REAL ACADEMIA DE INGENIERIA

Euro-CASE Policy Paper on “Transforming Manufacturing”
A path to a Smart, Sustainable and Inclusive growth in Europe

Euro-CASE Policy Paper on “Transforming Manufacturing”
A path to a Smart, Sustainable and Inclusive growth in Europe

About Euro-CASE:
The European Council of Academies of Applied Sciences, Technologies and Engineering is an independent non-profit organisation of national Academies of engineering, applied sciences and technologies from 21 European countries. Euro-CASE acts as a permanent forum for exchange and consultation between European Institutions, Industry and Research. Through its Member Academies, Euro-CASE has access to top expertise (around 6,000 experts) and provides impartial, independent and balanced policy advice on technological and innovation issues with a clear European dimension to European Institutions and national Governments. In 2012 Euro-CASE has launched an Innovation Platform which consists of members of Euro-CASE Academies from science, engineering and business. The platform develops policy recommendations relevant for member states and EU Innovation Policy.

EXECUTIVE SUMMARY

Europe was the cradle of the manufacturing industry and it has traditionally led important industrial fields. The industrial sector still provides 4/5 of all exports and 80% of private R&D in the European Union are financed by this sector. Nonetheless, the trend during the last few decades clearly shows that unless we adopt measures, the manufacturing sector of the UE as a whole might be seriously endangered in the immediate future. Current production is 10% down as regards pre-crisis levels and 3 million jobs were shed in this sector. If this trend continues, the weakening of the industrial sector will have financial, social, scientific and technological consequences that would seriously affect the EU economy as a whole, with a direct impact on its citizens and even its structure and social stability.

Generally speaking it could be said that, due to various reasons, during recent decades we have not paid enough attention to the manufacturing sector, thus giving ground to our competitors. However, now there is a growing understanding among political, business and academic classes of the fact that this sector is a key element both to overcome the current crisis, and to position ourselves on a new increasingly competitive global economy based on knowledge and a new energy paradigm: A new global economy that is already being called the **Third Industrial Revolution.**

We are on the verge of a profound transformation of our society, driven in the first place by **technological changes** of an unprecedented scope and size; by an inevitable **radical change of the current energy model** and by an **accelerated globalisation process**; interrelationships in real time inevitably entail an acceleration of international processes. The world will change faster and that will require a greater capacity to adapt. To a great extent, the driver behind the technological revolution and globalisation is the **digital revolution** that, in turn, is driven by the exponential development of technologies related to microprocessors. Scientific development is preparing for new technological advances in biology and new materials at a molecular and atomic level. This will bring unprecedented advances in food, medicine, new materials and new energy sources.

With the adoption by all Member States of the document *Europe 2020* the EU has already set the roadmap towards a new economic-industrial model in an increasingly globalised and rapidly changing future. The European Commission established a new objective to increase the share of industry on the GDP from the current 16% to 20% by 2020. Nowadays there is a broad consensus about the fact that it is not possible to create quality employment without a competitive industrial, technologically advanced and economically viable base.

This paper is based on the hypothesis that the future European industrial base should be focused mainly on keeping the leadership in those advanced production processes and on the manufacturing of **high-complexity and high-value manufacturing products** (**HCHVM**), since this type of production is the actual driver of technology and innovation.

In a time like this, trying predicting how the productive industrial fabric will be 10 years from now and beyond is a scarcely rigorous task and certainly a very risky one. The best that can be done is to forecast trends considering the foreseeable evolution of development according to certain general lines and, a bit more specifically, to core and enabling technologies. **Innovations in the fields of robotics, synthetic intelligence, 3D printing, new materials and nanotechnology will revolutionise the production centres as we know them today and therefore they will profoundly alter the current social organisation of work.**

In general terms, the first inference that can be made is that the future productive fabric will be determined by the unstoppable evolution of **digitalisation**. The **digital revolution** will enable **connectivity, automation, robotization and virtual simulation** levels with the potential to change the whole productive fabric. **Digital connectivity** in real time, with global coverage and virtually unlimited bandwidth, will enable the interconnection of all the elements in the value creation chain regardless of their geographical location. The technologies that are contributing to the extensive introduction of digital revolution into the productive fabric will foster the **creation of an integrated space of value creation**.

The European Commission acknowledges that the deep technological and economic changes. Therefore, it is absolutely vital for the EU to transform the manufacturing sector into the core element for sustainable development, becoming a source of quality and stable employment and a driver for innovation. The technological revolution we are going through advises to review the very definition of the term "manufacture", expanding the limits of its traditional meaning to another that also embraces biotechnology and the combination of mechanical, electronic, software and biological sectors. The following recommendations sum up the paper

For the EU:

- We recommend widening the concept of manufacturing and considering **integrated production spaces as part of the integrated space of value creation.**
- The EU and European States are equally advised to support **High Complexity, High Value Manufacturing (HCHVM)** that will allow European manufacturing businesses to compete on a global level.

- The EU is called to update and enhance the cybernetic infrastructure to support wide digitalisation, connectivity, robotization and automation of the industrial base so as to favour the establishment of **global integrated spaces of value creation.**
- To promote innovation and incorporation of new technologies to the whole value chain, especially to the productive part, Key Enabling Technologies (**KETS**) will become vital to the new knowledge-based intensive industrial fabric. We recommend that the European Commission extends the research activities regarding KETS and complement the supporting measures with a clear focus on industrial manufacturing.
- It is recommended to antedate the creation of the "Added-value manufacturing"-Knowledge and Innovation Community (KIC). In the light of the challenges laying ahead and the importance of manufacturing industries in Europe`s growth strategy the EU cannot miss out on the opportunities in terms of education and training, business creation and innovation provided by the KICs.
- To promote and retain the technology of microprocessor manufacturing and devise a strategy to face a potential **"beyond Moore"** scenario.
- It is recommended to launch a **"Bio Foundries"** initiative (similar to DARPA`s "living foundries") allowing to design a system engineering framework for the manufacturing of biological products at industrial level. The goal is to spur innovation by combining biology and engineering that enables on-demand production of new and high-value materials.
- Competitors outside the EU are actively pursuing the models of speeding up new materials research. Therefore, the EU should follow the US example and establish a "**Material Genome Initiative"** on the European level in order to accelerate advanced materials discovery and deployment.
- The EU should support the development and implementation of new technologies of system engineering in order to maintain leadership in processes such as "**Integrated Computational Material Engineering**" which enable to combine design, characteristics of new materials, production methods and virtual simulation of results.
- The EU is advised to develop the market of 3D printing technologies and other disruptive technologies. To keep our leading role in most of them it is imperative to establish and regulate a safe and predictable legal environment. It is recommended that the EU puts forward a long-term global strategy that expands beyond 2020 to provide investor security and that integrates the multiple initiatives launched on the different aspects related to the transition towards a new sustainable energy paradigm.
- With regard to future funding mechanisms we recommend to ensure that **Horizon 2020** provides financing channels and fiscal measures encouraging the development of the new industrial fabric required to compete in the Third Industrial Revolution and the ways to pass knowledge onto the market.
- EU legislation must adapt so as to allow new business models required to compete in a global market.

For Member States

- Robotization of the integrated production space is a technological priority. Robots are bound to bridge the gap between digital technologies and actual manufacturing. Thus, it is urgent to boost a European industrial base in this sector. It is recommended that European states consider robotization according to their industrial specialization patterns in order to lay the idiosyncratic foundations for the third industrial revolution.

- It is vital for future growth to combine the knowledge generation base with the industrial base. In this regard it is recommended to implement initiatives similar to the Manufacturing Technology Centres across Europe, easing the incorporation of innovative solutions to the productive processes especially of SMEs.
- Key for the new production paradigm will be skilled labour. The member states are encouraged to continue and increase their efforts in advancing education in science, technology, engineering, and mathematics (STEM). It is further recommended to introduce specific curricula and research activities at higher education institutions to meet the challenges of the Third Industrial Revolution.
- Education and training should be aligned according to the new production model. Competitiveness of the industrial base in the new economy will require educated and trained manpower with the professional skills needed. We therefore recommend a Restructuring of the Education System which, in the end, is the catalyst and the strategy to anticipate the needs of the Third Industrial Revolution.

