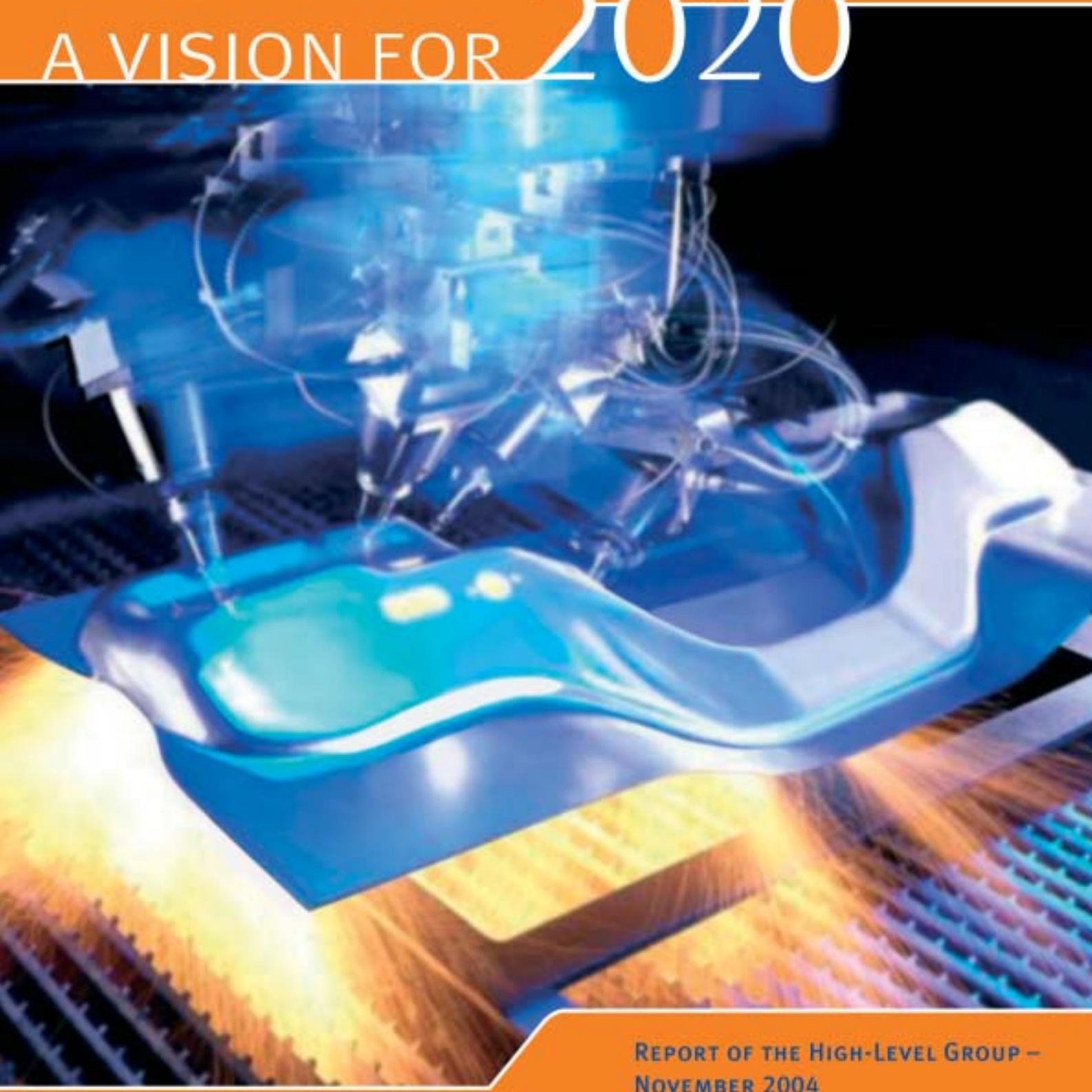
EUROPEAN COMMISSION

MANUFUTURE

A VISION FOR 2020



Report of the High-Level Group – November 2004

Assuring the future of manufacturing in Europe

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It can be accessed through the Europa server (http://europa.eu.int).

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Assuring the future of manufacturing in Europe

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PREFACE

“The only true realist is the visionary!” Federico Fellini

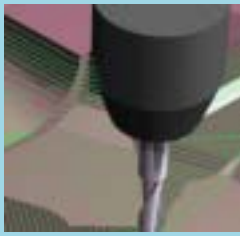
Standing still means moving backwards. This is particularly true for manufacturing and production. The production sector, as the mainstay of the European economy and employment, must continually confront new challenges in order to survive in competition. An active and foresighted technology development and a quick response to social and economic change are indispensable for this. Special R&D efforts are required for production to react quickly or, better still, to anticipate what is necessary. This document is to show some visionary aspects of the topic up to the year 2020.

