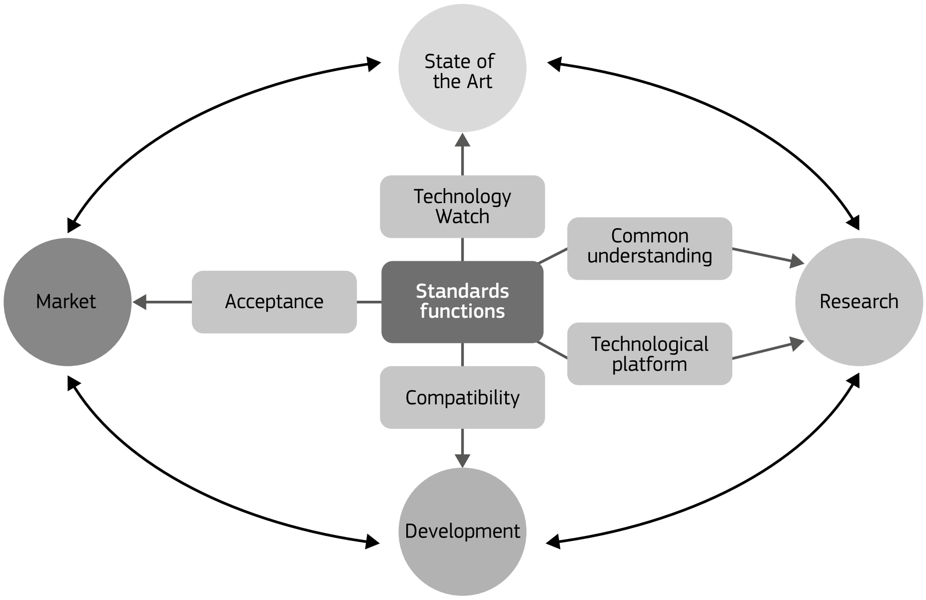


Fig 3. *Standards on support of innovation (Source: European Commission)*

To define the state of the art, standards should reflect the latest advances on sciences and technologies that are possibly implemented given the maturity of the market. There are currently efforts to bridge the research and the standardisation community as a mean to make standards better incorporate the latest scientific developments and to feed back the scientific community on areas where standardisation would benefit from further research. On the other side a balance have to be kept in order to make the implementation of the standard accessible for companies, including SMEs. Standards should be performance based keeping them flexible and innovation friendly.

Theoretically it would mean that the patents must be declared during the development of the standard, that they should be essential for the functioning of the standard and the licenses of the patents should be open to everybody at a reasonable price. Nevertheless those terms are not defined precisely enough which leads sometimes to abuse of the system in an anti-competitive and anti-innovative way.

Conflicts between patents and standards are more and more common, especially in the ICT sector but not exclusively. If a patented technology is incorporated into a standard, the patent holder could block the use of the standard or make their use expensive through royalties.

10. IPR and Standardisation

Standards and patents have in principle two opposite purposes. Whereas standards aim at innovation dissemination, patents prevent competitors from using a new technology or make it costly to do so. In a competitive context, it is not uncommon that the best technology for a technical standard is a proprietary technology, protected by one or more patents.

Ideally, when a standard is being developed, it should be known in advance how many essential standards would hold and how much the royalties will cost; allowing stakeholders to take decide how to proceed on the standard development.

In order to have the best technical standards, ESOs have a FRAND policy towards patents. FRAND stands for fair, reasonable and non-discriminatory terms.

11. Trade and Standardisation

European standardisation plays an important role on the development of the EU internal market; international standardisation aims at reducing technical barriers to trade in the global markets. The three formal international standards organisations are ISO, IEC and ITU which have similar scope as CEN, CENELEC and ETSI. Nevertheless, the ESOs are not members of the formal international standards organisations, but NSOs are.

WTO, as the organisation facilitating global trade, has set up the following standardisation principles: transparency, openness, impartiality, consensus, efficiency, relevance and consistency. Standardisation issues are an integral part of any trade negotiation and regulatory dialogues between countries and regions as the lack of harmonisation can create technical barriers to trade.

12. Glossary

Adverse selection is the result of information asymmetry. When buyers can not differentiate between high and low quality goods or services it is likely that high quality, which is generally more costly. is driven out. Information and labelling standards, based on quality and performance standards are used to diminish the information asymmetry.

Barriers to entry is the difficulty for firms to enter a particular market. Companies try sometimes to use standards as a way to prevent new entrants.

Consensus (as defined by ISO/IEC Guide 2-2004): "General agreement, characterized by the absence of sustained opposition to substantial issues by any important part of the concerned interests and by a process that involved seeking to take into account the views of all parties concerned and to reconcile any conflicting arguments. NOTE Consensus need not imply unanimity". Given the economic impact of the development of a standard on companies, this is not always an easy process.

Division of labour is the fragmentation of the production into complex supply chains allowing increase in efficiency, specialisation and interconnection. It has been one of the drivers of globalisation. Variety reduction, quality, performance and interoperability standards have enabled this fragmentation facilitating outsourcing.

Economies of scale are cost advantages that a firm obtains due to increased volumes of production. Mass production and automation of tasks are possible thanks to variety reduction, interoperability and measurement standards.

Harmonised standard is a European standard elaborated on the basis of a request from the European Commission to a recognised European Standards Organisation to develop a European standard that provides solutions for compliance with a legal provision. Such a request provides guidelines which requested standards must respect to meet the essential requirements or other provisions of relevant European Union harmonisation legislation...

Market acceptance relates to the perception of customers towards a product or a service. It is the result of some form of cost-value analysis (conscious or unconscious) which can include parameters such as environmental friendliness, safety, beauty, novelty, etc.

Network effect appears when the value of a product increases with the amount of total use. Economists distinguish between direct network externalities (e.g. more people with mobiles phones increase the value of having a phone) and indirect network (e.g. more people buying the same car increase the availability of spare parts).

Standardisation (as defined by ISO/IEC Guide 2 – 2004): "Activity of establishing, with regard to actual or potential problems, provisions for common and repeated use, aimed at the achievement of the optimum degree of order in a given context. NOTE 1 In particular, the activity consists of the processes of formulating, issuing and implementing standards. NOTE 2 Important benefits of standardization are improvement of the suitability of products, processes and services for their intended purposes, prevention of barriers to trade and facilitation of technological cooperation."

Standard: ISO/IEC Guide 2 – 2004 definition: "Document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context. NOTE Standards should be based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits."

A similar definition with more details is given by the World Trade Organisation (WTO) in its Code of Good Practice for the Preparation, Adoption and Application of Standards:

"Document approved by a recognized body that provides, for common and repeated use, rules, guidelines or characteristics for products or related processes and production methods, with which compliance is not mandatory. It may also include or deal exclusively with terminology, symbols, packaging, marking or labelling requirements as they apply to a product, process or production method."

State of the art (as defined by ISO/IEC Guide 2-2004): developed stage of technical capability at a given time as regards products, processes and services, based on the relevant consolidated findings of science, technology and experience

Technology transfer is the dissemination of skills, knowledge, methods and procedures that enable external entities to exploit them. Standards codify essential production knowledge contributing to this transfer.

Transaction cost is the cost beyond the price associated to an economical exchange. The main sorts of transaction costs are search and information costs, bargaining and decision costs, policing and enforcement costs. Standards reduce transaction cost through labelling and information standards and those standards that assure buyers about characteristics important for them.

Annex 5.

Implications of the Industrial Landscape Vision 2025 on Standards & Standardisation

Table of Contents

Introduction

Build upon the Industrial Landscape Vision 2025 (ILV 2025), the objective of this complementary document on standards and standardisation is to analyse and describe the need for standards and for evolution of the European Standardisation System against each component of the Production and Consumption System.

Based on an expert report produced by Prof. Dr. Knut Blind and completed by desk analysis as well as direct outputs from the workshops, this report aims at providing a general overview of standardisation issues related to each component of the Production and Consumption System.

The analysis for each component is structured according to the following scheme:

1. Current State of Standards;
2. Identified Gaps for Standards to Enable the ILV 2025;
3. Impacts of the ILV 2025 on the European Standardisation System

The information about current standards and standardisation activities is based mainly on searches into the ISO Online Browsing Platform (OBP)[1] to identify international standards, the CEN search platform[2] to identify published standards and standards under development, and the European Mandates web-based application[3] used to consult standardisation, programming and study mandates assigned to European Standards Organizations (ESOs). However, these brief overviews do not attempt to cover all available and relevant standards and standardisation activities. The search has in general been finished by the end of 2012.

1 www.iso.org/obp/ui/#search

2 http://esearch.cen.eu/esearch

3 http://ec.europa.eu/enterprise/standards_policy/mandates/database/index.cfm?fuseaction=search.welcome

1. Business Environment

1.1 Global Integration

Current State of Standards

The development of industrial markets in emerging countries – mainly the BRICS[4], the next-11[5] and some African countries such as Ethiopia, Kenya and Uganda – creates further opportunities for European manufacturing firms and the whole European economy, but also new challenges. These emerging markets with additional customers represent indeed an important opportunity for growth – more than the European markets – but they generate also new competitors for both local, European and global markets. Europe has already experienced significant outsourcing of its production and services to these emerging economies. An additional constraint is now the regulation of the governments of these countries, which requires more and more domestic production of originally imported products. Finally, the intensity of competition has also increased at the global level, with firms responding through new strategies aiming at increasing productivity and better exploiting economies of scale within global value chains.

The key role of standardisation in relation to all these issues is widely acknowledged. As a matter of fact, standardisation activities reflect quite well the globalisation of economy since they have already shifted from the national to the international level (e.g. key role of ISO and ICT-related international standardisation industrial fora and consortia). However, to the exception of China, most emerging actors are not yet / sufficiently involved in the international standardisation activities, and major players of the world economy are still actively publishing national standards to gain or secure competitive advantage for the domestic industry, and protect national markets. This broad share of national standards generates significant barriers to international trade, especially in the BRICS countries. For example, Mangelsdorf[6] found evidence that the stock of national standards in China hinders European exports, whereas European standards are no trade barriers for Chinese exporters. Furthermore, not only idiosyncratic national standards generate a problem for international trade, but also the implementation of national certification or accreditation procedures[7], which might be even based on international standards.

[4] Brazil, Russia, India, China and South Africa

[5] Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, Philippines, Turkey, South Korea and Vietnam

[6] Mangelsdorf, A. (2011). The role of technical standards for trade between China and the European Union. In *Technology Analysis & Strategic Management*, Vol. 23 (7), pp. 725-743.

[7] Blind, K. and Mangelsdorf A. (2012). The Trade Impact of ISO 9000 – Certifications and International Cooperation in Accreditation. In *17th EURAS Annual Standardisation Conference, Standards and Innovation*". Proceedings 2012 ed. by Marta Orviska and Kai Jakobs, pp. 21-33

Identified Gaps for Standards

Further geographic differentiation of the value chain and increasing specialisation of the companies are boosting the needs for coordination, and therefore for standards able to facilitate integration. Standards are also required to foster alignment between the European requirements and the production conditions in the emerging countries.

In order to support the European industry in its efforts to access emerging markets, shared standardisation initiatives and stronger collaboration with key countries like China, India or Brazil in international standardisation bodies are required. They will however not be sufficient if national requirements in the certification process are still misused as technical barriers to trade. Therefore, the relevance of national standards should be called into question, and the hurdles imposed by discriminating national certification and accreditation systems should be abolished. In addition, the positioning of European interests in international standardisation processes has to be strengthened to foster the competitiveness of European industry and the vision of European society in relation to future grand challenges.

Possible Impacts on the European Standardisation System

The key challenge for the European Standardisation System (ESS) lies in the tension between the defence of the interests of European companies, and the compromises needed with more and more international players of the global value chain when defining international standards. This is exemplified by the current free trade negotiations underway between the EU and the USA. It is all the more sensitive that it can lead, on one side, to increased outsourcing of European-based production to emerging countries, and on the other side, to the reduction of the conflicting national standards that create barriers to trade for European companies. To succeed in this challenge, a higher level and more effective engagement of European Standardisation Organisations (ESOs) in all international standardisation activities is required, with a strong support from national standardisation bodies of Member States in the defence of the European interest.

ESOs also need to seek more collaboration with emerging countries outside the formal standardisation framework (e.g. ISO technical committees), for example through joint bilateral initiatives with the BRICS countries on specific issues (e.g. current collaboration on biofuels with Brazil) or capacity building programmes in developing countries not yet involved in international standardisation.

A collateral issue arises with the internationalisation of standardisation activities. Indeed, many European companies are already focusing their standardisation activities on the international level, skipping the discussions that occur at the European level with other kinds of stakeholders, such as representatives of consumers and SMEs, trade unions and environmental groups. Consequently, the appropriate representation of these actors in the setting of European and international standards becomes more difficult. This trend is also increasing when standards help European companies further exploiting economies of scale to gain competitiveness. Indeed, it leads to a further concentration of multinational firms that eventually dominate the standardisation process even more. Thus, safeguards are needed to ensure the right representation of consumers and citizens in international standardisation activities, and the ESS should have a proactive role in defending this principle.

1.2 Value Chain Optimisation

Current State of Standards

In addition to their globalised nature, value chains have become more and more complex because they involve an increasing number of very heterogeneous stakeholders, often highly specialised in a particular area, who need to be coordinated so as to respond to current challenges (e.g. closer integration of various products and services, securing supply of materials, reduction of overall logistic costs, etc.)

As a main provider for common languages, specifications, methods and processes for interoperability and compatibility, standardisation has obviously a key role to play in the optimisation of value chains, and it already did so in many areas. As an example, and as stressed by one of the Europe 2020 Flagship Initiatives, "*standards have played an important role in promoting broadband mobile services and open systems with "interoperable standards", which enable information to be used for different purposes in the value chain automatically without further manual intervention*"[8]

Identified Gaps for Standards

To increase supply chain efficiency, existing standards need to be implemented in a consistent way by all stakeholders. The update or creation of series of standards with harmonised but differentiated guidelines for implementation – according to the size and the nature of businesses (firms, SMEs, service providers, factories, etc.) – could help reducing variation in implementation.