1. FOREWORD

Europe was the cradle of the manufacturing industry and it has traditionally led important industrial fields. The industrial sector still provides 4/5 of all exports and 80% of private R&D in the European Union are financed by this sector. Nonetheless, the trend during the last few decades clearly shows that unless we adopt measures, the manufacturing sector of the UE as a whole might be seriously endangered in the immediate future. Current production is 10% down as regards pre-crisis levels and 3 million jobs were shed in this sector. If this trend continues, the weakening of the industrial sector will have financial, social, scientific and technological consequences that would seriously affect the EU economy as a whole, with a direct impact on its citizens and even its structure and social stability.

The development of the industrial sector within the Community is uneven and geographically unbalanced and therefore it is hard to make an analysis including all the members without falling into contradictions. That is why the reader needs to understand that we have made an effort for all the conclusions and recommendations to be applicable to the entire Community.

Generally speaking it could be said that, due to various reasons, during recent decades we have not paid enough attention to the manufacturing industry, thus giving ground to our competitors. However, now there is a growing understanding among political, business and academic classes of the fact that this sector is a key element both to overcome the current crisis, and to position ourselves on a new increasingly competitive global economy based on knowledge and a new energy paradigm. A new economy that is already being called, in several official EU documents, the **Third Industrial Revolution.**[1]

In recent years, an exhaustive in-depth debate has taken place, and still is, on both sides of the Atlantic about what should be the role and relative importance of the manufacturing sector in the future economy. As a consequence of this, many private, public and joint private-public initiatives have been launched aimed at understanding the scope and all aspects of the subject and at proposing the relevant corrective action lines. The results of such initiatives can already be seen on specific policies -national and supranational- for transforming, promoting and strengthening the industrial fabric.

The experience of the recent crisis supports the hypothesis of the relevance of the manufacturing industry in the economy as a whole. The countries with strong industrial bases have better endured the deterioration of the productive fabric and, generally, they have lost fewer jobs. The hypothesis –widely accepted for decades in the developed world- that it was possible to give away the manufacturing sector to areas with lower salaries while at the same time retaining the capacity for design and development in the metropolis has proved completely wrong. We have seen that when manufacturing is given away, it is only a matter of time before the technology, design and capacity for innovation are also relinquished.

Another doubtful hypothesis is the one that states that an economic system primarily and nearly exclusively oriented towards services is viable within the framework of the new

---

[1] See e.g. http://ec.europa.eu/enterprise/initiatives/mission-growth/

economy. The truth is that if a country gives away its industrial sector, in the medium to long term, it will find it very hard to achieve a balance of payments only with the services it generates, irrespective of how good and exclusive they are. Finding the right balance between services and manufacturing is a matter that requires to be settled case by case at a local level and for each specific economy.

Recent studies[2] confirm without doubt that there is a correlation between the capacity to manufacture complex products and the level of economic wealth. Orienting the industrial base towards complex products with a high added value progressively creates an industrial fabric rich in interrelationships and job-creating at all levels. In the future, international competition will increasingly take place in the field of sophisticated products with great technological content and complexity, which are the result of integrating other products with an equal or smaller level of complexity. **The industrial fabric of the Third Industrial Revolution will have to be primarily oriented towards the production of complex products with great added value.[3]**

If we observe the evolution of the international market over the last few decades and the mechanisms that have contributed to developing competitiveness of emerging economies, by shortening the technological advantage of developed economies, it is obvious that there is a strong **correlation between production capacity, innovation capacity and economic wealth**. Emerging economies that started manufacturing components with a low added value and a low technological component, have quickly upgraded to more complex levels of high-technology formerly reserved to developed economies. In a few years, thanks to a learning process of manufacturing, China has become the leader of industrial sectors that were previously the exclusive domain of the USA, Japan and the EU, which confirms that the manufacturing industry is a powerful tool to generate innovation. A lesson that Japan had learned at the end of the Second World War.

As we will see later on, the Third Industrial Revolution will profoundly transform the whole production base. Although in order to overcome this crisis, in the short term, it is necessary to stop the deterioration of the existing industrial base, it would be a mistake to assume that this fabric –which could be useful to keep the employment level under the current emergency situation–, will survive on a much different future competition environment. The future economy will require to focus increasingly more on the **production of components and products with a high value and related services (High Complexity, High Value Manufacturing, HCHVM)** and it will therefore be necessary to change the European industrial base from a labour-intensive model to a knowledge-intensive one.

To invest in a knowledge-based industry is a safe bet for a richer society, with a high level of employment and the capacity to provide the social welfare we have attained in Europe.

An economy aimed at manufacturing HCHVM products, capable of competing in a sustained manner in domestic and international markets will need to be based on the following: implementation of science, technology and innovation in manufacturing processes

[2] Hausmann, Hidalgo et al. The Atlas of Economic Complexity.

[3] Going even one step further the concept of Industry 4.0 is based on the full implementation of ICT in manufacturing. It is putting emphasis on the internet of things and self-organizing production processes (see Chapter 6).

and products; an in-depth knowledge of the market; techniques to manage technical and programmatic complexity; and innovative business models that enable us to adapt to every circumstance of an evolving market as quickly as possible[4]. All of it in an environment of scarce natural and energy resources.

[4] Speech by Sir John Rose on RSA "Creating a High Value Economy"

WHERE WE STAND

2. WHERE WE STAND

Before approaching the subject in more detail and in order to maintain the thoroughness of this report, it is worth emphasizing certain things, although already mentioned in the previous section. When we refer to the European industrial fabric, please note Europe shows a very uneven scenario, with de-industrialised regions, regions in the process of recovering productive capacity along with other regions that are world leaders in the manufacturing industry. That is why readers need to understand that the analyses and recommendations contained herein are made for the EU as a whole in the abstract, even though we are aware that many regions are pioneers in the industrial sector.

2.1 CURRENT STATE OF THE EUROPEAN INDUSTRIAL FABRIC

During the last two decades, the manufacturing industrial sector of the EU has been under strong pressure due to various factors and particularly due to the deep financial crisis we are still suffering. In 2007 before the crisis, what has traditionally been considered as the manufacturing industry amounted to 17.1% of the GDP of the EU and provided 22 million jobs.[5]
From 1995 to 2007, this sector had surprisingly increased its productivity by 46% thanks to innovations in products and processes and to outsourcing certain steps of the value chain to areas with cheaper labour.

The impact of the crisis

It is estimated that the crisis has caused a decrease of 10% in production and that over 3 million jobs were shed in the sector[6], which means that manufacturing went back to the levels of the 90s, a step backwards of over a decade! However, what is most concerning are not these figures, although impressive, but the fact that the crisis arrived at a time of huge technological transformations, globalisation of the markets and changes in the energy paradigm.

A pernicious effect of the crisis that affects particularly SMEs is the difficulties of the industries of gaining access to financing. This is especially serious considering that when one is trying to keep a competitive position in the market it is vital to invest in new technologies and infrastructure.

The impact of energy

Solely for the purpose of establishing the framework of what will be analysed later on and to understand the impact of energy on the European industrial fabric, from 2005 to 2012 the price of energy increased by 27%[7] in the EU, which is a bigger increase than that suffered by our main competitors.

To this we must add the indirect costs resulting from the strict observance of the objec-

---

[5] European Commission, EU Manufacturing Industry. What are the Challenges and Opportunities for the coming years?
[6] COM (2012) 582 final
[7] COM(2012) 582 final

tives for reduction of greenhouse gas emissions by 2020 and 2050.