I would like to thank all the members of the High Level Group and the Expert group for the time and attention they have devoted to this exercise. I also wish to thank the European Commission services of the Enterprise, Information Society and Research Directorates-General for their support to the MANU*FUTURE* work. Finally, I would like to express gratitude to those numerous contributors who have commented the draft versions of this document.

Heinrich Flegel
Chairman of the MANU*FUTURE* High Level Group
November 2004







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EXECUTIVE SUMMARY

European manufacturing has great potential as part of a sustainable EU economy, but its success will depend upon continuous innovation in products and processes. In addition to demanding increased commitment from the private sector, it is essential to combine European Commission efforts with those of Member States and accession countries to develop a common vision – starting at the industrial level but going much further in addressing technical, environmental and social issues.

The March 2000 Lisbon European Council set the objective of making the EU 'the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion'. This ambitious target cannot be met without the continuing presence of a strong and competitive manufacturing sector.

Creation of a European Research Area (ERA) for industrial technologies is seen as the way to involve all Member States in meeting the interlinked challenges of competitiveness, environmental sustainability and employment. In this context, the European Commission invited a High Level Group of European executives from research organisations and industry to offer their expertise and insights as a basis for structured debate leading to a shared vision of the way ahead for EU manufacturing. 'MANU*FUTURE* – a vision for 2020' provides a synthesis of those views.

MANU*FUTURE* is a powerful vision encompassing the complex network linking human and societal needs (demand) to both the industrial and education systems (supply). It is intended as a tool to guide the development of foresight into the strategic future of manufacturing – possibly leading to the formulation of a manufacturing platform as the basis for concerted action to achieve success in the world economy.

The key conclusions of MANU*FUTURE*

There is a need for the development and implementation of a European manufacturing strategy based on research and innovation which would promote industrial transformation, secure and create high added value employment and ensure the maximum possible share of world manufacturing output.

An economy based on service industries alone will not survive in the longer term. Growing numbers of jobs in manufacturing related services and in the service sector in general have been compensating for the loss in direct manufacturing employment. However, the EU industry is currently under significant competitive pressures from developed and low-wage economies alike. As each job in manufacturing is linked to two jobs in services, the reliance on services cannot continue in the long term without a competitive EU manufacturing sector.

Industrial transformation is a must. In order to meet the competitive, environmental and social challenges, a concerted effort will be needed to transform European manufacturing from a resource intensive to a knowledge intensive, innovative sector capable of achieving and maintaining technological and production leadership in the global market place.

New approach to manufacturing is required – innovating production. The traditional structure of manufacturing industries is constructed upon the three pillars of *land, labour* and *capital*. The challenge is to move towards a new structure, which can be described as 'innovating production', founded on *knowledge* and *capital*. The transition will depend on adoption of new attitudes towards the continued acquisition, deployment, protection and funding of new knowledge.

A competitive R & D system is created by multiple factors. The knowledge driven economy demands a competitive R&D system, which is facilitated by favourable framework conditions, a new approach to knowledge generation and innovation, adaptation of education and training schemes, creation of easily accessible research, technological development and innovation (RTDI) infrastructures and finding solutions meeting new societal needs and the demands of an increasingly ageing public.

1. INTRODUCTION

The manufacturing activity in Europe represents today approximately 22% of the EU GNP. It is estimated that in total 75% of the EU GDP and 70% of employment in Europe is related to manufacturing. This means that each job in manufacturing is linked to two jobs in manufacturing related services.

European manufacturing has great potential as part of a sustainable EU economy, but its success will depend upon continuous innovation in products and processes. In addition to demanding increased commitment from the private sector, it is essential to combine European Commission efforts across several policy areas with those of Member States and accession countries to develop a common vision – starting at the industrial level but going much further in addressing technical, environmental and social issues.

The March 2000 Lisbon European Council set the objective of making the EU 'the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion'. This ambitious target cannot be met without the continuing presence of a strong and competitive manufacturing sector. Article III-180 of the proposed Constitution for Europe spells out that 'the Union and the Member States shall ensure that the conditions necessary for the competitiveness of the Union's industry exist'. An economy based on service industries alone will not survive in the longer term.