Data exchange and interface standards are increasingly needed to optimise information flows among the heterogeneous stakeholders of the value chain, especially because the integration within this value chain is increasingly done through virtual environments.

Standards ensuring compatibility between the proprietary interfaces used by different actors could also be developed.

1.3 Dynamic and Sustainable Business Models

Current State of Standards

Almost no standards are addressing business models, due to their highly competitive nature. However, the trend towards digitalisation of the economy has been supported by the promotion of eBusiness, which is strongly dependent on efficient and widely accepted standards. A key process within eBusiness is the invoicing. Recently, a series of CWAs on eInvoicing has been published by CEN. They include a European data model including implementation guidelines, an adoption programme compliance guidelines, a document addressing the legal requirements, an assessment of new business processes and technologies for eInvoicing, a framework for the emerging network infrastructure of eInvoicing service providers throughout Europe, as well as a dedicated CWA to foster the uptake of eInvoicing by SMEs.

Identified Gaps for Standards

Standards are needed for the measurement of the overall performance of business models, i.e. non only economic but also social and environmental. Indeed, companies are now expected to achieve profitable growth, environmental friendliness and social responsibility at the same time.

1.4 New Innovation Schemes

Current State of Standards

Even though standardisation and innovation can be seen as two antagonistic processes at first sight, the role of standardisation as a tool to bring innovation to the market has been acknowledged in many policy documents and initiatives. In 2008, the Communication COM(2008)133 *'Towards an increased contribution from standardisation to innovation in Europe'* stressed that "*standardisation that is lively and strong has the power to accelerate the access of innovation to both domestic and global markets."* It mentioned in particular the role of standardisation in giving innovators "*a level playing field facilitating interoperability and competition between new and already existing products, services and processes*", and the use of standards to diffuse knowledge and facilitate application of technology, which "*may then trigger innovation, in particular non-technological innovation in the service sector*". Since then, the Europe 2020 Flagship Initiatives, in particular Innovation Union[9]

[8] Supporting innovation in services, Department for Business Innovation & Skills

[9] COM(2010) 546 final, 'Europe 2020 Flagship Initiative. Innovation Union'

and Resource-Efficient Europe[10], as well as the new Regulation on European Standardisation, highlighted the role of standardisation as a policy instrument to enhance innovation in Europe.

As a result, the CEN-CENELEC Management Centre established an Innovation Directorate in order to promote standardisation and its benefits to unreached sectors and markets. Besides, the STAIR Joint Strategic Working Group was created to provide "*strategic advice to CEN and CENELEC Technical Boards in order to reach an integrated approach and develop the links between research and innovation and standardisation*". CEN also set up in 2008 the CEN/TC 389 'Innovation Management' to "*provide organizations with tools, in the form of standardisation documents, to ensure a more systematic approach to innovation and optimise the planning and management of all aspects fostering their innovation capabilities*".

Innovation is brought by an increasing number of actors, and this trend will become more important in the future. A guide on user-driven innovation is being prepared in Denmark.

Identified Gaps for Standards

More open standards are required to support new innovation schemes that involve increasingly heterogeneous and small players, who do not have the financial and human resources to access formal standard-setting processes or to pay for expensive standards.

1.5 New Business Partners

Current State of Standards

The increasing need for companies to meet mass customisation and personalisation of integrated product and services requires the development of multi-sector industrial partnerships that goes beyond traditional value chains. There are no particular standards focusing on business interactions, but standards in general help increasing trust between trading partners, build network effects and reduce transaction costs between them.

The need to integrate more environmental, social and ethical issues into business models also pushes for new partnerships, in particular NGOs. In the field of Corporate Social Responsibility, the ISO 26000 management standard was published in 2010 following five years of negotiations between representatives from industry, government, NGOs, consumer groups and labour organisations around the world.

Identified Gaps for Standards

If a wider range of stakeholders engages in standard-setting activities, standardisation itself will contribute actively to a new way of collaboration between actors of the value chain than had traditionally few interactions with each other.

1.6 Skills & Talents

Current State of Standards

The move towards the Knowledge Economy requires a larger share of highly qualified workers with an ever-increasing broader set of skills for almost all manufacturing sectors. Not only is it challenging in terms of education policy, but also in terms of demography considering the ageing population of Europe which will lead to a shrinking workforce.

Despite its crucial importance, the skill dimension is traditionally not addressed by formal standardisation activities, mainly because universities are responsible for the development of the curricula for the various Bachelor, Master and PhD studies, and sector specific organisations for changing existing and developing new training schemes. However, there is undoubtedly a strong demand for more formal standardisation activities in that field, which has already been identified by the ICT industry and the European Commission in several communications[11] related to eSkills and eLearning.

Since the establishment of the CEN ICT Skills Workshop in 2003, CEN has published a dozen of Consortium Workshop Agreements (CWAs), in particular to identify generic ICT skills profiles (CWA 14925:2004) and define guidelines for ICT curriculum development (CWA 15005.2004) for the ICT supply industry, as well as develop the European e-Competence Framework (CEN 15893:2008), which is a reference framework of 36 ICT competences. In 2009, the CWA 16053:2009 developed reference standards to ensure interoperability of European ICT career and e-skills services. More recently, the CWA 16367:2011 has provided guidelines to adapt the European e-Competence Framework to the needs of SMEs.

Since the creation of the Learning Technologies Workshop in 1999, CEN has also been involved in the development of European e-learning standards, with a focus on quality approaches, case studies and implementation guidelines. In 2007, the CEN Technical Committee 353 was created to work on standards in the field of ICT related to learning, education and training.

Another issue is the emergence of new collaborative working patterns (e.g. through open source software solutions) and more flexible working arrangements (e.g. homework, work during weekends, etc.), which

[10] COM(2011) 571 final, 'Roadmap to a Resource Efficient Europe'

[11] COM(2007) 496, 'E-Skills in the 21st Century'; COM(2010) 245, 'A Digital Agenda for Europe'; COM(2010) 682, 'An Agenda for New Skills and Jobs'

brings new challenges in the management of organisations and leads to a changing balance of power between employees and employers. Standards for these evolving conditions in labour markets have not yet been developed, most probably because companies have no short-term interests in promoting such initiatives.

In order to keep older and disabled people in the pool of the active workforce, standards are required to ensure that workplaces in particular – but also all the products, services and infrastructures that are used daily in an active life – are adapted in terms of accessibility, safety, and usability. Standardisation activities focusing on disabled and elderly people have been on-going since 1999, when the EC issued the M/273 mandate that required European Standards to integrate requirements for disabled and elderly people in terms of access to ICT products and services, and the M/283 mandate, which is a guidance document that explains how to address the safety and usability of products by people with special needs. These mandates resulted in several publications by the ESOs related to accessibility, which is now a core value of the ESS and its standards. The interests of disabled workers have also been taken into account at the international level, such as in the general series of Corporate Social Responsibility standards (ISO 26000), as well as in various ergonomics standards (e.g. the ISO 24500 series) and more specific standards (e.g. lifts, wheelchairs, etc.).

Identified Gaps for Standards

The need for standards related to skills have been highlighted at many occasions during this study by participants as a key enabler to promote the Industrial Landscape Vision 2025. The standardisation activities already launched by the ESOs in the field of ICT skills should be extended to other technologies and industries to foster a stronger alignment between academics and business, especially in scientific and technical fields but not only.

As for standards related to more flexible labour markets, the responsibility of their development belongs primarily to the unions and employers' organisations, and/or to the governmental institutions responsible for labour market regulations.

Finally, despite substantial efforts and advances, the full integration of the needs and preferences of elderly and disabled people into standardisation work is far from being achieved, and a focus on their accessibility to all working environments is particularly required to promote the Industrial Landscape Vision 2025.

Possible Impacts on the European Standardisation System

The main challenge for the European Standardisation System remains to establish its position in the field of skills, learning and training in relation to the already existing institutions.

A stronger interaction is also required with the stakeholders involved in setting the coordination mechanisms of labour markets.

1.7 Customer Involvement

Current State of Standards

With consumer requirements becoming increasingly important, companies have started to involve users in the earliest stages of their innovation processes to improve their products and services and foster their later acceptance, including in relation to ethical and social issues. As for governments, they have redirected their innovation policies from technology-push towards more demand-driven needs.

The European Standardisation System has already acknowledged the increased importance of consumers and citizens in the creation of standards, with several organisations representing their interest within the formal standardisation processes. At the European level, ANEC defends the consumer interests in the creation of European standards, in particular when they are developed to support the implementation of European regulation (harmonised standards) and specific public policies related to the environment (e.g. involvement of ANEC in Ecodesign, Ecolabel, Energy label, environmental footprint, etc.), health, safety and accessibility, the Information Society, etc. The interests of the consumer/user/citizen are also represented by more sector-oriented groups such as the European Environmental Citizens Organisation for Standardisation (ECOS) in the environmental field.

Understanding the behaviours of consumers is also crucial both for businesses and for policy-makers. However, few standards are integrating a behavioural component. For example, even though the ISO 14000 series of environmental standards has been developed largely in response to consumer expectations, there are no environmental standards focusing on the consumer behaviour related to the use of natural resources.

Identified Gaps for Standards

The changing consumer requirements and behaviours have only been taken recently into account in standardisation processes. The existing stock of standards needs to be reviewed – or new standards should be created – to better include these customer-related considerations, in particular consumer requirements towards "softer" product characteristics, like environmental and social sustainability. For the time being, "social aspects" of products and production are only partly covered by the ISO 26000 series of Social Responsibility standards. The challenge lies mainly on the higher degree of volatility in customer behaviours and the increased speed of technological development.

Besides, the expansion of the range of business models – from just selling products to offering comprehensive services – is also requiring completely new standards that are much more complicated to define because those business models require closer integration with the customers but also many more stakeholders within the value chain who should be involved in the standardisation process.

Finally, standards are needed for the technologies and processes which enable a stronger involvement of customers in the development of innovative products and services.

Possible Impacts on the European Standardisation System

The effective representation of consumers and citizens in standardisation processes is still not completely accomplished in most standardisation processes in the Member States, which leads eventually to an underrepresentation at the European level. It is even a greater challenge at the international level, especially in emerging countries where representatives of consumers and citizens are non-existent.

The integration of "soft" product characteristics, such as sustainability issues, into standards is much more difficult than technical specifications. They are indeed more difficult to understand and agree on, and the creation of related standards requires the involvement and approval of more interest groups.
More systematic and effective instruments have to be developed to integrate the new preferences and behavioural patterns of consumers effectively in the standardisation process.

The rise of individualism has also implications on the demand and consumption patterns leading to more personalisation and customisation of products and services, which is obviously challenging standardised products and services, and the very purpose of standardisation.

2. Infrastructure

2.1 Smart & Interoperable Physical Infrastructure

Current State of Standards

Physical infrastructure comprises energy, transport and water infrastructure. The main challenge consists in making these infrastructures smarter and more integrated across Europe.

The European energy infrastructure is currently dominated by the need to develop and implement smart grids, which will integrate in a cost-efficient manner the behaviours and actions of all connected users – producers and consumers – to enhance overall economic and environmental sustainability of the energy infrastructure. Various standardisation activities already exist to develop adequate related standards. The European Commission (EC) issued the Standardisation Mandate M/490 in March 2011 to European Standardisation Organisations (ESOs) to support European Smart Grid Deployment. Standardisation has indeed a key role for smart grids due to their complexity and to the involvement of many different sectors along the value chain. As a response, the three ESOs established in July 2011, together with relevant stakeholders, the CEN/CENELEC/ETSI Joint Working Group (JWG) on Standards for Smart Grids to better coordinate their work and perform continuous standard enhancement and development in this field. This JWG produced a strategic report which outlines the standardisation requirements for implementing the European vision of smart grids, in line with the Smart Grids Task Force of the European Commission. The standardisation work builds on already existing material delivered through other mandates such as M/441 on smart metering.

The main challenge for the European transport infrastructure – both passenger and freight – is to move towards stronger intermodality and interoperability so as to ensure overall transport efficiency, as reflected in the EU Transport White Paper[12]. For the time being, the various modes (air, rail, road, water) are only partly connected and their further integration is still suffering from national idiosyncrasies. Various activities have started to develop harmonised standards in Europe, in particular for railways, following the Mandates M/483 on Interoperability of the Rail System and M/486 on Urban Rail issued by the EC. However, there are still severe national frictions in this field. Furthermore, the interfaces between transport systems are recognised but not yet all sufficiently organised in an efficient way.

As for the water infrastructure, international standards for sustainable water management (e.g. piping and valves, treated wastewater reuse for irrigation, water quality, water footprint, etc.) have been devel-

[12] COM(2011) 144 final, White Paper, 'Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system', 2011

oped since several years and constitute an almost complete offering to water issues.

Identified Gaps for Standards

In the field of smart grids, a more comprehensive and integrated approach is needed to coordinate the various standardisation activities existing at the national, European and international level, to integrate and exploit the potential of all the relevant technologies, as well as to engage all stakeholders, such as the service providers – who develop new business models – and professional and private customers.
There is a strong need to harmonise the standards of the often nationally dominated transport systems, and to ensure closer coordination with international standardisation activities, especially for freight transport in response to increasingly globalised and fragmented supply chains. A very large variety of stakeholders also need to be involved in the standardisation process, from multinational companies to small and local-oriented companies, including state-owned institutions (e.g. in the railroad or air traffic system) and service providers.

The move towards electromobility requires the interoperability (e.g. charging infrastructure) and interconnectivity (e.g. data exchange supplier/consumer) between smart grids and electric vehicles. Standards are needed to ensure a certain level of harmonisation (i.e. compatibility) and enhance the quality, performance and safety of these operations.

On water infrastructure, the challenge remains mainly on the implementation of existing international standards, in particular in countries with weaker water regulatory institutions and lower technological capabilities. There is also some on-going development in water technologies which needs to be addressed by standardisation work.

Generally speaking, more standards are needed to reduce the risk and vulnerabilities of increasingly complex technical infrastructure and ensure their overall reliability and security. It is in particular the case in the context of climate change, with a need to enhance the resilience of critical infrastructure. These kinds of standards are indeed only starting to be developed.