The impact of globalisation

As we will analyse later on in this document, it is a fact that the manufacturing scenario is currently global. The policy of outsourcing the production towards areas with lower costs and social charges related to labour that many companies have followed during the last two decades has had a double effect: Firstly, the creation of a competitor industrial fabric and secondly, the undermining of the capacity for technological innovation.

We cannot ignore that if this started as a mere relocation of manufacturing, as the technological and scientific gap is becoming smaller, our competitors are creating a R&D base that can compete in prices with European countries, which is causing research and development activities to follow the lead of manufacturing activities. This new form of outsourcing may have much more dangerous long-term effects.

Latent structural weaknesses

The above are obvious factors that helped deteriorate the productive fabric, but there are other underlying structural causes –unrelated to the crisis– that have an impact on the loss of competitiveness, such as a lack of entrepreneurship, a lack of interest in technical studies, an ageing population, resilience to innovative changes, a lack of understanding of the consequences of the digital revolution, etc.

Lastly, it is worth noting that even though it is not the aim of this report to make an analysis by countries, it is an unquestionable fact that the nature of international competition will be mainly defined by Chinese policies –i.e. **state capitalism**– and, to a lesser extent, by India. China nowadays represents 20% of all world exports.

Several European Commission documents identify another vital aspect of the competitiveness of the industrial sector: the EU, which is a power in the field of knowledge generation, has not been able to effectively market this capacity and that must be the core of the efforts needed as regards **industrial innovation.**

2.2 A CHANGING WORLD. THE THIRD INDUSTRIAL REVOLUTION

We are on the verge of a profound transformation of our society, driven in the first place by **technological changes** of an unprecedented scope and size in the history of humanity that are being exponentially developed; by an inevitable **radical change of the current energy model** and by an **accelerated globalisation process**. This is what has come to be referred to as the **Third Industrial Revolution.**

On another scale, humanity has gone through different globalisation processes in other historical periods –such as the Roman Empire–, but the big difference lies in the fact that now, for the first time, the phenomenon affects the whole planet and comes with an ecumenical connectivity in real time. All this is already having an impact on different aspects of our life, from an increasing cultural standardisation, to a uniformity in the way of doing business, and most importantly –as regards this analysis– it is changing the nature of international competition. We live in an increasingly interlinked world where **challeng-**

es are global and solutions must therefore be holistic. A flatter, more interconnected and smaller world where thanks to technology, time and space have been compressed.

However, interrelationships in real time inevitably entail an acceleration of international processes. The world will change faster and that will require a greater capacity to adapt.

As a background of these drivers of change, global warming and an exponential growth of population are already a reality, regardless of their possible causes.

To a great extent, the driver behind the technological revolution and globalisation is the **digital revolution** that, in turn, is driven by the exponential development of technologies related to microprocessors. According to Moore's Law, so far, the capacity of processing and memory storage is doubled every 18 months compared to the previous generation. This exponential growth in the capacity for processing, storage and distribution of digital information, along with the development of specific software tools for different fields and distribution networks of digital data, is transforming the scientific and industrial world and eventually society as a whole.

Particularly in the manufacturing industry, innovations such as the next generation Internet and the processes carried out in "the cloud" will enable even a larger geographical distribution of value chains of manufacturing processes and that will affect global production models.

Scientific development is preparing for new technological advances in biology and matter at a molecular and atomic level. This will bring unprecedented advances in food, medicine, new materials and new energy sources.

However, the geo-strategic scenario where the competition will take place will also be different. We are evolving towards a multipolar international system with a change never seen before in the distribution of wealth and economic power from west to east. The core of economic activity is moving to China and India.

But we are not only seeing a change in the centre of economic activity, along with this phenomenon, distances in science and technology between emerging powers and the USA and EU –who have held for centuries an undisputed supremacy– are becoming shorter. In a short period of time, China has climbed the slope towards production niches with high added value and is already posing a threat in international markets to industries that were traditionally an exclusive domain of the EU and the US.

This transformation is taking place at a time when Europe is facing a severe economic crisis that has imposed cutbacks in education, R&D and innovation, which is only making the situation worse.

THE STABILITY, SAFETY AND LIVING STANDARDS OF EUROPEANS WILL DEPEND ON THE ABILITY OF THE EU TO ADAPT TO THE NEW SCENARIO OF THE THIRD INDUSTRIAL REVOLUTION

2.3 THE CHALLENGE OF EUROPE– ADAPTING TO CHANGE

What is the EU doing to adapt its production base to these changes?

Europe has many advantages to face the current crisis, position itself and carry out a transformation of its production base in order to adapt to the new economy of the Third

Industrial Revolution: an excellent scientific and technological base; good infrastructure; a legal framework that safeguards intellectual property; exceptional education centres; and accountable institutions operating pursuant to the strictest codes of ethical conduct.

Nevertheless, it also has significant weaknesses as regards energy sources and raw materials; structural problems such as an increasingly ageing labour force; a lack of motivation to undertake the risks related to entrepreneurial activities; excessively bureaucratised public management structures; an over-regulated market and overhead costs arising from our welfare state; an increasing lack of interest for science and technology; a loss of innovation capacity.

As a consequence of the crisis, the EU has developed a wide range of directives and communications to confront the new world that is emerging as a result of the profound changes our planet is going through.

In a more or less official manner, the European Commission has endorsed the concept of the Third Industrial Revolution and all the ample regulations –in the fields of energy, technology, digital strategy and industry– are coherent with this scheme.

With the adoption by all Member States of the document drawn up by the European Commission, *Europe 2020*, and its related "flagship" communications, the EU has already set the roadmap towards a new economic-industrial model in an increasingly globalised and rapidly changing future. This has the clear goal of leading the way towards a new industrial revolution.

As for the energy pillar, the "20-20-20" objective established in *Europe 2020* about the energy future of the EU proposes a reduction in greenhouse gas emissions by 20%, an increase in the contribution of renewable energies up to 20% of the total and an increase of 20% in energy efficiency. This will entail a change going far beyond the energy strategy that will result in a major transformation of the European society of the future and will require putting in place "intelligent" networks of energy distribution, urban transport, efficient buildings capable of generating energy and a new infrastructure for industrial production. Without these changes, it will not be possible to attain such objectives.

THE EUROPEAN COMMISSION ESTABLISHED A NEW OBJECTIVE TO INCREASE THE SHARE OF INDUSTRY ON THE GDP FROM THE CURRENT 16% TO 20% BY 2020

With the recent publication of communication COM (2012) 582 final, "**A Stronger European Industry for Growth and Economic Recovery"**, the European Commission just confirmed its support to the vital role of industry in this double mission: first to restore the damaged industrial fabric and second to make it competitive for the new economy.

NOWADAYS THERE IS A BROAD CONSENSUS ABOUT THE FACT THAT IT IS NOT POSSIBLE TO CREATE QUALITY EMPLOYMENT WITHOUT A COMPETITIVE INDUSTRIAL, TECHNOLOGICALLY ADVANCED AND ECONOMICALLY VIABLE BASE.

QUO VADIS MANUFACTURING?

3. QUO VADIS MANUFACTURING?– TRENDS

3.1 HIGHLY VALUE AND ADVANCED MANUFACTURING

This manifesto is based on the hypothesis that the future European industrial base, although it needs to cover the whole broad range of production, should be focused mainly on keeping the leadership in those advanced production processes and on the manufacturing of **high-complexity and high-value manufacturing products** (HCHVM)[8], since this type of production is the actual driver of technology and innovation. It will also serve as a catalyst to create a complex industrial and technological fabric due to its nature, which generates a great number of interrelationships.

Advanced production –which is not only a synonym for high value-added final products, but also for the use of more innovative and high-technology integration and production processes– must be considered as a holistic system including the design, prototyping, production processes based on new manufacturing technologies, integration of software and hardware, qualification, certification, system engineering necessary for a technical management of processes, a labour force with the necessary knowledge and the best possible management of resources. **To break the restraint of limiting ourselves to the traditional concept of manufacturing requires a profound cultural change.**

3.2 TOWARDS A NEW INDUSTRIAL BASE

The European industrial base has suffered the effects of the financial crisis; three million jobs shed and 10% of the activity lost compared to pre-2008 levels. In order to recover from this situation, the European Commission has launched various initiatives [9] based on a commitment to create an industrial sector that will be the driver for growth and economic recovery, for innovation and technological development.