Possible Impacts on the European Standardisation System

Those identified gaps in terms of coordination, integration of technologies, and involvement of heterogeneous stakeholders have serious impacts on the European Standardisation System (ESS) since there is a clear trade-off between the very time-consuming efforts required to address those gaps and the overarching need to speed up the standardisation process as an answer to shorter innovation cycles and rapid technological developments.

Besides, the stronger supranational involvement of governments needed to ensure better integration of transport infrastructure, and the mix between public stakeholders, which often represent specific national interests, and private companies – with their own standardisation initiatives – may also result in stronger tensions in the governance of the process, both at the EU level and between the EU and the rest of the world.

Finally, the deficit in the implementation of international standards related to water management highlights the new role that standards could play for knowledge and technology transfer.

2.2 ICT Infrastructure

Current State of Standards

Standardisation in the field of Information and Communication Technologies (ICT) is a fundamental condition of an efficient ICT infrastructure, which has become the backbone of the global economy and the new Information Society. The main challenge for the ICT infrastructure lies in the exponential amount of data generated, stored and analysed due to the pervasive role of modern information and communication technologies (e.g. smart mobile communications, the Internet, the Internet of things, etc.). An almost unlimited bandwidth is now required, as well as a more secure and efficient management, both in terms of data flows and ICT-related environmental impact (c.f. overall energy efficiency, related greenhouse gas emissions, etc.). Besides, ICT infrastructures are not yet fully interoperable, both among themselves and with physical infrastructures (e.g. smart grids).

Standardisation's role in addressing these challenges is now well acknowledged, and ICT standardisation has indeed a long tradition, which is reflected in the current international and European standardisation systems. Besides the specialised and formal standardisation organisations, like the International Telecommunication Union (ITU) and the International Electrotechnical Commission (IEC) at the international level, and ETSI at the European level, a series of standardisation consortia has emerged, especially in the context of the development of the Internet, such as the World Wide Web Consortium (W3C), the Internet Engineering Task Force (IETF), the Organization for the Advancement of Structured Information Standards (OASIS), the Institute of Electrical and Electronic Engineers Standards Association (IEEE-SA), etc.

Much of the standardisation activity related to ICT infrastructure is carried out by these industry consortia[13], even though the ESOs, and in particular ETSI, have on-going standardisation activities on most of

[13] CEN-CENELEC listed 234 ICT Standards Consortia in its *Comprehensive List of Consortia, 17th Edition.*
Cf. www.cen.eu/cen/sectors/sectors/isss/consortia/pages/default.aspx#

the above-mentioned issues, sometimes in collaboration with these informal standardisation organisations (e.g. ETSI and IEEE-SA's long-standing cooperation). For example, ETSI is working to improve the energy efficiency of ICT equipment in response to EC Mandate 462, with deliverables on measurement methods, control and monitoring systems, Key Performance Indicators (KPIs) on energy efficiency, best practices, etc. Another example is the collaboration is the on-going collaboration between ETSI and ITU-T to produce a common methodology for assessing the environmental impact of ICT. Furthermore, under the umbrella of the ICT Standards Board (ICTSB), the three ESOS are coordinating specification activities in the field of ICT with the participation of specification providers[14]. Activities deal notably with Smart House, Network & Information Society, Electronic Signature, Design for All, or Intelligent Transport Systems.

The ESOs are already quite involved in standardisation in the field of Intelligent Transport Systems (ITS), with dedicated technical committees in CEN (CEN/TC 278) and ETSI (ETSI/TC ITS). The two ESOs are ensuring strategic coordination through the ITS Coordination Group (ITS-CG), as well as alignment of working groups with the ISO/TC 204 Technical Committee on ITS at the international level. ITS has indeed become a focus of the European Commission with in particular the issuance of a mandate on Co-operative Systems (M/453) in 2009, as well as an earlier mandate on Electronic Fee Collection (M/338) in 2003. Besides, a 2010-2013 ICT standardisation work programme, including the field of Intelligent Transport, has been established to promote the use of standards as a mean to increase interoperability between services and applications.

Greening the ICT infrastructure is an issue also covered by ESOs. The EC issued in 2010 the M/462 mandate in the field of ICT to enable efficient energy use in fixed and mobile information and communication networks. ETSI, in collaboration with CEN and consortia, is dealing with architectural aspects of broadband deployment and eco-environmental issues, like measurement methods, definition of power consumption targets, thermal management and powering architecture and supervision.

Identified Gaps for Standards

The main challenges for standardisation consist in helping making ICT infrastructures more efficient, fully interoperable, and safe and secure in order to get the full economic and social benefits of ICT-based services and applications. These needs are taken into consideration by an increasing number of standardisation organisations but for the time being, and despite some efforts to enhance coordination, their activities are still often competing or even conflicting. This situation is all the more problematic than the needs for coordination at the international level are increasingly important due to the global dimension of the ICT infrastructure, the catching up of several emerging countries (e.g. China), the heterogeneity and the dynamism of the standardisation landscape in that field, and the broadening variety of technologies involved.

Interoperability and in particular cross-border interoperability between infrastructures are crucial to allow widespread use of ICT in many sectors, and standardisation has a key role to play in Europe – and beyond – to reach that objective.

Existing standardisation activities on greening the ICT infrastructure need to be further extended.

Possible Impacts on the European Standardisation System

The European Standardisation System (ESS) is particularly challenged because of its less prominent role in the field of ICT standardisation compared to other sectors. Many heterogeneous players with different capacities and interests are involved worldwide. The ESS needs to strongly interact with informal standardisation organisations as well as with new partner countries so as to promote and better influence international standardisation activities.

The challenge in developing common international standards is particularly tough when related to the public dimension of the ICT infrastructure, e.g. security and privacy issues, because of different – and sometimes conflicting – visions among actors.

Generally speaking, CEN, CENELEC and ETSI need to work even more closely with each other, using for example the same kind of framework used in the Joint Working Group on Standards for Smart Grids, in order to address properly the overall objective of integration and interoperability between physical and ICT infrastructures, systems, applications, products, and services in a wide range of sectors.

2.3 Knowledge Infrastructure

Current State of Standards

As the basis of education, research and innovation, knowledge is probably the key asset for the European economy. An efficient European knowledge infrastructure – based upon enhanced physical and digital facilities, systems, environments, methodologies and languages – is needed to promote full accessibility and sharing of data, information and knowledge across Europe and beyond, as well as across generations.

However, specific standardisation activities are mainly *de facto* or consortia-based, whereas formal standardisation activities from the ESS are either not existing or in embryonic stages, such as the recent Cloud Standards Co-ordination (CSC), launched

[14] For example, the European Broadcasting Union (EBU), Digital Europe, Open Mobile Alliance, the W3C, etc.

in December 2012 by ETSI in response to a request from the European Commission, that will "*identify a detailed map of the standards required in areas such as security, interoperability, data portability and reversibility"*. In response to EC Mandate 473, ETSI is also starting to focus on eInclusion to "*ensure that developments in technology are accessible to all in our society, including the elderly, the young and those with disabilities*" and the three ESOs are cooperating in the field of eAccessibility to address the EC Mandate 376 on the accessibility requirements for the public procurement of ICT products and services.

Identified Gaps for Standards

With an increasing volume of data available for knowledge generation and new technological developments, continuous efforts in standardisation will be needed to ensure full digital accessibility to the knowledge infrastructure to all European citizens. A series of ownership and privacy questions will challenge this objective and will need to be addressed by ESOs in coordination with standardisation industrial fora and consortia. ESOs should push for a standardisation approach to cloud computing that allows full interoperability, portability and privacy of files exchanged among clouds.

Furthermore, standards should aim more strongly at facilitating collaboration among educational and research institutions, e.g. through the development of digital research repositories, research information systems and data mining techniques, as well as the use of common metadata, statistics and identifiers.
Another challenge for standardisation is to foster the emergence of a sustainable knowledge infrastructure, which will ensure the access to past and current knowledge for future generations. Standards are in particularly needed for the development of secure, long-term and robust digital storage usable by all economic stakeholders.

Possible Impacts on the European Standardisation System

Since the standardisation activities are often outside the traditional standardisation system, there is no alternative for ESOs but to increase coordination efforts towards international fora and consortia so as to promote stronger integration of standardisation activities related to the knowledge infrastructure.

These efforts will be all the more important than stakeholders are quite heterogeneous in that field, with data producers, academic research libraries and archival institutions, service providers offering storage and analysis, the potential users of the new insights, as well as the national regulatory authorities and their conflicting data protection preferences, not to forget the future generations of users, which interests have to be considered in a way or another in standardisation processes.

2.4 Financial Infrastructure

Current State of Standards

Over the last few years, the financial crises have clearly showed the importance of a robust financial infrastructure to promote and maintain an efficient European production and consumption system.

For the time being, standardisation activities in that field have been modest, since the financial infrastructure is mainly coordinated through regulations or by very specific type of standards, e.g. accounting and financial reporting standards. There are however some activities in the field of financial services, and ESOs and regulators are already investigating an expansion of dedicated activities, such as the identification of securities, the classification of financial instruments, and terminology for financial instruments.

Identified Gaps for Standards

The current status of standards related to the financial infrastructure reflects their limited relevance for formal standardisation activities. The influence of regulatory institutions and the strong position of other types of standardisation bodies give the ESOs only a small niche for more basic activities, e.g. on classifications and terminology.

However, with today's challenges of re-establishing the trust in the financial system and improving the efficiency of the financial flows and the allocation of funds, there is undoubtedly a potential role for standards related to measurement, quality and traceability.

Possible Impacts on the European Standardisation System

The standardisation system has investigated the opportunity to contribute through standards to the efficiency and stability of the financial infrastructure. However, the further expansion of standardisation activities in that field has not been particularly welcome by existing institutions yet. Only an increased demand from the clients of the financial system would authorise the launch of new standardisation activities.

3. Materials

3.1 Materials & Reusable Parts For Sustainability

Current State of Standards

The increasing global population and its growing consumption raise the demand for raw materials, which leads to higher prices and a further exploration of extraction opportunities often accompanied by environmental problems. Besides, the consideration of the finite stock of natural resources on Earth accentuates the pressure to recycle the available materials and to develop alternative eco-friendly materials. It leads to a new approach where frontiers between materials, parts and products are blurring, with the overall objective to close the material loop.

Formal standardisation activities related to materials are obviously numerous, since materials are the main traditional input of the production and consumption system. As an example, the Work Programme of CEN related to materials covers all kinds of metallic (e.g. aluminium, copper, zinc, tin, lead, powder, etc.) and non-metallic (e.g. paper, ceramics, textile, plastics, etc.) materials, and the standardisation work deals with classification, terminology, sampling, test methods, equipment, technologies, etc. However, the above-mentioned challenges are not fully covered by these traditional standardisation activities.

Indeed, there are for example a few but not many standards related to the exploitation and harvesting of raw materials. When standardisation activities exist, they have been initiated by other private or public international organisations, such as the International Accounting Standards Boards (IASB), which has developed an International Financing Reporting Standard for extractive industries, or the United Nations Economic Commission for Europe (UNECE), which has developed the UN Framework Classification for Fossil Energy and Mineral Reserves and Resources (UNFC 2009) to get a more reliable and consistent estimate of global quantities of fossil energy.

In contrast, there are already various standards for recycling processes and product characteristics to facilitate recycling and re-use. For instance, the ISO 15270 provides guidance for the development of standards and specifications covering plastics waste recovery, including recycling, and the ISO 30000 series are a set of standards for ship recycling. In the context of promoting environmentally safe product recycling or disposal, the IEC Guide 113 provides guidelines assisting companies which have to develop materials declaration questionnaires for products. The ISO 14000 family of environmental management standards include a focus on life-cycle assessment (LCA), which helps companies identifying and evaluating the environmental aspects of products and services from the "cradle to the grave" (ISO 14040 and following). ISO 14051 provides a general framework for material flow accounting. Very recently, standards for the recycling of RFID tags (ISO 17365) or nanotechnology particles (ISO/TR 13121) or even software (ISO/IEC 12207) have been published. In parallel, numerous standards on recycling machines have been produced and are currently under development (prEN ISO 20500). ISO 15926 standardises the lifecycle activities and processes of production facilities. Its aim is to provide data integration for these activities and processes. Although it focuses in the oil and petrochemical industry, its concepts are generic and may be extended to cover other domains.

At the European level, the CEN/TC 261 on 'Packaging' issued a report on material recycling that "*describes substances or materials which cause problems or inhibit the recycling process, or which have a negative influence on the quality of recycled materials, and for which it is considered that technological solutions will not be developed in the near future*". The CEN/TC 292 activities on 'Characterisation of Waste' also better prepares the re-use of waste as secondary raw materials. Standards on paper recycling (EN 643), issued more than ten years ago, are currently under revision. Recycling standards have also been released for other materials, such as aluminium (EN 15330). Besides, the European Commission has recently issued the M/518 Mandate on Waste Electrical and Electronic Equipment (WEEE) to foster the implementation of the Directive on WEEE revised in 2012. The ESOs are requested to develop standards for the treatment of WEEE, which includes recovery, recycling and preparing for re-use.

Standardisation activities are already on-going in the field of bio-based products, which refer to products made from renewable biological raw materials such as plants and trees. The European Commission stressed the importance of standards for promoting bio-based products in its Communication on a 'Bioeconomy for Europe'[15] and on its 2012 Industrial Policy Communication Update[16], where bio-based product markets are one of the six priority lines. The EC issued a series of related mandates[17] to the ESOs, and CEN is consequently developing general horizontal standards as well as specific standards in the areas of bio-lubricants, bio-polymers, bio-surfactants and bio-solvents. Standardisation is expected to aggregate initial demand and to increase market transparency by providing common reference methods and requirements in order to verify claims about these products (e.g. bio-degradability, bio-based content, recyclability, sustainability).

[15] COM(2012) 60, 'Innovating for Sustainable Growth: A Bioeconomy for Europe'

[16] COM(2012) 582, 'A Stronger European Industry for Growth and Economy Recovery'

[17] M/429 for the elaboration of a standardisation programme for bio-based products; M/430 on bio-polymers and bio-lubricants; M/491 on bio-solvents and bio-surfactants; M/492 for the development of horizontal standards for bio-based products.

Identified Gaps for Standards

Standards are needed to complete the closure of the material loop and foster a sustainable management of natural resources worldwide. First, an increased number of scarcer materials need to be covered by recycling standards. Critical raw materials, including noble metals and rare earth elements should be a priority. Besides, there is not yet a complete series of recycling standards that have an international consensus. But more importantly, closing the material loop requires a broader and more integrated approach than just recycling. Standards are also required to foster the reuse, recovery and remanufacturing of materials, parts and products in the most-efficient way. This requires in particular the gathering, processing and exchange of information throughout the product life, from the extraction of materials to their reuse or disposal. Existing Product Lifecycle Management (PLM) standards are able to trace parts of the lifecycle, but not all the details of it, which is now possible through the integration of real-time sensor data and their sharing to all relevant stakeholders. Data and communication standards defining the format and content for data exchange are needed.

As for the exploitation and extracting of raw materials, the existing standards could be effectively and efficiently transferred in the short-term to those countries with large and even expandable stock of raw materials. A good example is the already mentioned collaboration with Brazil in the area of biofuels.

Possible Impacts on the European Standardisation System

Common standardisation activities with developing countries could be used as a channel of technology and knowledge transfer in the field of material detection, exploitation and processing leading to more efficient international standards that include the technological know-how of European industries, and stress the environmental considerations of the European society.

However, countries like Brazil and China, which are becoming stronger partners in international standardisation, are also following their own interests. Consequently, the efforts of European stakeholders in international standardisation have to be strengthened in order to response to the increasing international competition and defend a circular and sustainable approach to the use of materials worldwide.

3.2 Advanced Materials For Performance

Current State of Standards

In addition to raw materials, new advanced materials such as nanomaterials and smart materials are increasingly being developed, and foster advanced manufacturing processes, such as additive manufacturing. The European Standardisation System has reacted to these new developments, although with some delay.

Nanomaterials are raising considerable social concerns, as the interactions of nanoparticles of a substance with our bodies and the environment are not fully understood yet. On the other hand, nanotechnologies have also a huge potential for innovation and economic development. Standardisation has consequently a key role to play in balancing social expectations for consumer protection and risk management of technological development, so as to reinforce eventually consumers' confidence when nano-based products are reaching the market. The CEN/TC 352 is engaged in standardisation in the field of nanotechnologies since 2006, working closely with ISO/TC 229 and other European and international bodies (in particular the OECD) to avoid redundancy of standardisation activities. The 2010 EC Mandate M/461 has identified standardisation as a building block of the "*safe, integrated, and responsible*" approach recommended in the European Strategy for Nanotechnologies[18] and emphasised the need to deliver standards in priority for the "*characterisation of and exposure from nanomaterials*".

The ISO/TC 261 was established in 2011 to address standardisation issues in the field of additive manufacturing with one of the four working groups dedicated to *'methods, processes and materials'*, and dealing with material definition, material certification and specific standards to combine technology with materials. The work is done in close cooperation with the ASTM F 42 International Technical Committee on Additive Manufacturing Technologies formed in 2009.

International standardisation activities have also been launched recently in the field of biomimetic materials under the ISO/TC 266 technical committee to contribute to the overall acceptance of biomimetic products. It will start on the basis of guidelines already developed by the Association of German Engineers (VDI) to create international standards focusing on terminology, advanced materials and biomimetic structure optimisation.

Identified Gaps for Standards

The need for standards on nanomaterials has been well acknowledged by standardisation organisations. However, new developments, like bionanotechnology or combination of nanotechnologies with ICT, are missing and are challenged by the current structures of the standardisation system, which do not foster the integration of such converging technologies (e.g. split between ISO and ITU, or CEN and ETSI, as well

[18] COM(2004) 338 final, 'Towards an European Strategy for Nanotechnology'; COM(2005) 243 final, 'Nanosciences & Nanotechnologies Action Plan for Europe 2005-2009'

as at the level of technical committees). Besides, standards in the field of nanomaterials should go beyond technical requirements and embed appropriate knowledge and user-friendly information for the consumers regarding safety and environmental issues. Efforts should be made on communication around these issues to foster acceptance of these new materials.

As for additive manufacturing technologies, materials are necessarily used in a very different way than for subtractive manufacturing, which was the implicit reference for material specifications until now. Consequently, the specifications of materials that can be used for additive manufacturing, e.g. ceramics, polymers, metallic powder, etc., need to be reviewed to include the material properties in response to additive manufacturing technologies.

A vast number of advanced materials (e.g. graphene) and smart materials (e.g. self-healing materials, self-assembling materials, materials acting as sensors by design) are being developed, and even though it is not yet the right timing for standardisation, the ESOs should already seek close and continuous interaction with researchers in these fields.

Possible Impacts on the European Standardisation System

The challenge for the standardisation system is to increase its absorptive capacity for complex converging technologies, which components are currently dealt with in different standardisation bodies. Furthermore, the development in nanotechnology, which is characterised by a strong involvement of the OECD, shows the increasing competition of numerous organisations to set standards in promising new fields of technology, but also the threat of a fragmentation of standardisation activities. Consequently, stronger coordination is needed between all standardisation organisations involved.

To foster innovation in the field of additive manufacturing, the European Standardisation System should in particular contribute to and promote the development of open databases for material characterisation.

4. Knowledge Management

4.1 Data Capture

Current State of Standards

Thanks to recent ICT technological development, manufacturing firms will seek to capture an increasing amount of data from all kinds of internal and external sources, and make it available for processing, visualisation, analysis, and transformation into knowledge, in particular in order to better understand and respond to consumer behaviours and requirements.

The increased harvesting of personal data from consumers will lead to further concerns for data protection and the right to privacy, which are already acknowledged by European public authorities. The European Commission is currently working on a General Data Protection Regulation to unify data protection within the European Union with stronger global considerations as well as inclusion of recent technological developments, such as social networks and cloud computing.

Data protection standards have already been developed, such as the ISO 27001 standard and its data protection controls within an Information Security Information System, and the BSI specification for a Personal Information Management System[19], which offers guidance on how to implement a framework to effectively manage personal information and allows companies to maintain and improve compliance with regulations.

A crucial data-related issue for manufacturing is the Internet of Things (IoT), which can be defined as a "*dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities, use intelligent interfaces, and are seamlessly integrated into the information network*"[20]. Standardisation of these protocols is one of the priority domains of the Annual European Standardisation Work Programme 2012, which is in line with the 2009 EC Communication on the Internet of Things[21] where IoT standardisation was considered to "*play an important role in the uptake of the IoT*".

In Europe, "Connecting Things" is now a key focus for ETSI, which is actively working on end-to-end Machine-to-Machine (M2M) communications. ETSI has indeed joined forces with six other key ICT standards-setting organisations[22] as a first step towards a global initiative for M2M standardisation, called the oneM2M Partnership Project, which aims at developing technical specifications for "*a common M2M Service Layer that can be readily embedded within various hardware and software, and relied upon to connect the myriad of devices in the field with M2M application servers worldwide*"[23]. Recently, ETSI has also completed the 'Foundation Standards Package for M2M Services', comprising three Technical Specifications addressing requirements, functional architecture and interface descriptions. Within CEN,

[19] BS 10012:2009, 'Data Protection. Specification for a Personal Information Management System'

[20] Definition proposed by the European Research Cluster on the Internet of Things

[21] COM(2009) 278 final, 'Internet of Things – An Action Plan for Europe'

[22] This global initiative has currently gathered representatives from the Association of Radio Industries and Businesses (ARIB) and the Telecommunication Technology Committee (TTC) of Japan; the Alliance for Telecommunications Industry Solutions (ATIS) and the Telecommunications Industry Association (TIA) of the USA; the China Communications Standards Association (CCSA); the European Telecommunications Standards Institute (ETSI); and the Telecommunications Technology Association (TTA) of South Korea.

[23] www.onem2m.org

the CEN/TC 225 technical committee on 'Automatic Identification and Data Capture Technologies' will act as a focal point for IoT issues, even though the focus is comparably narrow on auto-identification related issues (mainly RFID and bar codes). At the international level, ITU has launched the 'Internet of Things Global Standards Initiative' (IoT-GSI), and has also formed a 'Focus Group on Machine-to-Machine Service Layer', which deals more with coordination activities than actual standards development.

Identified Gaps for Standards

With Big Data, further standards will be needed to ensure data quality and improve data sharing and comparability. Companies will also need to adopt efficient internal data cleansing and archiving processes to avoid redundancy and overload of information, which could be subject to standardisation.

Robust international standards on data protection are urgently needed to answer the serious concerns of users, citizens and public authorities related to their privacy and the security of their communication. This need will only been more pressing with the Internet of Things.

The promising development of quantum computing, and the associated shift from (binary) bits to qubits, will require completely new data standards, both in terms of format and content.

Possible Impacts on the European Standardisation System

Similarly to the ICT infrastructure, informal standardisation bodies generate most standards related to data capture and associated communication protocols. Therefore, the ESOs need to ensure constant coordination with these private initiatives.

Regarding the Internet of Things, the main challenge is to ensure consistency among specific standards on RFID, M2M, Wireless Sensor Networks (WSN), Near Field Communication (NFC), etc., to foster coordination among the existing standardisation initiatives, as well as to include security and privacy considerations.

4.2 Knowledge Generation

Current State of Standards

The highly diversified nature of knowledge, the specific needs of companies and its increasing competitive value have not led to many standardisation activities in that field. However, some aspects related to knowledge management are more appropriate for standardisation, and several guides have already been published by ESOs and their national counterparts.

In 2001, the British Standards Institute (BSI) issued the 'PAS 2001 – Knowledge Management: A Guide to Good Practice', which examines knowledge management challenges, approaches and benefits with examples of good practice from industry, commerce and academia. Other guides completed the PAS 2001, e.g. on 'Skills for Knowledge Working' and 'Measurements in Knowledge Management'. Following the British initiative, CEN published in 2004 a 'European Guide to Good Practice in Knowledge Management' in five volumes as a CEN Workshop Agreement (CWA). The guide includes a Knowledge Management Framework and addresses issues on the organisational culture needed for introducing knowledge management, on the specific requirements for implementations of small and medium-sized enterprises, as well as measurement and terminology issues. Knowledge management guides were produced by other standards-setting organisations worldwide, such as Standards Australia who issued in 2005 a guide with an implementation framework flexible enough to be adapted to individual, organisational or community level.

Identified Gaps for Standards

The increasing availability of data, the involvement of more and more actors in knowledge generation, distribution and usage, as well as the continuous progress in technologies for processing, storing and transferring this knowledge will create a demand for knowledge management, which should be more strongly addressed by standardisation.

Furthermore, the increasing mobility of skilled workers is not only challenging human resource management, which is now covered by the recent ISO/TC 260 Technical Committee, but also knowledge management. As the mobility is global, cultural disparities should be taken implicitly into account in standardisation processes.

Possible Impacts on the European Standardisation System

Standardisation in the field of knowledge management requires a comprehensive and integrative approach where all stakeholders of the value chain, and all departments within companies (R&D, Human Resources, Marketing, etc.), need to be involved. Therefore, the current fragmented structure and standards-setting processes of the European Standardisation System are particularly challenged if the work should go beyond the elaboration of guides and also include the creation of standards.

4.3 Intellectual Property Management

Current State of Standards

In line with the central role of knowledge, intellectual property has become more and more important for manufacturing companies. However, the globalisation of markets, the distribution of goods via the Internet and the related counterfeiting issues are challenging companies' intellectual property. Furthermore, new open forms of collaboration in the innovation process are making an appropriate attribution of rights much more difficult to realise.

There are no explicit international standards on intellectual property, although the ISO 9000 series is mentioning it. Attempts to establish standards to assess the value of patents failed at the international level. Currently, some European activities have started, but are not yet completed.

In fact, the main issue related to intellectual property relates to the standard-setting process itself. Indeed, the aim of defining the best possible standard in a particular field often leads to include in that standard the best available technology which is generally proprietary and protected by one or more patents. CEN and CENELEC have developed an intellectual property rights (IPR) policy under the provision of the CEN-CENELEC Guide 8 "Standardisation and intellectual property rights", which is in line with ISO and IEC and which "*encourages early disclosure and identification of patents that may relate to standards under development*" and requires patent-owners to license their essential patents on fair, reasonable and non-discriminatory terms (FRAND) to other standard users. Following the Communication COM(2008) 133 'Towards an increased contribution from standardisation to innovation', a study on the 'Interplay between Standards and Intellectual Property Rights' was commissioned by the European Commission and covered broadly the issue.

Identified Gaps for Standards

There are clearly gaps in IP-related standards, in particular to help SMEs improving the management of IP (mainly patents, copyrights, trademarks) within their businesses, enhancing IP creation and reinforcing IP protection.

Besides, strong international IPR standards are particularly needed to tackle IPR infringements in Europe and abroad.

Possible Impacts on the European Standardisation System

Successful approaches to set standards for IP management requires the involvement of various stakeholders within companies, e.g. R&D, legal and marketing departments, and across companies, e.g. patent attorneys, IP services, etc.

Due to the global dimension of IP infringement issues, an international solution is required, which has to balance heterogeneous regional approach to IP. ESOs need to assure that the European interests are reflected.

Besides, there is still a need to clarify the relationship between standardisation and IPRs, and in particular to stress the possible misuse of IPRs in the standardisation process that goes against innovation and fair competition. Indeed, strategic behaviours are occurring in standard-setting organisations (e.g. leading to patent hold-up, patent ambush and trolling, royalty stacking, etc.), and collusions happen in informal SSOs. This trend was already stressed in the Innovation Union Communication: "*standard setting processes require clear IPR rules to avoid situations where a company can gain unfair market power by incorporating proprietary IPRs in a standard*". Those behaviours can be particularly detrimental to SMEs in their access to markets. As for the implementation of FRAND terms, it is still difficult to identify what is "fair and reasonable". ESOs need to continue their efforts in solving these issues.