One of the four pillars defined in communication COM (2012) 582 as essential elements to restore the strength of this sector establishes that we must not only keep fostering research and development but also searching for the most efficient mechanisms to bring the results achieved with research efforts into the market.

The EU as a whole has an excellent scientific and technological base, but lacks the ability to market the results. Among the enormous amount of literature published on the matter, we find an unanimous agreement that the future industrial base of the Third Industrial Revolution needs to be much more closely connected to knowledge-generating sources. This is what has come to be referred to as **knowledge-based economy**.

If anything can be anticipated, it is the fact that the industrial fabric resulting from this crisis and that we will need to compete in the 21st Century will be very different from the current one.

3.2.1 How is the productive fabric of the Third Industrial Revolution going to

[8] High complexity, high value manufacturing
[9] COM(2012)582 final

be?

Since the beginning of civilization, every productive system –from the sole point of view of engineering– may be considered as a system of interrelationships between technology, skills of the human element, knowledge, available energy sources and raw materials.

The Industrial Revolution caused the gradual replacement of **craftsmen**, who were skilful with their tools as a result of a long apprenticeship, for more or less automatic machines, handled and controlled by **operators**. The main consequence of this was that the final product no longer depended exclusively on the mastership and skills of a craftsman, but on the training and ability of an operator to interact with a machine.

The production system resulting from the replacement of craftsmen for operators enabled large-scale production of standardised products. The manufacturing industry that was born then was based on semi-automatic and interrelated processes that still required an intensive workforce, concentrated in factories under the strict discipline of production times and ultimately of the clock. The organisation of work in factories meant a radical break with the production system organised in small family units. The change was so radical that it ended up causing profound social and political transformations all around Europe.

The next main innovation related to the organisation of production was introduced by Ford, with the creation of the production and assembly line that –to a great extent– has survived until the present day. However, nowadays, automation and robotization levels are much higher and therefore, so its productivity and job creation. At the same time higher levels of productivity and increased competitiveness will spur employment not only in the supply sector but also across the whole economy due to rising incomes.

The automotive industry is without a doubt the paradigm of survival and evolution of the production line. Without the need for revolutionary changes, just through the continuous incorporation of new technologies and innovations, the productivity of automobile assembly lines has steadily increased. A production that in 1965 required 5000 operators can now be done with 1500.

The factory and the production line were the two radical transformations of the industrial fabric that occurred during the first two industrial revolutions, but **what will be the transformation of the Third Industrial Revolution?**

Before trying to answer this question, it is worth revising the concept of manufacturing itself. The arrival of biotechnologies, synthetic biology and its interaction with other critical technologies –such as nanotechnology, photonics, etc.– along with the increasing incorporation of software as part of the final product will most likely result in totally innovative products, some bio-mechanical hybrids, that could hardly be included under the traditional definition of what we consider manufactured "products" nowadays. **Technology is enlarging the traditional definition of manufacturing.**

In a time like this, full of exponential technological developments, trying to use a crystal ball to predict how the productive industrial fabric will be 10 years from now and beyond is a scarcely rigorous task and certainly a very risky one. The best that can be done is to forecast trends considering the foreseeable evolution of development according to certain general lines and, a bit more specifically, to core and enabling technologies.

Innovations in the fields of robotics, synthetic intelligence, 3D printing, new materials and nanotechnology will revolutionise the production centres as we know them today and therefore they will profoundly alter the current social organisation of work.

3.3 GENERAL TRENDS

As stated before, it is risky to forecast how a factory will be in 20 or 25 years from now, and even more the topology of the future industrial fabric. And we would need to be able to read the future in order to imagine the range of products –some of which would be even hard to imagine– that will be found in the market then. But what we can do is to extrapolate some of the evolutionary trends we observe today.

In general terms, the first inference that can be made is that, similarly to what is happening in other industries, the future productive fabric will be determined by the unstoppable evolution of **digitalisation**, by the implementation of all the aspects of **knowledge to products and processes and by the need to compete in an environment of continuous innovation**. This innovative scenario will be partly generated by market demand and partly by the dynamics resulting from the extensive implementation of knowledge to industrial fabric.

We live every day more immersed in a digital civilisation and industry will not be an exception. The driving force behind the transformation in the manufacturing industry will be **digital revolution**, the amazing evolution of which will enable **connectivity, automation, robotization and virtual simulation** levels with the potential to change the whole productive fabric.

Digital revolution is changing the planet and particularly the production industry, on a "flat" space that is smaller and completely interconnected.

3.3.1 Connectivity: the Integrated Space of Creating Value

Digital connectivity in real time, with global coverage and virtually unlimited bandwidth, will enable the interconnection of all the elements in the value creation chain regardless of their geographical location. The evolution of the next Internet generation and the increasing importance of processes based on databases and virtual applications (cloud computing) will constitute a real incentive for the productive fabric and business models as we currently know them.

Connectivity at a new machine-machine scale, regardless of geographical location, and global access to the "cloud" will result in a productive environment with a potential that is hard to imagine or forecast. These progresses will enable a seamless interconnection, nearly in real time, between design and development centres spread out all around with testing and production centres also distributed all around the globe. This is not entirely a new situation, but what will certainly be new is the scale at which it will happen.

But connectivity is not only about interconnecting production centres and design offices, it is also about machine-machine and machine-person interchanges of huge volumes of data in real time and in multiple formats in a highly reliable manner. We can already find many computing tools in the market that allow us to take advantage of connectivity with the aim of enhancing productivity. The potential and capacity of technological innovations will keep growing exponentially in years to come, thus contributing to the distribution and relocation of the production of subsystems and components at al global scale, to shortening distances and times and therefore to creating **a new distribution of global industrial fabric.**

Another consequence of connectivity will be the reduction of the gestation period of products as well as the concept-client cycle therefore achieving greater flexibility to adapt to a fast-evolving market.

Considering that the introduction of a series of innovations in automatic looms in England during the 18th Century, along with a change of the energy model, brought in the long run the transformation of the whole European industrial fabric with huge political and social impact; we could similarly imagine that the next industrial revolution will generate a different productive fabric, a strongly digitalised industrial base that will be part of a superior continuum: **an integrated digital space for value creation**, that in turn will generate a more efficient base for the management of resources based on a different paradigm of the energy model, most likely more spread out, respectful with the environment and able to **create highly-qualified and better paid jobs** for the whole working demographic pyramid.

The concept of an **integrated space of production and value creation** goes beyond what we currently understand for manufacturing activity isolated form the rest of activities of the value creation chain. The new paradigm requires –and digital technology enables– integration into a sole continuum of innovation, design, production, directly related services and customer management.

This new concept entails considering the manufacturing industry as an indivisible element of the value creation system. This will mean that interconnection between phases will be possible without a direct intervention of operators and all agents involved will be able to use the same database under real-time setting control and that will be translated as efficiency in time-saving and avoiding human errors when it comes to transferring information from one step to another of the processes. On the other hand, this concept breaking with the traditional way of establishing responsibilities will invigorate global supply chains, removing risks and increasing efficiency.

THE TECHNOLOGIES THAT ARE CONTRIBUTING TO THE EXTENSIVE INTRODUCTION OF DIGITAL REVOLUTION INTO THE PRODUCTIVE FABRIC WILL FOSTER THE CREATION OF AN INTEGRATED SPACE OF VALUE CREATION

3.3.2 Automation and Robotization

But let's go back to the **automation and robotization** sphere of future production centres.