5. Services

5.1 Services For Customers

Current State of Standards

As a response to increasing competition from low-cost producers of physical goods around the globe as well as to changing consumer requirements, companies offer – and will increasingly offer – products accompanied by value-added services to escape competitive pressure, and increase turnover and profits.

Even though services contribute to almost 70 % of EU GDP, European standardisation in the field of services has been slow. Indeed, European service standards represent less than 10 % of all standards. However, the need to develop service standards is now well acknowledged at the European level, in particular to promote stronger integration of the Single Market for Services. The Directive 2006/123/EC clearly stressed the need to develop "*voluntary European standards with the aim of facilitating compatibility and comparability between services supplied by providers in different Member States, as well as facilitating information to the recipient and the quality of service provision*", which was recently confirmed by the Regulation on European Standardisation. In March 2013, the European Commission addressed a mandate (M/517) for the programming and development of horizontal service standards. CEN had already carried out feasibility studies on standardisation in different service fields, in response to the previous service-related mandate M/371. The Strategic Advisory

Group on Services (SAGS) was created in November 2011 and acts as an advisory and coordination body to the CEN Technical Board on political and strategic matters related to service standardisation.

Key horizontal issues for service standardisation are mainly related to quality and accessibility. The BS 10001 series already deals with customer satisfaction and quality management, and provides guidelines for codes of conduct for organisation, complaints handling in organisations and dispute resolution external to organisation.

Service companies, especially technology-based services, are significantly engaged in technology or product standardisation in order to adjust their services to the related technologies. They are reluctant to engage in service standardisation because these services are critical for their competitiveness and profits.

Identified Gaps for Standards

Despite the above-mentioned constraints, more standards are needed in the field of customer services, customer satisfaction and customer relations. As stressed by ANEC, "*customers should be able to easily and reliably recognise quality in service provision*", and compare services offered by different providers on the basis of standardised criteria. There should be strong European standards related to complaint management and dispute resolution, as well as measuring user satisfaction and also in the field of contract management, both to better protect the consumer and to enable companies to better understand the customer demand. Standards are also needed to ensure accessibility to services for disabled people.

Possible Impacts on the European Standardisation System

To produce quality standards in the field of services, there is obviously a need to better understand consumer expectations, which requires a stronger involvement of consumers in standards-setting processes, which leads eventually to the recurrent issue of funding consumer participation. This problem is not specific to the field of services, but the underrepresentation of the demand side is indeed aggravated in the service sector due to the rather small average company size.

National standardisation bodies have been recently more active in the production of service standards than ESOs. In the period 2005-2009, 453 national service standards were developed by Member States while only 24 at the European level. As stressed by NORMAPME, "*this trend may lead to proliferation of overlapping and heterogeneous national standards that could create new barriers to intra-EU trade in services by requiring businesses to adopt a range of different national standards within the internal market*". Consequently, coordination needs to be improved in the production of service standards at the European level, which would foster stronger integration of services in the internal market.

Not all stakeholders are in favour of the horizontal service standard approach and would prefer narrower standards on particular elements of a service, such as complaints handling, outsourcing of services, the provision of inclusive services for vulnerable persons, etc.

5.2 Services For Production

Current State of Standards

Manufacturing companies often use support services to optimise their product assortment along the production life cycle. Even though there is still the option to build and keep these capacities in-house, it might be more efficient to outsource these services, in particular in order to achieve a broad geographic coverage, e.g. for the maintenance and repair of products and production sites, with adjustment to regional preferences.

In order to assure high quality of these support services, companies – and especially large firms – often establish their own internal guidelines or so-called company standards.

Identified Gaps for Standards

Even though standards on services supporting the production life cycle are certainly facilitating the whole production and consumption system, there is little room for formal standardisation activities. Indeed, on the one hand, the customers of such services – i.e. large manufacturing companies – are often setting their private standards, and on the other hand, the service providers derive their competitiveness by not sharing essential assets of their knowledge or business models.

Possible Impacts on the European Standardisation System

Since there are insufficient incentives for both services companies and from large manufacturing companies to engage in standardisation (and consequently to disclose part of their knowledge), initiatives from public authorities might be required to boost formal standardisation in that field. However, the limited impact of the service-related mandates issued by the European Commission in relation to the European Service Directive could constitute a dissuasive precedent.

5.3 Services For Business

Current State of Standards

The further differentiation of the value chain also leads to further business services in addition to the traditional services.

For the time being, there are very few standards focusing on business services. However, CEN has developed European standards on business services such as maintenance, facility management and management consultancy. For example, the Technical Committee CEN/TC 395 'Engineering consultancy services' has recently developed two standards that set out common definitions of terminology to describe engineering services for the construction of buildings, infrastructure and industrial facilities (EN 16310), as well as engineering services for manufacturing industrial products and equipment (EN 16311).

Furthermore, CEN and CENELEC are currently contributing to the work of the European Commission's High Level Group (HLG) on Business Services which aims at examining "*market gaps, standards, and innovation and international trade issues in industries such as logistics, facility management, marketing and advertising*"[24]. Indeed, the need for quality standards that was identified for services for consumers was also stressed for services for businesses: "*industrial users of external services are thus confronted with a market which is heavily fragmented, non-transparent, and often lacking well-defined quality standards. Creating a thriving Single Market in business-related services requires these issues to be urgently addressed.*"

Identified Gaps for Standards

A comprehensive production and consumption system would certainly benefit from standards dedicated to new business services, in particular focusing on eco-innovation or energy efficiency. However, the emerging character of these service sectors, characterised by rather small companies and highly specific business models, leads to rather small incentives to start standardisation activities that could possibly threaten their future businesses.

[24] COM(2010) 614, 'An Integrated Industrial Policy for the Globalisation Era – Putting Competitiveness and Sustainability at Centre Stage'

6. Technologies & Production Processes

6.1 Resource-Efficient & Clean Production Processes

Current State of Standards

Manufacturing firms will face increased pressure (e.g. from consumers and regulation) – but also find greater interest (e.g. reduction of costs) – to use less energy and material throughout their production processes, as well as to exploit cleaner energy sources and manufacturing systems.

Energy efficiency issues – even though not focused on the industry – have been reflected in various standardisation activities, in particular following the EC Mandates issued in 2010: M/478 in the field of greenhouse gas emissions, M/479 in the field of energy audits, and M/480 for a methodology calculating the integrated energy performance of buildings and promoting the energy efficiency of buildings. Energy performance of buildings had already been taken into account in the European Standard EN 15459 published in 2007. The CEN and CENELEC Sector Forum on Energy Management published in 2010 the TR 16103 technical report defining a glossary of terms on energy management and energy efficiency. One of the functions of the Sector Forum is to "*investigate and evaluate standardisation needs in relation to the objectives of European legislation dealing with energy management*". The CEN/CENELEC Joint Working Group on 'Energy Management and Related Services" published the European Standards EN 15900:2010, which provides definitions and sets requirements for energy efficiency services, and EN 16231:2012 on energy efficiency benchmarking methodology. The JWG on 'Energy Efficiency and Saving Calculations' published in 2012 a European Standard EN 16212 that provides methods of calculation of energy consumption, energy efficiencies and energy savings. At the international level, ISO 50001 supports organisations in all sectors to use energy more efficiently through the development of an Energy Management System, which is based on the management system model used for the widely used ISO 9001 and ISO 14001. As a result, it should foster the spread of energy management standards along the manufacturing supply chain.

In the field of climate change mitigation, in addition to the series of ISO 14000 on environmental management, further international standards have been developed since 2006 to help streamlining procedures and harmonising definitions and requirements. The ISO standards 14064 to 14067 provide now an internationally agreed framework for measuring greenhouse gas emissions, while ISO 14069 provides guidance for the application of ISO 14064. International standards have also been developed with a positive impact on climate change mitigation for areas such as building environment design, energy efficiency of buildings and sustainability in building construction, intelligent transport systems, solar energy, wind turbines, nuclear energy and hydrogen technologies. Furthermore, numerous standards are now taking climate change explicitly into account or are adapted to the new framework conditions generated by climate change. Finally, a methodology to estimate the potential for reducing greenhouse gas emissions through cloud technologies is under development by ETSI.

Identified Gaps for Standards

The progressing energy scarcity – or at least its increasing cost – will continuously create pressure on the European standardisation system to generate standards, which might help to exploit alternative energy sources and improve the efficiency of traditional energy production.

The update of existing standards to integrate climate change mitigation considerations will become more crucial, as well as new standards for processes and technologies for climate change adaptation.

The establishment of a European sustainable manufacturing system requires new measurement standards to compare sustainability performance of production processes, as well as between products, in particular to enable consumers to make enlightened choices. It includes in particular international standardised and clear definitions and methodology to go beyond existing inconsistencies among the different product environment-related labelling schemes, as stressed by ANEC for example.

In addition to all recycling, reuse and remanufacturing standards for materials (cf. section on materials), standards are needed at the factory level to integrate new demanufacturing and disassembly lines that will enable to close the material/product loop.

Possible Impacts on the European Standardisation System

Generally speaking, "standardisation is seen as important in enabling the uptake of eco-innovation and environmental technologies"[25]. Regarding standardisation for the exploitation of renewable energy sources, it is particularly important that all stakeholders, in particular SMEs and service providers, get involved into future standardisation processes. Furthermore, existing national initiatives are not sufficient, even though they are in the interests of leading countries and companies in that field, and international initiatives are required to address this global challenge.

New stakeholders will be seriously affected by climate change, e.g. farmers, and they should therefore be integrated into the relevant standardisation processes, which need to be run at the international level.

6.2 Flexible, Smart & Customer-Oriented Technologies

Current State of Standards

In their attempt to gain competitive advantage, in particular against low-cost manufacturing competitors in emerging countries, European manufacturing firms will need to keep pace with technological development, in particular advanced manufacturing technologies that will help them increase quality and performance of products and production processes, and enhance flexibility of their overall manufacturing system.

Many international and European standards already exist on current manufacturing technologies, e.g. on industrial automation systems, machinery and industrial robots, industrial measurement and testing methods, control systems, microelectronics, chemical processes, etc. The need to update existing standards to foster high-performance manufacturing (i.e. faster, more precise and more flexible) is well acknowledged by standardisation bodies, and related activities are on going.

In particular, standardisation has already begun in the field of additive manufacturing (AM), which gather some of the most promising advanced manufacturing technologies, both at the international level – with the work of the ASTM F42 Technical Committee – and at the European level, where some new approaches are even tested. Indeed, CEN and CENELEC created the Standardisation, Innovation and Research Platform on Additive Manufacturing (STAIR-AM) as a meeting point for stakeholders from the AM research and innovation community and the international and European standardisation bodies to discuss AM standardisation issues. Besides, a dedicated FP7 project, called SASAM (Support Action for Standardisation in Additive Manufacturing), has been recently created to support the development of additive manufacturing in Europe through standardisation.

Identified Gaps for Standards

Although the trend towards mass customisation and personalisation make standards on product specifications superfluous, new technologies enabling customer-oriented production generate a further need for more process-oriented standards.

In order to respond quickly to changing consumer requirements, manufacturing firms would benefit from a high degree of modularity between assembly and disassembly lines, which could be achieved by standardisation. Standards could also foster the reuse of machine components and the reprogramming

[25] COM(2008) 133 final, 'Towards an increased contribution from standardisation to innovation in Europe'

of control systems to foster full and fast reconfigurability of the plant floor. Further interface standards allowing plug and play interconnectivity between machinery, robots and tools are also required.

Possible Impacts on the European Standardisation System

Mass customisation is on the one hand challenging the standardisation of products and services and will drive it to more generic and performance-based standards. On the other hand, the technologies and processes to allow customer-oriented production represent an opportunity for new fields of standardisation. The new challenge is to create incentives for companies developing and implementing these technologies to get actively involved in standardisation, and not only create company standards.

The convergence of technologies is clearly challenging the current European and international standardisation systems where sectors are split within and among different standardisation organisations.

6.3 Human-Centered Factories

Current State of Standards

In order to attract and keep a high-skilled workforce and to respond to consumers social and environmental expectations, factories will be more and more human-oriented with a focus on making the workplace safer and more inclusive (e.g. adapted for disabled and elderly people), ensuring safe and 'human-like' interactions with machines and robots, enhancing workers' performance, and integrating the factory more closely within its environment.

The ISO series of management standards, such as the ISO 14001 environmental standard and the ISO 26000 Corporate Social Responsibility (CSR) standard, are already contributing to answer consumers and citizens expectations on social and environmental issues.

Workplace safety standards are in place for specific sectors and issues, such as. ISO 18893 on 'Mobile Elevating Work Platforms', ISO 13688 on 'Protective Clothing', as well as the CEN standards related to the assessment of workplace exposure to chemical and biological agents and other standards related to occupational health and safety (OH&S) issues. It should be noted that a dedicated CEN Strategic Advisory Board for OH&S was created in 2008 to coordinate related activities among CEN technical committees.

BSI has issued a fast-track standard providing guidance on the management of psychosocial risks in the workplace (PAS 1010:2011), with the overall objective to minimise work-related stress and improve the overall conditions of employment for everyone.

Regarding human-robot interactions on the plant floor, the ISO 10218 standard on 'Safety Requirement for Industrial Robots' was updated in 2011. It provides requirements and guidelines for ensuring safety in robot design and construction, and for assuring worker safety during the integration, installation and maintenance of robots.

Identified Gaps for Standards

Standards are missing to foster an inclusive workplace within factories that would integrate employees and workers with disabilities, and facilitate insertion of elderly employees.

New standards are needed to enable a closer but safe interaction between humans and robots.

6.4 Digital Factories

Current State of Standards

Digital factories are using the options made available by ICT technologies, mainly integrated digital modelling, simulation and visualisation tools, to optimise the design and production processes of factories. As the digitalisation of factories requires a high level of integration and interoperability, this trend generates a strong demand for standards, which has been acknowledged by standards-setting organisations. In 2012, the IEC Technical Report 62974[26] gave an overview of the numerous standardisation activities related to the digital factory in ISO and IEC technical committees, as well as the work of the International Standards on Auditing (ISA). Examples of relevant standards are the ISO 13399[27], the ISO 15745[28], the ISO 23570[29], the IEC 61987[30], etc.