The use of "robots" for welding in assembly chains, more specifically in chassis assembly, goes back to the beginning of 1930s. Robots with articulated arms appeared in 1960s and since they were introduced in the market as assembly chain elements, until the present day, industrial robots, mainly static and pre-programmed, have been performing iterative tasks –although increasingly complex as regards freedom of movements and task sequences– in production chains, thus enhancing productivity drastically. However, if we leave the automotive industry out, the use of robots in manufacturing is limited[10]. In fact, the kingdom of manufacturing robots is still the mass production industry and particularly automotive industry.

Nevertheless, the advances in artificial intelligence and robotics open a new field for action that enable the use of new generations of mobile robots[11] capable of learning (these advances are already a reality in the field of defence) with the ability to interact with operators and share with them the same tools, hardware, software and workplace. It is no longer a thing of performing only standardised tasks which are perfectly defined and programmed, but of contributing directly to the tasks of the chain being totally integrated with the human element in the processes.

But the most important and revolutionary feature of these robots is that they will be able to share "knowledge" in real time with humans, other robots, computers, databases, etc. and this capacity will entail other possibilities hardly foreseeable today.

Another trend we should really consider in tasks requiring a continued physical effort –especially taking into account the general ageing of the European population– is the sector of exoskeletons. Hybridisation and inter cooperation between operators and robots is going to keep evolving and changing the industrial fabric.

Widespread incorporation of next-generation robots and exoskeletons into the manufacturing industrial fabric will require significant investments in R&D and infrastructure. In the short term, this raises the problem of financing, particularly if we take into account that new-generation robots will fit better in SMEs, which are the ones that experience more difficulties with obtaining funding.

What will be the effects of robotization on employment levels? Without a competitive industrial fabric it is not possible to create employment. The future industrial base should be able to generate highly-qualified jobs in the EU, in a scenario with an ageing demographic pyramid. *Europe 2020* has established the goal of employment as 70% of the population between 20 and 64 years old, although most likely, due to social and economic reasons, the Member States of the EU will have to raise the higher limit of the productive ageing pyramid and consequently the distribution of work throughout the active life of an individual will be changed.

But the paradox is that the new **highly automated and robotised** industrial fabric will need ever less direct labour in the factory, but the labour needs in higher levels of the value chain will increase, so the total count should be able to attain full employment, which logically requires a profound professional evolution of the workforce.

Such transformation of the social base of the productive fabric will not be automatic or free of traumas. The new economy of the Third Industrial Revolution will require a better educated and trained labour force to adapt to a very technical production environment that will demand new professional skills.

---

[10] In Japan, the most robotised country, the number of robots for every 10,000 employees is lower than 300
[11] The base is not attached to the ground

THE NEW INDUSTRIAL BASE WILL REQUIRE NEW PROFESSIONAL PROFILES AND EDUCATIONAL SYSTEMS NEED TO GO ONE STEP AHEAD OF THIS SOCIAL REALITY

The **integrated production space** –or value creation space as we may consider it– will not only be increasingly integrated, but also increasingly **global and spread out**. The end of the Cold War, the liberalisation of international market, the advances in digital technology and the arrival of emerging countries to the international arena have contributed to the current environment where production –especially that with a lower added value– is outsourced to different parts of the world, although closely related to each other.

The inevitable fragmentation and relocation of value chains and the world-level distribution of their elements will lead to increasingly global and more widely spread **integrated production spaces**. In principle, the relocation of chain elements is not intrinsically bad and in general it will encourage the competitiveness of companies. On the other hand, we cannot avoid the economy becoming increasingly free and interconnected. However, from a strategic industrial standpoint, public administrators and political leaders should take into account the following aspects:

- Outsourcing –particularly in the industrial base of defence– may cause vital dependencies of foreign countries.
- There is a proved correlation between production capacity and innovation capacity; when production is outsourced, in the long term innovation will be lost.
- As regards complex products, vertical integration capacity must be maintained, since the added value will mostly lie in integration processes.
- In the middle run, outsourcing alters the nature of international competition. When a part of the value chain is assigned to a developing country. That country will end up acquiring the technology and will become a competitor.

3.3.3 Adaptability

On the other hand, in a time of accelerated and often unforeseen changes of market conditions, the industrial fabric needs to be **adaptable** to abrupt changes in the demand. A flexible industrial base that is able to adapt to abrupt changes, for example as regards prices of energy and raw materials, tastes, needs and market regulations, requires a reconfigurable infrastructure, probably a much more spread fabric and certainly new management models.

3.3.4 Sustainability

A sustainable industrial base needs a correct management of material and energy resources in a foreseeable scenario of a change of energy paradigm in Europe. Decisions taken in the EU about energy policies –and more specifically about electric power– will be one of the decisive factors when it comes to transforming the production base. Industrial competitiveness depends directly on a safe, sustainable, affordable energy supply.

The European Council and the European Commission have set a strategic objective called 20-20-20[12] related to the energy policy by 2020, and the goal of reducing the carbon footprint by 80/95% by 2050[13]. However, there is no clear strategy that includes the whole union nor an unanimous interpretation of these objectives. The interpretation of the aforementioned goals and the priority they must have in time may result in completely different global solutions with absolutely different consequences as far as the composition of the industrial fabric is concerned.

The objective of reducing gas emissions by 20% is a measure we need to understand as part of an environmental policy framework. On the contrary, the 20% improvement in consumption efficiency and the increase by 20% in the contribution of renewable energies should be considered within an industrial policy. These three objectives are related to each other, but there is no direct correlation between them.

If the environmental policy prevails and the most essential objective before any other consideration is the decrease of CO2 emissions, then private initiatives and public resources could be oriented towards technological solutions that will not necessarily meet the technological effort required by a change of energy paradigm and a sustainable transition towards renewable energies with an intelligent distribution network.

On the other hand, the transition towards renewable energy shares determined by the Commission needs, in certain regions of the Union, a great deal of public-private financing in a situation of deep economic crisis of the Eurozone. This effort requires also important technological advances in the fields of production, storage and distribution that do not seem feasible under current circumstances within the established deadline. Furthermore, the change of the energy model brings the need of a holistic strategy that includes various initiatives that come together as a sole effort: smart grids, smart cities, green cars and future factories.

Likewise, we cannot ignore the cost-effectiveness ratio of the political decision to change to an alternative and sustainable energy supply since it is directly related to the competitiveness of the productive sector. As it has already been mentioned, competing in the Third Industrial Revolution consists mainly of having an energy supply at competitive, foreseeable, safe prices that are not dependent on foreign countries and at the same time defining a global energy strategy for the whole EU.

THE ENERGY POLICY HAS A DECISIVE EFFECT ON THE EUROPEAN MANUFACTURING INDUSTRIAL BASE. THE EU NEEDS A GLOBAL STRATEGY FOR A CHANGE OF ENERGY PARADIGM WITH COHERENT, ATTAINABLE AND PRIORITISED OBJECTIVES.

3.4 INNOVATION & TECHNOLOGY

[12] Europe 2020
[13] COM(2010)639 y COM(2011) 885/2

Industry as a driver of innovation

As explained before, there are enough data and evidences that support the close relation between innovation and the manufacturing industry and this is not the time to insist on these arguments again. Manufacturing activities generate and need innovations. Today, in an increasingly competitive market, in order to open new markets and keep the already consolidated ones it is essential to be able to periodically launch innovative products to the market that help us maintain our position and displace our competitors. The market is constantly demanding innovation.

But on the other hand, even without modifying products, production processes need to adapt constantly to the changing conditions of the market, new supplier networks, new customers' requirements, new business models, changes in production infrastructure, new cost structures, etc.

There are various fields of innovation in the manufacturing industry:

- Innovation in products
- Innovation in the supply chain
- Innovation in processes
- New management methods
- New business models
- And, through the implementation to virtually all the above, technological innovations.