Identified Gaps for Standards

Existing standards and on-going standardisation activities should be sufficient to cover the current needs related to digital factories. However, continuous update will be needed to keep track with next generation networks and innovative technologies enabling the management of Big Data.

[26] IEC Technical Report 62794, 'Industrial Process Measurement, Control and Automation – Reference Model for Representation of Production Facilities (Digital Factory), 2012

[27] ISO 13399 *'Cutting tool data representation and exchange'*

[28] ISO 15745 'Industrial Automation Systems and Integration – Open Systems Application Integration Framework' (several parts)

[29] ISO 23570 'Industrial Automation Systems and Integration – Distributed Installation in Industrial Applications'

[30] IEC 61987 'Industrial Process Measurement and Control – Data Structures and Elements in Process Equipment Catalogues'

Possible Impacts on the European Standardisation System

Although the existing stock of standards and on-going developments related to the digital factory indicate that there are no significant gaps for standardisation in that field, the standardisation system is facing other challenges. Indeed, a great number of technical committees from different standards-setting organisations are involved in this area, and cover a large diversity of technical aspects. Consequently, significant efforts are needed to ensure coordination within and between standardisation organisations. It is especially important since the digital factories face quite heterogeneous national or even local regulatory framework conditions, which have to be aligned or adapted to the set of relevant standards. This aspect should be a particular area of concern for the specifications of the standards.

6.5 Logistics & Supply Chain

Current State of Standards

With the globalisation of the economy and the further differentiation of value chains, the development of smart, efficient and integrated logistic tools and supply chains has become increasingly important, in particular to answer the challenge of delivering highly personalised products and services "just in time" and in a secure way, not to mention consumer expectations for a minimal environmental impact during this process.

Several international standards have already been developed in relation to supply chain management and the risks associated. First and foremost, the ISO 28000 series[31] specifies the requirements for a security management system, including those aspects critical to security assurance of the supply chain, and is applicable to all sizes of organisations. As logistics and supply chains are increasingly being supported by ICT technologies, there are already a large amount of ISO and IEC standards related to RFID, which enable accurate tracking and management of goods in the supply chain. Among them[32], ISO/IEC 15961 and 15962 provide guidelines and specifications on RFID for item management, while ISO 23389 defines RFID for Freight Containers. Within CEN, the CEN/TC 225 technical committee is working on RFID related issues, in compliance with the EC Mandate M/476 on 'ICT applied to RFID systems'.

Asset management is another area where standards have already been developed, such as BSI PAS 55, or are currently under development, such as the ISO 55000 series, which will build on the BSI standard to assist companies in improving the management of business assets. The series will define the overview, concepts and terminology in asset management, and requirements for an integrated, effective management system for assets, as well as guidance for the implementation of this system. The ISO/IEC 19770 standard also focuses on Software Asset Management (SAM) which corresponds to "*all of the infrastructure and processes necessary for the effective management, control and protection of the software assets [...] throughout all stages of their lifecycle*"[33].

Identified Gaps for Standards

Despite the existing stock of standards supporting the supply chain and related technologies like RFID, the further globalisation of production and differentiation of the global value chain will increase the demand for the fast and efficient freight transport of components and products worldwide, with an increasing pressure from consumers and regulation to minimise the impacts on the environment and to save energy and material. Consequently, existing standards need to be updated to include these environmental and resource-efficiency aspects, and new standards should be developed for innovative technologies that support supply chains.

As for infrastructures and production processes, data and communication exchange standards are required to allow smart logistics tools to communicate with others.

Possible Impacts on the European Standardisation System

The global value chain requires standardisation activities on the international level, which integrate all stakeholders being involved in the supply chain. Due to rather heterogeneous conditions of national and local transport systems, a broad variety of preferences has to be considered. In addition, large multinational logistics companies have implemented their private standards to optimise their logistic services. These dominant players might be reluctant to get involved in formal standardisation processes. Consequently, the standardisation system is challenged by integrating various interests from quite heterogeneous stakeholders.

6.6 Holistic Design

Current State of Standards

The design of products and services are of increasing importance to companies in their attempt to increase competitiveness through differentiation, but also to public authorities, if public interests, like environmental, health and safety issues, are affected.

[31] ISO 28000:2007, 'Specification for Security Management Systems for the Supply Chain'

[32] A complete list can be found at http://rfid.net/basics/186-iso-rfid-standards-a-complete-list-

[33] Guide to Software Asset Management, Information Technology Infrastructure Library

As a result, companies do not seek standardisation in that field since it would lead to undesired harmonisation of products and services. However, they do benefit from standardisation in some functional aspects of design, such as Ecodesign, Design for All, Privacy by Design, Security by Design, to comply with regulation and customer requirements related to sustainability, accessibility and privacy issues.

In the field of Ecodesign, which "aims at improving the energy and environmental performance of products throughout their life cycle [...] by systematically integrating environmental aspects at the earliest stage of product design"[34], the European Commission has issued several mandates following the first 'EuP' Directive of 2005[35] and later the second Ecodesign Directive[36] of 2009. In 2006, the EC Mandate M/341 programmed standardisation work in the field of Ecodesign of Energy-Using Products. It was followed by a dozen of more specific mandates covering different kinds of products in the field of Ecodesign, until the M/495 mandate relating to harmonised standards in the field of Ecodesign was issued in 2011 to implement a more horizontal approach in that field. The CEN-CENELEC Ecodesign Coordination Group has been operational since April 2013 to avoid overlap or conflict of activities at the European level. At the international level, it should be noted that the IEC Guide 114:2005 on 'Environmentally Conscious Design' aims at integrating environmental aspects into design and development of electrotechnical products.

As for accessibility issues, the EC Mandate M/473 requested ESOs to include the 'Design for All' concept, which "*encourages manufacturers and service providers to design products and services in such a way that they can be used by everyone*", into their relevant standardisation activities. A Strategic Advisory Group on Accessibility (SAGA), including representatives of national standards bodies, CENELEC and ETSI, as well as organisations representing disabled and older persons, was set up in 2011 to help that process. Among its tasks will be the revision of the different CEN, CENELEC or ETSI guidance documents[37] related to accessibility.

As for privacy issues, the European Parliament stressed that "the consumer has the right to privacy by opt-in and/or privacy by design, notably through the use of automatic tag disablement at the point of sale, unless the consumer expressly agrees otherwise".

Identified Gaps for Standards

Standards optimising the process of designing products and services could be an objective for standardisation. However, companies or experts specialised in this area are not interested in disclosing their knowledge for the development of formal standards, and prefer to define private standards.

The standardisation work in the field of Ecodesign should be extended to the factory level in order to foster the design of sustainable supply chains and production processes.

Standards are needed for product design aiming at optimal disassembly (e.g. through the definition of criteria and methods for enhanced separability between parts of a product).

Standards could help companies to adapt the design of their products and services according to local requirements of a given region.

Possible Impacts on the European Standardisation System

It remains a challenge for the European Standardisation System to involve end users to create the best possible standards, in particular to improve accessibility of products and services for disabled and elderly people.

[34] SWD(2012) 434 final, 'Establishment of the working plan for 2002-2014 under the Ecodesign Directive'

[35] EU Directive 2005/32/EC of 6 July 2005 establishing a framework for the setting of Ecodesign requirement for energy-using products (often referred as the 'EuP' Directive)

[36] EU Directive 2009/125/EC of 21 October 2009 establishing a framework for the setting of Ecodesign requirements for energy-related products

[37] CEN-CENELEC Guide 6 'Guidelines for standards developers to address the needs of elderly persons and persons with disabilities'
CENELEC Guide 28 'Accessibility in interfaces in low voltage electrical installations – a guide for standards writers'
ETSI Guide EG 202 116 'Human Factors (HF); Guidelines for ICT products and services; "Design for All" '

Annex 6.

Background Document on Additive Manufacturing

This Background Document on Additive Manufacturing was used as an introduction to the subject for all participants during the related case study. It constitutes an example of the kind of background documents which should be prepared in preparation of multidisciplinary expert workshops when applying the Foresight Template for Standardisation.

1. Additive Manufacturing

1.1 Definition

1.1.1 Definitions

Additive Manufacturing (AM) is a layer-by-layer technique of producing 3D objects directly from a digital model.

It is "*the term given to a group of technologies that are capable of creating physical objects from Computer Aided Design (CAD) files by incrementally adding material such that the objects 'grow' from nothing to completion*"[1].

The ASTM F42 standardisation committee[2] validated the following definition:

> *"Additive manufacturing is the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies."*[3]

1.1.2 Additive Manufacturing or 3D Printing?

Since its creation 30 years ago, several terminologies have been used to describe additive manufacturing techniques. Initially used to make prototypes quickly and cheaply, they were first known as "rapid prototyping" in the 80s. Then different companies developed their own terminology such as "solid freeform fabrication", "rapid manufacturing", "rapid tooling", "direct manufacturing" or "advanced digital manufacturing". The expression "3D printing" appeared in the 90s as a de facto term for all low-cost additive manufacturing systems. "Additive manufacturing" and "additive layer manufacturing" were eventually introduced in the 2000s.

Among all these terminologies, 3D Printing has become recently the most popular term to describe all additive processes, technologies and applications in manufacturing, thanks especially to heavy media support (e.g. The Economist, but also CNN, BBC, TED, Wired, TheEngineer.co.uk, Engineering.com, Forbes, etc.) and to its inherent marketing potential for people at large ("3D" becoming a buzzword in all kinds of sectors and technologies).

Fundamentally however, 3D Printing is a specific class of additive manufacturing systems. For ASTM, this class corresponds to the systems using a printing-like process or all the low-cost desktop systems.

The two terms are used today with 3D Printing applying more to less demanding applications targeting mass customisation and additive manufacturing to professional users of higher end machines. We will use independently the two terms in this document and we will use the acronym AM to signify both.

1.2 Technologies and Processes

1.2.1 General description

All additive manufacturing technologies imply a series of different steps to produce an object:

1. First of all, a model of the object has to be created on a computer, either from virtual design or from a 3D scan of a physical object that needs to be reproduced or adapted;
2. A software takes cross-sections of this object and calculates how each layer has to be constructed;
3. Then, the 3D printer builds a first layer of the object, using one of several existing approaches (cf. *infra*);
4. After the completion of each layer, it starts the next one and goes on;
5. When all the layers have been completed and possible excess materials cleaned away, the final object is ready to use.

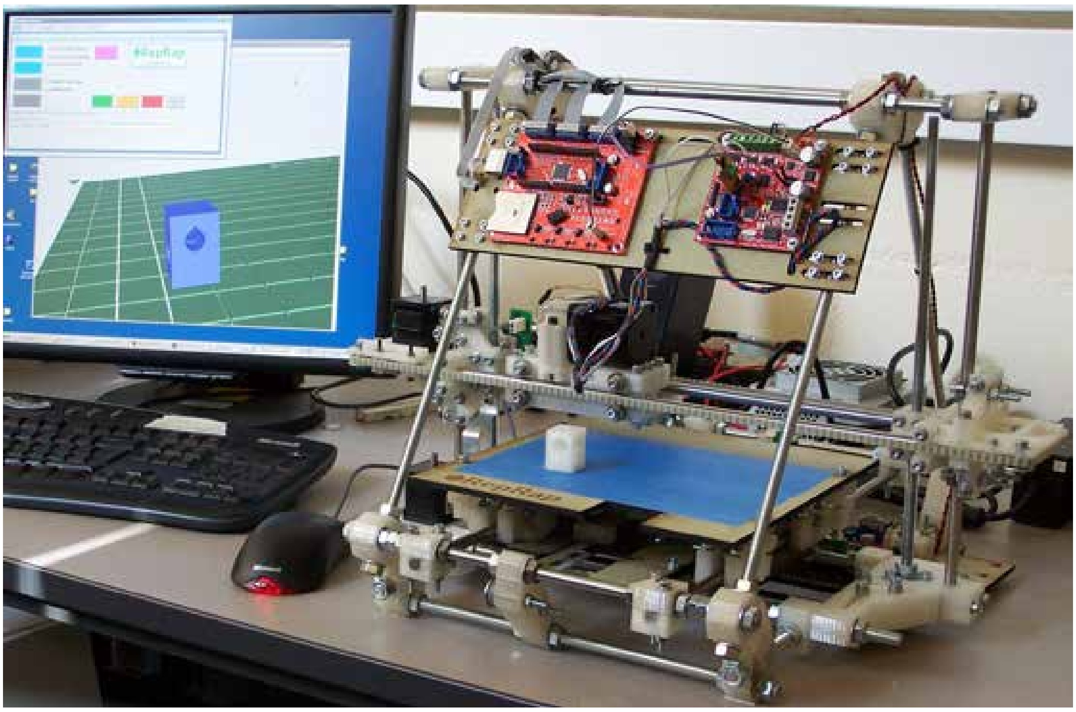
[1] Hopkinson (2010)

[2] The ASTM Committee F42 was formed in 2009 to develop standards on Additive Manufacturing Technologies. It is now one of the main international stakeholders doing this task. Cf. Part II for more information.

[3] ASTM (2012)

Fig 1. *Example of a basic 3D Printer: From Computer-Aided Design to the physical object*

Source: RepRap Wiki



1.2.2 Overview of main technologies

Different approaches are used to build the successive layers, including:

- **Stereolithography** (SLA) was developed by Californian company 3D Systems in 1986 as the pioneered approach for the creation of physical prototypes. This fast and accurate technology consists in using an ultraviolet laser to make photopolymer resin harden in the required pattern of the layer;

- **Selective Laser-Sintering** (SLS) uses a high-temperature laser to melt and fuse together powdered ceramics, metal, glass, or thermoplastics. It enables the production of very complex forms but it is slow and the granularity and porosity remain high;

- **Inkjet Printing** can be used in different ways. The heads of the 3D printer can squirt a liquid binder onto a bed of white powder in the areas where the layer needs to be solid, and then moves to next layer. They can also deposit extremely thin layers of two types of liquid photopolymer, one type where the cross-section is required to be solid and the other where it is not. An ultraviolet light-source will then harden the first polymer and transform the second one in a gel-like state to provide structural support;

- **Fused Deposition Modelling** (FDM) involves unwinding a plastic filament or metal wire from a coil and feeding it through a moving extrusion nozzle, heating the material to melt it and deposit it in the desired pattern on the build tray. The material then hardens to form the solid parts required in each layer. As subsequent layers are added the molten thermoplastic fuses to the layers below. It has been developed to aim at the low-cost end of the market;

- **Laminated Object Manufacturing** (LOM) will successively glue together layers of adhesive-coated paper, plastic or metal laminates which are then cut to shape with a laser cutter. The process is fast and accurate but does not allow complex forms.