In a knowledge-based economy, with an advanced industrial base oriented towards a high value-added production, a **scientific-technological ecosystem** that generates innovations in which to base **the integrated value creation space** is vital. And for that it is necessary to have mechanisms that encourage a permanent flow of ideas and technical innovations for the consumer market. But what matters is not only to ensure the knowledge arrives to the markets, another feature of competitiveness in the future will be to be able to adapt promptly to market changes and this requires to be capable of mobilising resources of technology and design innovation, development and production with the aim of arriving in the first place to the market.

The integration of the knowledge and innovation-generating fabric with the manufacturing industrial base is going to be the key to increase productivity and provide a competitive advantage in an ever-changing global market that demands innovations constantly. This is a different scheme, we shouldn't go back to former schemes according to which, if a need was identified that could not be answered with internal resources the alternative was to contact a University to find a solution. The speed required nowadays can only be achieved with a close integration of the resources available with the value chain in its entirety.

In Europe, a great number of the Universities and research programmes are financed with public funds and therefore this huge breeding ground for knowledge must be at the service of the society that supports it through taxes. Without abandoning academic goals, the academic world should be reoriented to become the pool of knowledge needed as a basis for innovations of the productive fabric that will meet the market demand. The manufacturing industry is in charge of materialising and marketing that knowledge. In the end, the real motivation of innovation is to generate benefits. But what should be the mechanism to transfer the knowledge from the centres that generate it to the industrial base?

In other words, **national innovation systems** must be enough agile to passively meet the markets while at the same time being proactive and going ahead of changes.

To focus on an advanced production doesn't mean to stop manufacturing less advanced and complex products, but the manufacturing of complex products will create in turn a substratum for increasingly complex value chains. That is, if we decline to compete at the top range of manufacturing, we are giving up on a complex industrial fabric and losing high technology fields and eventually, our capacity for innovation too.

Emerging economies that will be our future competitors, without renouncing their competitive advantage of low skilled labour costs, are escalating fast towards more complex levels in many fields where, paradoxically enough, the innovation efforts were undertaken in the EU or in the US –laptops, solar panels, lithium batteries, monitors, etc.– and which are essential for sectors such as defence, aerospace or energy.

When we transferred manufacturing capacity to cheap labour areas based solely in economic reasons, we progressively created a technology and innovation base there. The current situation is not only that the core of world economic activities has moved to the Asian Pacific coast, but that the same is happening with the core of scientific and technological activities. Countries such as China and India are already present in high technology industries such as defence, aerospace and energy. We are in a position to state that in less than one decade they will be ready to compete in fields so far reserved exclusively to the US and the EU.

For years it has been argued that R&D activities could be detached from production, reserving research, innovation, design and development to developed societies and assigning the manufacturing to third parties based exclusively in economic reasons. But the truth is that this strategy leads in the first place to a loss of the production capacity –and the relevant jobs– and in the middle run, also to the transfer of design, development and integration capacity. Besides, the effects on the balance of payments are very negative. How much design do we need to export to compensate the massive purchase of products manufactured by others?

3.5 TRENDS IN TECHNOLOGY

An advanced industrial productive base aimed at manufacturing complex and high value-added products (HCHVM) must necessarily rely on the advances of a series of key enabling technologies that will transform the market: nanotechnology, photonics, micro and nanoelectronics, biotechnology, advanced materials and new production technologies.[14]

Independently of the above, there are a series of "soft" technologies –such as System Engineering, virtual simulation, hybrid simulation with hardware in the loop, synthetic in-

---

[14] COM(2012) 341 final: “A European strategy for Key Enabling Technologies – A bridge to growth and jobs”

telligence, etc. that are also key to maintaining the competitive advantage in many production sectors. Indeed, what has probably a greater impact on the industrial fabric is the combined effect of artificial intelligence, robotics, nanotechnology, new materials and 3D printing.

Based on the great amount of literature available, a group of technologies has been selected among all of them, which are considered to be key to maintain a competitive advantage in a wide range of industrial activities.

3.5.1 Nanotechnology. Trends in Microprocessor Technology

The evolution of current microprocessor technology and the substitute technologies that may arise to keep the exponential growth of processing capacity available[15] in terms of price, weight and energy consumption are the true reason behind the expansion of the digital revolution.

Few technologies are so important for the general development of technology and for keeping the momentum of the advance of the digital revolution and its driving effect on industry as the manufacturing of microprocessors.

Integrated circuits today are still based on silicon technology. This technology has been so far able to duplicate the number of transistors per chip every 2 years (Moore's Law).

The combination of exponential growth of processing capacity, connectivity and next generation Internet is what will enable to establish the actual **integrated spaces for value creation**.

It is safe to predict that no physical system is able to provide an enhancement of features at an exponential rate for an indefinite term, thus even though for now we can follow a "more Moore" strategy, it is urgent that we start preparing a "beyond Moore" strategy.

3.5.2 Trends in Advanced Materials

Maintaining competitiveness in the new economy will basically depend on the capacity to develop and market new materials, shortening the technological readiness cycles needed to incorporate them into new products.

The cold war and the space race were stages that contributed greatly to the development of a new generation of materials that have been progressively introduced in the market. The exponential evolution of many key enabling technologies (or key enabling technologies) will bring a new generation of materials that will foster industries such as automobiles, aeronautical, medical, energy, etc.

We cannot even begin to anticipate a map of where and when will they arise, but we can indeed infer that maintaining the competitive advantage in various technological and productive sectors of the global market will require a European-level initiative for a coordinated evolution of the new generation. For instance, just to mention one area of interest, the replacement of critical minerals and rare earths is a strategic issue for the industrial future of the EU and particularly of its manufacturing industry. Without a whole series of new materials it will be very hard to attain the objectives of Europe 2020.

---

[15] Moore's Law

The technological readiness cycle of new materials is extremely long. Particularly interesting is the case of lithium batteries –without which the last progresses of commercial electronics would not have been possible. Their scientific basis was created in the 1970s but they were not extensively marketed until 1990s.

To meet the requirements of new markets will entail significantly shortening the time needed to develop new materials and to perfect their manufacturing processes.

The EU must urgently adopt a "**Materials Genome Initiative**"[16] similar to the one that is being implemented in the US, capable of reducing the cycle to around five years. In order to do that, a new innovation structure must be put in place through the integration of tools for experimenting, simulating and design and centres capable of developing manufacturing processes.

3.5.3 Trends in Synthetic Biology

The field of synthetic biology applied to manufacturing is at an early stage that could be compared to the beginnings of the application of the transistor. However, the advances in this sense are expected to have unpredictable effects on the manufacturing fabric.

Initiatives such as "**Living Foundries**"[17], launched by the DARPA, constitute an important boost to create a system engineering methodology applied to the world of biology that will enable to establish predictable manufacturing processes for biological products on an industrial scale.

Some EU Member States have already adopted strategies in this area[18], but a community-level strategy is needed to enable the EU hold the leadership in this field.

3.5.4 System Engineering

Advances in new system engineering techniques are also closely related to the development of new materials and their use in the market. Such advances hardly fall under what has traditionally been considered the technical management of a project.

The extraordinary evolution of computing tools has brought the arrival of a new methodology of "**Integrated Computational Material Engineering**" (ICME). This methodology integrates in one only process the technical characterization of materials and the analysis of their features for specific uses, as well as manufacturing processes, thus connecting in a continuum the characteristics of a material, the product design and its manufacturing.

Some EU Members are making significant efforts in this area, but the Commission should nevertheless establish a joint strategy aimed at maintaining the leadership in **ICME**.

3.5.5 Production Technologies through 3D Printing

---

[16] Materials Genome Initiative for Global Competitiveness. June 2011. National Science and Technology Council

[17] DARPA, Microsystems Technology Office. Quote, The Living Foundries Program seeks to create the engineering framework for biology, speeding the biological design-built-test cycle and expanding the complexity of systems that can be engineered. The Program aims to develop new tools, technologies and methodologies to decouple biological design from fabrication, yield design rules and tools, and manage biological complexity through abstraction and standardization. unquote

[18] A Synthetic biology road map for the UK

What has come to be generically known as 3D printing or additive manufacturing, although still at an early maturing stage, is presented as a technology –or more specifically a series of technologies[19]– that could revolutionise the productive ecosystem.