1.2.3 Process classification

These processes can be differentiated according to several characteristics, which will give them specific advantages for different kinds of market (prototyping, tooling, direct part manufacturing, maintenance and repair, etc.)[4]:

- The **materials** they can utilize: polymers, metals, glass, sandstone, paper;

- The **build speed**;

- The dimensional **accuracy and quality of the surface finish**;

- The **material properties** of the produced parts (e.g. robustness);

- The machine and material **costs**;

- **Accessibility and safety** related to complexity of operation;

- **Other capabilities**, such as multiple colours.

[4] Scott (2012)] based on Wolhers (2011) and Hartke (2011)]

Processes have been standardised by ASTM F42 into the following seven classes:

Process	Example Companies	Materials	Market
Vat Photopolymorization	3D Systems (US), Envisiontec (Germany)	Photopolymers	Prototyping
Material Jetting	Objet (Israel), 3D Systems (US), Solidscape (US)	Polymers, Waxes	Prototyping, Casting Patterns
Binder Jetting	3D Systems (US), ExOne (US), Voxeljet (Germany)	Polymers, Metals, Foundry Sand	Prototyping, Casting Molds, Direct Part
Material Extrusion	Stratasys (US), Bits from Bytes, RepRap	Polymers	Prototyping
Powder Bed Fusion	EOS (Germany), 3D Systems (US), Arcam (Sweden)	Polymers, Metals	Prototyping, Direct Part
Sheet Lamination	Fabrisonic (US), Micor (Ireland)	Paper, Metals	Prototyping, Direct Part
Directed Energy Deposition	Optomec (US), POM (US)	Metals	Repair, Direct Part

Fig 2. *Additive manufacturing process types and attributes, including companies, materials utilised in machines, and typical markets*

Source: Scott (2012) based on the work of ASTM F42

1.3 The Usage Today

1.3.1 Manufacturers and providers

3D printers are currently being manufactured by a range of US and European companies, among them pioneer companies such as 3D Systems, Stratasys and Z Corporation in the USA, EOS in Germany and Arcam in Sweden. Other European medium-size additive manufacturers are for example Materialize in Belgium, Materials Solutions and 3T RPD in the UK. Some manufacturing companies exist in China, Japan, Israel (e.g. Objet), South Korea or India.

Besides, more and more start-ups are selling low-cost 3D printers and/or providing 3D printing services for the public at large in an attempt to follow a mass customisation business model. Examples of these companies in Europe are Digital Forming, MakieLab, Bits from Bytes in the UK, Fabbster in Germany, Sculpteo in France, Uformia in the Norway, Ultimaker in The Netherlands.

3D printers now range in price from under $500 ("home-use 3D printers"[5]) to more than $1 million for the more complex industrial machineries.

1.3.2 Main users

Initially used for rapid prototyping and modelling, an increasing number of industries are using AM technologies to manufacture directly final parts that satisfy to the mechanical requirements. The aerospace, automotive and electronics industries have found a particular interest in AM because of its "*potential to reduce parts production and process costs, shorten cycle times, and better enable demand-driven production of spare parts*"[6]. They also benefit from some significant competitive advantages compared to traditional manufacturing in terms of lightness, freedom of design, complexity-friendliness and customisation. Examples of big industries using 3D Printers in their direct manufacturing process are Siemens and BMW in Germany, Nokia in Finland, Rolls-Royce in the UK, EADS and Airbus in Europe.

3D printers are now being used also by the public at large, especially tinkerers willing to explore the new possibilities offered by these affordable manufacturing technologies. They are also used by a wide range of professionals in SMEs to manufacture different kinds of products serving their businesses (cf. 3.d.). Architects, designers and artists are using 3D printers to create more innovative, complex or disruptive design and explore matter in an artistic way.

1.3.3 Market value and share

The global market for additive manufacturing has grown from $485M (374M€) in 2002 to $1.3 billion (1b€) in 2010 and is predicted to double by 2015 and increase fourfold by 2020.[7]

Market growth in terms of machine sales has been greatest for the low cost machines: sales have increased from 500 in 2001 to 4000 units in 2008.[8] For higher end machines, sales growth has been less impressive.

5 A recent list is available at www.3ders.org/pricecompare/3dprinters

6 Gausemeier (2011)

7 All figures in this section from Wohlers Associates reports

8 Wohlers 2009, State of the Industry, Annual Worldwide Progress Report, Wohlers Associates, USA, 2009

Fig 3. *AM-market share in several industries*

Source: Wohlers (2010)

Industry	Part of the total AM-market volume (%)	Industry AM-market volume ($)	Whole market volume of the industry ($)
Aerospace (2010)	9.6	115 million	475 billion
Armament (2008)	6.8	70 million	385 billion
Automotive (2009)	17.5	190 million	3000 billion
Consumer Products (2009)	24.1	260 million	
Dental & Medical (2008)	14.7	157 million	

Regarding global market shares, a good indicator is the destination of all industrial additive manufacturing systems sold worldwide in 2012. The USA arrives in first position with 36,9 % of the global shares, followed directly by Germany (14,2 %) and further the UK in seventh position (2,6 %).

1.3.4 Products

Model making and rapid prototyping are still the most popular uses of 3D Printing with 80 % of current outputs because of the competitive advantages of AM in this application. As an example, it used to take Timberland one week to turn the design of a new shoe sole into a model, at a cost of $1,200. Using a 3-D printer it has cut the time to 90 minutes and the cost to $35.[9] It is predicted that the time it will take to take a digital design from concept to production will drop by 50% - 80% by 2020[10].

However, the proportion of final products is quickly increasing and could reach, according to Terry Wohlers[11], a 50 % share in 2020. Indeed, additive manufacturing has found already applications in a broad range of industries, from aerospace to dentistry, including jewellery, design and fashion. The first final products that are likely to know the biggest development are:

- **Customised items that fit in with the biological features of an individual**, such as medical implants, dental crowns, prosthetics, hearing aids, stents for unblocking arteries, specialised surgical tools in the medical field but also sport protective gears, body armour, etc.;
- **Objects where personal preference is important and "totems"[12]**, such as fashion related products, customised toys and gadgets, jewellery, furniture, lighting systems, customised mobile phones, food printing, etc.;
- **Parts of industrial products that are complex or need to be light**, which is particularly relevant in sectors like aerospace & defence, automotive, etc.;
- **Products with embedded electronics,** such as electronic sensors (RFID) and controls**.**

In a more distant future, bio-printing with the ability to print organic tissues, kidneys[13], hearts and the related blood vessels[14] could have a tremendous impact on health. Micro- and nano-additive manufacturing would also multiply the possibilities offered by these technologies. The printing of buildings is being tested at research centres such as the University of Loughborough Additive Manufacturing Research Group whereas the printing of a whole airplane is explored by Airbus[15].

1.3.5 Recent trends

Some recent trends show that these technologies and their applications could be at a tipping point in their development:

- **Increased attention in the popular media** (in particular The Economist, but also CNN, BBC, TED, Wired, TheEngineer.co.uk, Engineering.com, Forbes, etc.);
- **Great number of workshops, forums and exhibitions worldwide** (even though coordination remains fragmented), e.g. for 2012, AM International Conference, AEPR, TCT Show, 3D Printshow in London, RapidTech, EuroMold in Frankfurt, ICAT, etc.[16];
- **Growing personal use** (thanks to home-use 3D printers available at $1,000) **and open collaboration** among tinkerers, designers and start-ups (FabLab, RepRap project, online forums);
- **International growth of the sector** (USA, Europe, Australia, South Africa, Japan, China);

[9] The Economist, 2009, Case History: A Factory on Your Desk, Technology Quarterly 3 2009.

[10] The Economist, 2011, 3-D Printing: The Printed World, 10th February 2011.

[11] Idem

[12] Institute for the Future, 2011, The Future of Open Fabrication: "Personalised fabricated objects have the potential to become totems and be imbued by their possessors with spiritual significance»

[13] Atala A., 2011, Printing a Human Kidney, TED.com, March 2011

[14] BBC News Technology, 2011, Artificial blood vessels created on a 3D printer. September 16, 2011.

[15] Forbes, 2012, Airbus Explores Building Planes With Giant 3D Printers. July 2012

[16] Cf. Bibliography for websites on these forums and workshops.

- **Increasing number and development of standardisation initiatives** (ASTM: F42, ISO: TC 261, AFNOR: UNM/920, SASAM, etc.).

- **Increased government support** (USA[17], UK[18], South Africa, etc.);

1.4 Advantages, Challenges and Implications

1.4.1 Main advantages

Additive manufacturing technologies present some comparative advantages compared to traditional manufacturing:

- **Less material needed**: Being additive, these technologies need only (almost) the exact quantity of materials that compose the final item, to the difference of subtractive manufacturing where much waste is produced in the process. AM reduces waste enormously, requiring as little as one tenth of the amount of material compared to other production techniques[19]. Besides, the freedom of design inherent to 3D Printing enables the use of less material;

- **Re-use of materials possible**: A possible concern accompanying the foreseen mass customisation of these technologies is the waste coming from the increased production of all types of gadgets by the public at large as well as the trend to throw away objects more easily (including if some error occurs in the process of manufacturing). However, these technologies offer possibilities to re-use the raw material which consists in powder for most applications. Tinkerers are already collaborating online to develop solutions to reuse feedstock. For example, "a hack of the MakerBot home printing system [named RecycleBot] allows users to make their own feedstock from used milk bottles".[20] Besides, current work at Cornell University on "rapid fabrication of physical voxels[21]" has for purpose "to print future products by precisely adhering thousands of individual microscopic spheres made of a wide variety of different materials";

- **Less energy required:** Additive manufacturing allows in particular a massive reduction in highly energy-consuming tooling and assembly lines;

- **Reduced costs** as a consequence of the reduction in material and energy. Besides, these technologies foster on-demand business models that require less storage and inventory. However, it has to be put into perspective with the cost of materials and the running costs of the machines;

- **Less pollution** even though it depends heavily on the materials used which are, for the time being, mainly plastics. As a whole, the demand-driven production of spare parts could increase the life duration of many products and reduce waste. Besides, the potential for more localised productions and the reduction of transportation costs could also reduce carbon-dioxide emissions;

- **Multi-material direct manufacturing**: Embed electronics can be directly deposited within the body of the manufactured part or product. Applications include energy storage devices, electronic sensors and electronic controls[22];

- **Complexity-friendly**: The layer-by-layer manufacturing approach and the inherent "freedom of design" allow the production of more complex parts and consequently, the realisation of more efficient designs particularly important in aerodynamics (wing-shape optimisation) or thermodynamics (efficient heating, cooling channels). More high-value products with high complexity can be produced in an easier way;

- **Lightness of final products**: The new possibilities offered for optimal design enable lighter final products, which are particularly important in sectors such as aerospace. Indeed, "a reduction of 1kg in the weight of an airliner will save around $3,000-worth of fuel a year and by the same token carbon-dioxide emissions";

- **Time saving**: 3D printers have decreased considerably the time needed for manufacturing a prototype or a model and manufacturers have been using these specific applications for more than 30 years. They now enable as well to save time for the production of high-tech final parts in small series;

- **Customisation**: 3D printers allow consumers or professional users to customise a standard product by modifying its CAD design format (obtained by download from the company's website or by 3D scanner for example);

- **Easier and cheapest entry to manufacturing**: AM reduces the cost of manufacturing (at least for a small series of product) and enables anyone to test their invention in their own garage. Start-ups can access easily and affordably professional manufacturing solutions, through the acquisition of a mid-range 3D printer or the rent of a more sophisticated 3D printer on an ad hoc basis. For

[17] In the USA, President Obama announced in August 2012 the creation of the National Additive Manufacturing Innovation Institute (NAMII) in Youngstown, Ohio that will serve as a platform between more than forty companies, nine research universities, five community colleges, and eleven non-profit organisations to bridge the gap between basic research and product development., provide shared assets to SMEs and training to employees. The financial support is US$70 million with $30 million in federal funding and $40 million from the winning consortium.

[18] In the UK, David Willets, Science Minister, announced in October 2012 a new £7 million public investment to promote innovation in additive manufacturing and "help UK companies (to) make the step change necessary to reach new markets and gain competitive advantage". This fund is to be added a £20 million of previous Technology Strategy Board support for additive manufacturing innovation.

[19] The Economist, 2011, Print Me a Stradivarius. February 10, 2011

[20] Institute For The Future (2011)

[21] A «voxel» is the physical equivalent of an image pixel.

[22] Scott (2011)

Jeremy Rifkin, AM "*has the potential to greatly reduce the cost of producing hard goods, making entry costs sufficiently lower to encourage hundreds of thousands of mini manufacturers [SMEs] to compete effectively in regional, continental and global markets*"[23].