3D printing constitutes a paradigm of production distributed without intermediaries, which in theory is able to make the whole productive process available to nearly any user, from the design and development of a virtual world to the physical materialisation of an object.

As these technologies mature, the foreseeable trend of the market will be similar to that followed by other technologies in the past: one evolution branch for general consumption that will reduce prices as the market evolves, and another industrial branch that will evolve towards the capacity to reproduce more complex and bigger pieces with precision tolerances.

The EU must attain and keep leadership in the maximum possible number of 3D printing technologies.

3.6 A FAVOURABLE ENVIRONMENT

One of the aspects to be considered by public administrators and political leaders is that, the industrial base of the Third Industrial Revolution will have to rely necessarily on a SME fabric with an appropriate size to individually make the effort of translating R&D results into competitive industrial solutions in order to face new infrastructure requirements. It is the responsibility of public administrations to foster and create a network of centres similar to **Manufacturing Technology Centres**, to which small and medium enterprises, assuming a reasonable risk, can go to develop and prove industrial solutions and processes applicable to the industrial world.

The EU needs a workforce prepared to compete in the new industrial revolution; managers trained in administration of complex processes, in a scenario of spread out value chains that will demand new integration skills, and public administrators who understand the complexity of such scenario and who are able to create a favourable environment for a viable and competitive industrial fabric.

As far as the workforce is concerned, everything points at a potential solution based on one hand on the **recovery of the prestige of scientific and technical studies** at all educational levels and, on the other hand, on the return of training to **specific professional centres** specialized by industrial sectors, production units or even processes. The advances in digital technologies will allow for training in virtual environments representing real environments with an extraordinary accuracy.

Another matter to be considered is that the workforce of the future will have to **interact and cooperate with AI robots** designed to operate in non-predefined environments, in more and more processes.

Process management and complex product integration will require a formal training of all managers in **System Engineering.**

If we want an industrial base capable of competing in the new Industrial Revolu-

[19] Stereolithography; Fuel Deposit Modeling (FDM);Powder Bed laser Sintering, Inkjet Deposition; Ultrasonic Consolidation

tion, the educational system will have to be oriented to such purpose.

BEAT TO QUARTERS!
A CALL FOR ACTION

4. CONCLUSIONS & RECOMMENDATIONS. BEAT TO QUARTERS

We are heading towards a highly multipolar world where the economic and technological gravity centres are being pushed to the Asian coast of the Pacific Ocean. New trade, industrial and technological powers are coming onto the scene and the number of competitors is becoming increasingly higher. In brief, we are living in a flatter, smaller and much more interconnected world featuring a different distribution of the manufacturing industry. Technology in general and particularly digitalisation will drive international trade to higher levels of globalisation and independence. The EU has acknowledged this situation and places new emphasis on re-industrializing Europe.[20]

Supply chains will unavoidably become more and more global and interconnected along with the productive ecosystem. Therefore, competing in an interconnected world requires global and holistic solutions. The simultaneous development of global connectivity and automation, including the unprecedented development of synthetic intelligence, advances in robotics, discovery of new materials and 3D printing technologies will turn the industrial fabric upside down. The competition for the control of markets will be fought in these integrated spaces of value creation. It would be risky and, to a certain extent, useless to try to predict which new products and processes will arise in the middle and long run.

The European Commission acknowledges that the deep technological and economic changes, the new energy paradigm and the effects of the financial crisis are driving a phenomenon that the Commission itself has called the Third Industrial Revolution.[21] The stability, safety and life standards of the EU will depend on our capacity to adapt ourselves to this new era. Nowadays, it is widely agreed that we cannot escape from the crisis in this new scenario. It is just impossible to keep a competitive position and create jobs without a competitive industrial base, technologically advanced, sustainable and feasible.

Therefore, it is absolutely vital for the EU to transform the manufacturing sector into the core element for sustainable development, becoming a source of quality and stable employment and a driver for innovation. The technological revolution we are going through advises to review the very definition of the term "manufacture", expanding the limits of its traditional meaning to another that also embraces biotechnology and the combination of mechanical, electronic, software and biological sectors.

These recommendations sum up the content of the paper.

<u>Recommendations to the EU</u>

- Exponential advances in digital technologies will enable us to adopt a holistic approach towards the concept of manufacture which comprises the multiple parts of the value chain both horizontally and vertically. We therefore recommend widen-

[20] European Commission 2012: COM(2012) 582 final
[21] http://ec.europa.eu/enterprise/initiatives/mission-growth/index_en.htm

ing the concept of manufacturing and considering **integrated production spaces as part of the integrated space of value creation.**

- Competing in the Third Industrial Revolution will require the EU to primarily turn production towards complex products with high added value. The EU and European States are equally advised to support **High Complexity, High Value Manufacturing (HCHVM)** that will allow European manufacturing businesses to compete on a global level.
- The EU is called to update and enhance the cybernetic infrastructure to support wide digitalisation, connectivity, robotization and automation of the industrial base so as to favour the establishment of **global integrated spaces of value creation.** A modern cybernetic infrastructure will spur economic and social benefits and allows the new productive fabric to be anchored to an Internet network –**Next Generation Access Network–** featuring great band width and providing comprehensive coverage to the whole EU. In the Third Industrial Revolution, the cybernetic infrastructure will play the same catalysing role as the railway, did during the first revolution.
- To promote innovation and incorporation of new technologies to the whole value chain, especially to the productive part, Key Enabling Technologies (**KETS**) will become vital to the new knowledge-based intensive industrial fabric.[22] The European Commission has already identified key enabling technologies in communication COM(2009) 512/3 along with the measures required to foster them. We recommend that the European Commission extends the research activities regarding KETS and complement the supporting measures with a clear focus on industrial manufacturing.
- It is recommended to prepone the creation of the "Added-value manufacturing"-Knowledge and Innovation Community (KIC). In the light of the challenges laying ahead and the importance of manufacturing industries in Europe`s growth strategy the EU cannot miss out on the opportunities in terms of education and training, business creation and innovation provided by the KICs.
- To promote and retain the technology of microprocessor manufacturing and devise a strategy to face a potential **"beyond Moore"** scenario[23].
- In the light of the growing complexity of production systems and the importance of Biotechnology it is recommended to launch a **"Bio Foundries"** initiative (similar to DARPA`s "living foundries"[24]) allowing to design a system engineering framework for the manufacturing of biological products at industrial level. The goal is to spur innovation by combining biology and engineering that enables on-demand production of new and high-value materials.
- The promotion of the development of new materials remains of key importance for future industrial applications and growth opportunities. Competitors outside the

[22] COM(2009)512/3 "Preparing for our future: Developing a common strategy for key enabling technologies in the EU"
[23] Moore's law has boosted the digital revolution based in exponential computing power. The computing technology has been engineered on silicon technology. The physical limitations announces the end of this evolution path, the 21st Century will deliver a new generation of new technologies for microprocessors.
[24] http://www.darpa.mil/Our_Work/MTO/Programs/Living_Foundries.aspx

EU are actively pursuing the models of speeding up new materials research.[25] Therefore, the EU should follow the US example and establish a “**Material Genome Initiative”** on the European level in order to accelerate advanced materials discovery and deployment.