1.4.2 Main challenges and barriers to adoption

Several studies[24] have already identified the main barriers to the adoption of additive manufacturing technologies and the resulting challenges. Key obstacles are mainly related to materials and design tools but not only:

- **New (multi-) material development**: For the time being, the narrow range of materials used in 3D printing (mainly plastics, resins and metals) limits its applicability. The surface finish and accuracy could be seriously improved with the development of new materials. Multi-material printing is also required to use the full potential of these technologies (e.g. integrating electric wires, batteries and motors) and some materials such as carbon focus the attention since it can be configured in allotropes ranging from super-soft graphite to ultra-hard diamond;

- **Cheaper materials**: The cost of current materials is expensive, with classic thermoplastics like ABS and polylactic acid reaching $30 a pound and metals even more[25]. Research is on-going and some recently developed material such as sugar/maltodextrin ceramic powder costs $1 a pound[26];

- **Material specifications**: Databases are needed on material properties when applied in the different AM processes. This will imply an increasing effort from material suppliers, researchers and users to share and organise the data on material specifications and properties. An open and collaborative approach might enter in confrontation with a more restricted approach on IPRs;

- **Design tools, software and rules:** The current offer of CAD software[27] is not adapted for the two targeted markets of AM. When considering mass customisation, there is a need for more easy-to-use and affordable 3D CAD software as well as web-enabled co-design environments. When considering professional applications, more sophisticated tools allowing optimal shape design and integrating material properties according to processes used have yet to be developed. Design rules need also to be standardised. 3D scanners have to be improved and "haptic design interfaces" need to be developed;

- **Costs**: apart from the cost of materials, running costs and cost transparency of the processes are also a concern;

- **Process control, understanding and modelling**: "*Methods are needed for in-process monitoring and closed-loop feedback to help improve consistency, repeatability, and uniformity across machines [and] new physics-based models of AM processes are needed to understand and predict material properties such as surface roughness and fatigue*"[28]. In situ sensors for thermal control and better process controls for downtime reduction are two areas to investigate[29];

- **Machine qualification and modularity**: Current closed architecture controllers and machine modules prevent the users to test and improve build routines and materials, and qualification at a machine or a process level has to be improved[30];

1.4.3 Implications

Additive manufacturing has a wide range of implications:

- **New business model**: The current concept of "economies of scale" will be seriously undermined since it will be as cheap to produce single items as it to produce thousands of items[31]. Besides, the costs and risks associated with manufacturing will be reduced[32]. "A world of open fabrication will transform the role of the retailer" who will need to "offer access to a much wider range of stock-keeping units"[33]. Extreme customisation will offer new development opportunities for manufacturers and designers;

- **New production model**: AM removes the need for production lines, and reduces the importance of cheap labour in many production cycles. This may change the geographic distribution of production and foster the repatriation of manufacturing capacity from low-wage countries to the distribution location. Production will be undertaken closer to the customer with "a fabricator in every village", rather than in large and centralised production facilities. The demand-driven model accompanying this evolution would also mean that

23 Rifkin (2012)

24 For example, Institute For The Future (2011) and Heinz Nixdorf Institute (2011)

25 The Economist, 2011, *3D Printing: Difference Engine: Making It!*, November 25, 2011

26 Idem

27 Current free or low-cost 3D modelling software are for example Google SketchUp, 3Dtin, Blender, OpenSCAD or Tinkercad.

28 Scott (2011(for the section on "Process control, understanding and modelling" and "Machine qualification and modularity"

29 Bourrel (2009)

30 Scott (2011)

31 The Economist, 2011, *Print Me a Stradivarius.* February 10, 2011.

32 The Economist, 2011, *The Printed World.* February 10, 2011

33 Institute For The Future (2011)

stockpiles of products are no longer necessary[34]; "The Boston Consulting Group reckons that in areas such as transport, computers, fabricated metals and machinery, 10-30% of the goods that America now imports from China could be made at home by 2012, boosting American output by $ 20-55 billion a year"[35];

- **Infrastructure & logistics**: AM reduces the amount of conventional industrial infrastructure – machine tools, testing equipment, related factory hardware, assembly lines – that companies require to be considered serious industrial players[36];

- **New distribution of jobs**: AM is less labour-intensive than traditional manufacturing and consequently, it is unclear whether the repatriation of manufacturing facilities in European countries would be sufficient to offset this job loss. A more certain implication is the new skill distribution of jobs with the need for more high-skilled workers such as engineers, software developers and designers;

- **Accessibility of manufacturing:** Additive technologies make manufacturing more accessible[37] which will be both beneficial for small players in industrial countries and for nations in the early stages of industrial development in their attempt to "leapfrog" the traditional route towards production capabilities[38];

- **Gap between design and production**: AM reduces immensely the gap between design and production since "manufacturers will be able to say to their customers 'Tell us what you want' and then they will be able to make [specific products] for them"[39]. "Now engineers can think of an idea, print it, hold it in their hand, share it with other people, change it and go back and print another one"[40];

- **Creativity and innovation**: AM opens the door to a period of much deeper creativity and innovation. Product developers will be able to design "off piste" becoming freer to devise new goods in fields ranging from medical devices to home electronics[41]. Trying out new products will become less "risky" and expensive[42]. It also allows the creation of parts in shapes that conventional techniques cannot achieve, resulting in new, much more efficient designs in areas such as aircraft wings or heat exchangers[43];

- **Open-source collaboration** on designs for objects and hardware are already a massive phenomenon in AM thanks to FabLabs[44], hackerspaces (communities of technophile tinkerers), worldwide collaborative projects (e.g. the RepRap project[45]) and online forums such as Thingiverse for sharing user-created 3D files or Fab@Home to exchange ideas about hardware and software; The high level of iteration on development can boost creativity and innovation within these communities;

- **Standardisation*:*** The implementation of AM technologies changes the concept of standardisation in production. No longer will there be a "fixed menu" of products, based upon "standard" components. Customisation to meet the requirements of the individual or the market will be greatly enabled[46];

- **Intellectual property*:*** 3D Printing could have a major impact on intellectual property, as objects described in a digital file are much easier to copy, distribute and pirate[47]. The very same scenario that occurs with the music and movie industry could happen with the development of new non-commercial models and an increasing tension between hampering innovation and encouraging piracy. ThePirateBay, a well-known actor in peer-to-peer music and movie sharing has already included "physibles" (printable object files) in its catalogue of downloadable files. Public Knowledge, whose work aims to keep the Internet open, published in 2010 a White Paper to try to prevent hostile use of IP legislation[48];

- **Risks:** 3D Printing is likely to encourage the production of "substandard goods" as well as "crapjets" (for "crappy objects") defined as "unwanted waste created by unskilled designers and fabricated using inferior materials with poor surface resolution". "Physical spam" could increase if "people simply use 3D printers with abandon, producing a large number of objects of infinitesimally small value"[49]. There is also the risk of dangerous items (e.g. guns[50]) or products

34 Neil Hopkinson, University of Loughborough Advanced Manufacturing Research Group, as reported in BBC News Business, 2011, *Will 3D printing revolutionise manufacturing?,* July 27, 2001

35 The Economist, 2012, *Manufacturing the Third Industrial Revolution.* April 21, 2012

36 Prof. Brent Stucker, University of Louiseville in Kentucky USA from Financial Times, 2011, *Production processes: A lightbulb moment*, December 28, 2011

37 The Economist, 2011, *The Printed World*. February 10, 2011

38 Prof. Brent Stucker, University of Louiseville in Kentucky USA from Financial Times, 2011, *Production processes: A lightbulb moment*, December 28, 2011

39 Additive Manufacturing Consortium from Financial Times, 2011, *Production processes: A lightbulb moment*, December 28, 2011

40 David Reis, Chief Executive of Object Geometries quoted in The Economist, 2009, *Case History: A Factory on Your Desk.* Technology Quarterly, Q3 2009

41 David Abbott, General Electric from Financial Times, 2011, *Production processes: A lightbulb moment*, December 28, 2011

42 The Economist, 2011, *Print Me a Stradivarius*. February 10, 2011

43 Idem

44 A FabLab (Fabrication Laboratory) is a small-scale workshop offering digital fabrication facilities

45 The RepRap project is an initiative to develop a 3D printer that can print most of its own component. It was founded in 2005 by Dr Adrian Bowyer at the University of Bath in the UK and has taken on a life of its own since then.

46 The Economist, 2011, *The Printed World*. February 10, 2011

47 The Economist, 2011, *Print Me a Stradivarius*. February 10, 2011

48 Weinberg (2010)

49 Institute For The Future (2011)

50 The Telegraph (2012)

affecting health and safety (e.g. ABS plastics) being produced;

- **Education and awareness**: 3D printing allows to engage a broad population in science, technology, engineering and mathematics (STEM) topics. In particular, additive manufacturing fosters better visualisation and improved hand-on experiences, which ultimately "helps students [to] better comprehend complex, difficult-to-understand topics such as chemical and biological phenomena"[51]. AM can "bring the manufacturing experience to a personal level"[52].

- At the international level, the **ASTM F42 initiative** was launched in 2009 by ASTM International, a US standardisation organisation, and four technical subcommittees are now working towards standards in terminology, materials and processes, design and data formats, and test methods. F42 meets twice a year in January and July. Four standards were produced to date and several are in progress. They are available in the Volume 10.04 in the Annual Book of ASTM Standards.

- Work under progress is summarised in the following table:

Fig 4. *Work of ASTM F42 Sub-Committees*

Source: IMS-MTP (2012)

Sub-committee	Work under progress
Terminology	Selection and definition of terms, check of usability in other languages, comparison to existing standards
Materials and processes	Development of standard protocols for AM material conformance (raw material data delivered by suppliers, requirements for materials, requirements for information, guaranteed mechanical properties of parts, quality issues, etc.) and process capabilities and performance (system description, calibration methodology, energy sources, beam delivery systems, definition of periodical maintenance, etc.)
Design	Development of design guidelines, data standards and file formats
Test methods	Development of standard protocols that will be used to characterise AM systems, materials, and parts (selection of applicable standards, definition of needed data, measurement methods of mechanical properties, porosity and surface quality measurement, etc.)

2. Additive Manufacturing and Standardisation

2.1 On-Going Standardisation Initiatives

Several initiatives have emerged quite recently to develop standards for Additive Manufacturing:

- At the international level, the **ISO TC 261 technical committee** was proposed by Germany and accepted by the ISO international community. Four working groups are working on technologies (WG1), methods, processes and materials (WG2), tests and methods (WG3) and digital processes (WG4). Participating countries are Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, the UK and the USA and observing countries are the Czech Republic, Finland, Israel, New-Zealand, South Africa, South Korea and Switzerland;

[51] Scott (2012)

[52] Idem

A cooperation agreement was signed with the ISO so that ASTM standards can be fast-tracked as a ISO final draft international standard (FDIS). Standards will be mutually referenced in the publications of each other organisation in compliance with each organisation' policies and directives in order to eliminate duplication of effort;

- At the European level, the **SASAM** (Support Action for Standardisation in Additive Manufacturing) was initiated in September 2012 to "*drive the growth of AM to efficient and sustainable industrial processes by integrating and coordinating standardisation activities for Europe by creating and supporting a standardisation organisation in the field of AM*";

- In France, the **UNM 920 committee** of AFNOR (*Agence française de normalisation*) was launched by UNM (*Union de normalisation de la mécanique*) to develop standards on Additive Manufacturing. One norm was published in March 2012 and eight norms are currently being developed[53]. UNM 920 wants to be proactive for proposals at the ISO international level;

[53] Cf. www2.afnor.org/espace_normalisation/structure.aspx?commid=2860

- In Germany, the **NA 145-04-01 AA** is the national mirror committee of ISO/TC 261 within the DIN (*Deutsches Institut für Normung*). The DIN has in charge the Secretariat of the ISO TC 261 technical committee;

- In the UK, the **AMT/8** is the BSI (British Standards Institute) committee developing standards for Additive Manufacturing. Four sub-committees are working on data processing, machine safety, materials & test methods, and processing methods. ;

2.2 Standards Already Adopted

ASTM has already developed the following Additive Manufacturing standards:

- F2915-12 - Standard Specification for Additive Manufacturing File Format (AMF) Version 1.1 (*Design*);

  Scope: Description of a framework for a new interchange format (AMF) that contains provisions for representing color, texture, material, substructure, and other properties (to the difference of the current STL format). It will facilitate the switch *"evolving from producing primarily single-material, homogenous shapes to producing multimaterial geometries in full color with functionally graded materials and microstructures".* The AMF File Format is "*based on XML (an open standard markup language",* and is "*about half the size of a compressed STL file"*[54].

- F2921-11e2 - Standard Terminology for Additive Manufacturing - Coordinate Systems and Test Methodologies *(Test Methods)*

- Scope: Definition and description of terminology on the basis of and in complement of the ISO 841 (Industrial automation systems and integration – Numerical control of machines – Coordinate system and motion nomenclature) [55]

- F2924-12 – Standard Specification for Additive Manufacturing Titanium-6 Aluminium-4 Vanadium with Powder bed Fusion (*Materials and Processes)*

- Scope: Indication of the classifications of the components, the feedstock used to manufacture Class 1, 2, and 3 components, the microstructure of the components, and identification of the mechanical properties, chemical composition, and minimum tensile properties of the components[56].

- F2792-12a - Standard Terminology for Additive Manufacturing Technologies *(Terminology)*

- Scope: Definition, description and regular revision of terms, nomenclature, and acronyms[57].

The UNM 920 Committee of AFNOR published in March 2012 the XP E67-010 technical specifications on powders for AM[58].

Beyond these published standards, ISO is currently developing the following AM standards (still at an early stage):

- ISO 17296-1 on Terminology;

- ISO 17296-2 on Methods, processes and materials;

- ISO 17296-3 on Test methods;

- ISO 17296-4 on Data processing

[54] Cf. www.astm.org/Standards/F2915.htm

[55] Cf. www.astm.org/Standards/F2921.htm

[56] Cf. www.astm.org/Standards/F2924.htm

[57] Cf. www.astm.org/Standards/F2792.htm

[58] Cf.www2.afnor.org/espace_normalisation/structure.aspx?commid=2860#npubliees

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Main related workshops, forums and conferences in 2012

– 3D Printshow, London, 19-21 October 2012

www.3dprintshow.com

– Additive Manufacturing & 3D Printing International Conference

www.am-conference.com

– Asssises Européennes de Prototypage Rapide (AEPR), Paris, 12-14 June 2012

www.code80.net/afpr/content/assises/2012/AN/v_index.htm

– EuroMold, Frankfurt, 27-30 November 2012

www.euromold.com/index.php?id=51

– International Conference on Additive Technologies (ICAT), Maribor, 19-21 September 2012

www.icat.rapiman.net

– RapidTech, Erfurt, Germany, 08-09 May 2012

http://uk.rapidtech.de/index.html

– TCT Show, Birmingham, 25-26 September 2012

www.tctshow.com

Credits

– Figure 1: Adrian Bowyer (GNU Free Documentation License)

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