- The EU should support the development and implementation of new technologies of system engineering in order to maintain leadership in processes such as “**Integrated Computational Material Engineering**” which enable to combine design, characteristics of new materials, production methods and virtual simulation of results.
- The EU is advised to develop the market of 3D printing technologies and other disruptive technologies. To keep our leading role in most of them it is imperative to establish and regulate a safe and predictable legal environment. In this system we must reach a balance between the legitimate protection of IPR of companies and institutions and the emergence of disruptive technologies that, as 3D printing, will test certain established intellectual property concepts.
- Energy policy has a crucial role to play in shaping the industrial base and its competitiveness in the international market. What needs to be put in place are "intelligent" networks of energy distribution, urban transport, efficient buildings capable of generating energy and a new infrastructure for industrial production. It is recommended that the EU puts forward a long-term global strategy that expands beyond 2020 to provide investor security and that integrates the multiple initiatives launched on the different aspects related to the transition towards a new sustainable energy paradigm.
- With regard to future funding mechanisms we recommend to ensure that **Horizon 2020** provides financing channels and fiscal measures encouraging the development of the new industrial fabric required to compete in the Third Industrial Revolution and the ways to pass knowledge onto the market.
- EU legislation must adapt so as to allow new business models required to compete in a global market.

Recommendations to the Member States

- Robotization of the integrated production space is a technological priority. Robots are bound to bridge the gap between digital technologies and actual manufacturing. Thus, it is urgent to boost a European industrial base in this sector. It is recommended that European states consider robotization according to their industrial specialization patterns in order to lay the idiosyncratic foundations for the third industrial revolution.
- It is vital for future growth to combine the knowledge generation base with the industrial base. In this regard it is recommended to implement initiatives similar to the **Manufacturing Technology Centres** across Europe, easing the incorporation of innovative solutions to the productive processes especially of SMEs.

---

[25] http://www.whitehouse.gov/sites/default/files/microsites/ostp/materials_genome_initiative-final.pdf

- Key for the new production paradigm will be skilled labour. The member states are encouraged to continue and increase their efforts in advancing education in science, technology, engineering, and mathematics (STEM). It is further recommended to introduce specific curricula and research activities at higher education institutions to meet the challenges of the Third Industrial Revolution.
- Education and training should be aligned according to the new production model. Competitiveness of the industrial base in the new economy will require educated and trained manpower with the professional skills needed. We therefore recommend a **Restructuring of the Education System** which, in the end, is the catalyst **and the strategy** to anticipate the needs of the Third Industrial Revolution.

FINAL CONSIDERATIONS

5. A FINAL CONSIDERATION

Although it is not the purpose of this manifesto to deal with specific aspects of the productive sector in particular, we cannot ignore the fact that the EU wishes to achieve its own trustworthy and technologically advanced independent defence, and to that purpose, an industrial technological base for defence is required.

The defence industry constitutes a driver both for technological innovations and for keeping an advanced R&D infrastructure from which the rest of the industrial community can benefit.

As this document is being drawn up, the European Commission is also devising a communication in this regard.

Another point should be added to this manifesto:

- The EU should set up an agency similar to the DARPA in the USA aimed at promoting innovation in dual-use technologies.

6. OUTLOOK: THE GERMAN INITIATIVE INDUSTRY 4.0

Compatible to the issues raised above regarding a full integration of IT and manufacturing the German initiative Industry 4.0 presents a vision of economic opportunities and pathways to a competitive manufacturing industry. Industry 4.0 is a "strategic initiative" of the German government that was adopted as part of the High-Tech Strategy 2020 Action Plan in November 2011.

The strategy refers to a fourth industrial revolution based on the Internet of Things and Services. In the future, businesses will establish global networks that incorporate their machinery, warehousing systems and production facilities in the shape of Cyber-Physical Systems (CPS). The decisive factor will be introduction of smart production systems that allow for an autonomous exchange of information, triggering actions and controlling each other independently.

Due to fundamental improvements to the industrial process in supply chain and life cycle management smart products that are uniquely identifiable, may be located at all times and know their current status and alternative routes to achieving their target state are imaginable. Industry 4.0 holds enormous economic potential. Smart factories allow to take individual customer requirements into account and to manufacture even one-off items profitably. The large degree of flexibility of embedded manufacturing systems allows for last-minute changes to production and swift reaction to disruptions. All of this leads to new business models and value creation that provide start-ups and SMEs opportunities to provide downstream services.

The Industry 4.0 Working Group believes that action is needed in the following eight key areas that are all compatible with the issues raised in the remainder of the paper and require an extensive political effort by the EU and the European states:

- Standardisation and reference architecture

- Managing complex systems
- A comprehensive broadband infrastructure for industry
- Safety and security
- Work organisation and design
- Training and continuing professional development,
- Regulatory framework and
- Resource efficiency

The vision of the Industry 4.0 initiative has not sprung from nowhere. It is commonly agreed that Germany and Europe cannot compete with manufacturing industries in other countries based on low production costs. Also, this present paper is in line with an emerging consensus that highlights the importance of manufacturing industries and calls for action regarding the deindustrialization. However, competitors in Asia and the US are tackling these challenges as well (elsewhere the discussion has been on-going under the heading “advanced manufacturing”). Therefore Europe is well advised to go even one step further and fully employ the concepts of High Complexity, High Value Manufacturing (HCHVM) and the visions and recommendations put forward by the Industry 4.0 initiative.

Information about the Euro-CASE Innovation Platform:

Launched in 2012, the Euro-CASE Innovation Platform brings together the expertise of representatives of its member Academies from science, engineering and business. The purpose of the Innovation Platform project is to help put in place the necessary conditions for Europe to increase its innovative power.
If Europe is to succeed we need to create the best possible conditions for individual innovators, entrepreneurs, education systems, research organisations and enterprises. We need to develop a culture that stimulates renewal, innovation and calculated risk-taking.
The Euro-CASE Innovation Platform works on policy papers for Euro-CASE in order to give science based policy advice to relevant EU-Institutions and national governments.
In line with Europe 2020 and the flagship Innovation Union and Horizon 2020, the Euro-CASE Innovation Platform contributes proactively to making Europe the most successful innovation region in the world.
Euro-CASE strives to support and advise the EU and national governments on relevant topics where Euro-CASE, as a pan-European organization with broad links to both academia and industry, are in a unique position to contribute.

Members of the innovation platform

Magnus Breidne, Vice President, IVA, Sweden
Timothy Brick, Executive Director, IAE, Ireland
Mark Eliot Caine, International Policy Advisor, RAEng, United Kingdom
Sir Mike Gregory, Fellow, RAEng, United Kingdom
Rudolf Hielscher, Head of Brussels Office, acatech, Germany
Rolf Hügli, General Secretary, SATW, Switzerland
Kai Husso, TAF, Finland
Janosec Jiri, Technology Tvansten Manager, TC ASCR, EACR, Czech Republic
Karl Klingsheim, CEO NTNU, NTVA, Norway
Karel Klusacek, Director, TC ASCR, EACR, Czech Republic
Vojteh Leskovšek, President, IAS, Slovenia
Shane McHugh, Head of International Activities, RAEng, United Kingdom
Bjorn Nilsson, President, IVA, Sweden
Richard Parker, Fellow, RAEng, United Kingdom
Ian Ritchie, Hon Treasurer, RAEng, United Kingdom
José Manuel Sanjurjo, Fellow, RAI, Spain
Germain Sanz, Fellow, NATF, France
Thomas Stehnken, Scientific Officer, acatech, Germany

Guest speakers

Prof. Elías Fereres, President of the Royal Academy of Engineering, Spain
María Luisa Poncela, General Secretary of Science, Technology and Innovation, Ministry of Economy and Competitiveness, Spanish Government
Juan Miguel Villar-Mir, member of the Royal Academy of Engineering and president of the Association of Engineering and Technology Enterprises (COTEC)

Alejandro Cros, Deputy General Director of Industrial Politics, Ministry of Industry, Energy and Tourism
Sarah Lambert, Deputy Director of the European Commission in Spain

This paper complies with the "Euro-CASE Guidelines on advising policy makers and society"

Contact address of Euro-CASE:
Euro-CASE
Grand Palais des Champs-Élysées | Porte C
Avenue Franklin D. Roosevelt
75008 Paris, France

T. +33 1 53 59 53 40
mail@euro-case.org
www.euro-case.org

Approved by the Euro-CASE Board in December 2013