For European industries to remain competitive in the increasingly complex global economic environment, it is crucial that they modernise their manufacturing base and strengthen the links between research and innovation. The establishment of appropriate research infrastructures, adoption of new approaches to education and training, life-long learning to re-skill or up-skill the workforce, and encouragement of the mobility of researchers will be further key aspects of the drive to achieve the Lisbon objective. Creation of a European Research Area (ERA) for industrial technologies is seen as the way to involve all Member States in meeting the interlinked challenges of competitiveness, environmental sustainability and employment. In this context, the European Commission invited a High Level Group of European executives from research organisations and industry to offer their expertise and insights as a basis for structured debate leading to a shared vision of the way ahead for EU manufacturing. 'MANU*FUTURE* – a vision for 2020' provides a synthesis of those views.

A number of sector-specific 'vertical' action plans and Technology Platforms have already been produced or are in course of preparation, with support from the European Commission for specific sectors such as chemicals, construction, paper, steel, textiles and transport. MANU*FUTURE* goes one step further to address issues that can be applied across the whole sphere of manufacturing in a synergistic manner. Given the diversity of needs and the varying levels of economic development currently existing in nations across the enlarged EU, no single solution can meet all cases. Rather, the intention is to define broad strategic concepts leading to ideas that can be applied, shared and adapted across countries, regions and industries.

The present document is complemented by a more detailed research agenda containing specific recommendations for bringing together the stakeholders, defining research and development priorities, identifying technological and policy-related barriers, and proposing concrete actions for joint public-private support at European, national and individual levels. Finally implementation plans will also be developed.

2. WHY MANU*FUTURE*?

According to a recent Commission Communication[1] on industrial policy: "Industry makes an essential contribution to Europe's prosperity. The European economy continues to depend on the dynamism of its industry." This is the second such manufacturing-oriented document on industrial policy that the Commission has produced in the past two years, prompted largely by concern at the loss of manufacturing activities from Europe to lower wage economies – and the realisation that this deindustrialisation is inevitably accompanied by a loss of productive employment.

The MANU*FUTURE* mission

The mission of MANU*FUTURE* is to propose a strategy based on research and innovation, capable of speeding up the rate of industrial transformation in Europe, securing high added value employment and winning a major share of world manufacturing output in the future knowledge-driven economy.

As well as providing employment opportunities, an active manufacturing (encompassing both discrete manufacturing and continuous processes) sector is essential to stimulate innovation and provide the means whereby intellectual property can be exploited in the form of world-class products and services sourced from within Europe. Ireland and Spain, for example, owe their recent economic success largely to the boom in their manufacturing industries.

A concerted effort will be needed to transform European manufacturing from a resource-intensive to a knowledge-intensive, innovative sector with all the strengths necessary to achieve and maintain leadership in the global marketplace.

Multi-perspective approach

The vision for this change cannot be framed from a single perspective, nor realised through narrow, highly specialised approaches. An integrated knowledge community must be created, embracing a broad swathe of manufacturing interests, and including as many actors and stakeholders as possible – from Europe and beyond.

Environmental and social targets will dictate new paradigms that reflect the long-term needs for a more sustainable way of manufacturing and a new knowledge-based work culture.

New business models will be required, in which:

- Much closer coordination exists between the demand and supply sides;
- Self-sustaining innovation permits efficient uptake of new technologies in parallel to the development of new products – thereby reducing time to market;
- Sharing of knowledge within and between organisations becomes the norm;
- Supply chains take the form of flexible collaborations, networks of specialised small and medium-sized enterprises (SMEs) and 'virtual enterprises';
- Well-defined work procedures and specifications are commonly used to maximise efficiency;
- Social, environmental and economic considerations get equal weight in decision making; and
- Provision of services, rather than the outright supply of goods, facilitates the transition towards sustainability.

Tomorrow's solutions will be holistic, identifying multiple perspectives and linkages between novel approaches to customisation, customer response, logistics and maintenance. A broader definition of the term 'manufacturing' will encompass an integrated system that includes the whole cycle of creation, production, distribution and end-of-life treatment of goods and product/services, realising a customer/user driven innovation system[2].

The current typically linear approach to research, development, design, construction and assembly will be replaced by simultaneous activity in all areas to satisfying global demand and shorten time-to-market. Special emphasis will also be put on embedding information and communications technologies (ICT) within other techno-organisational developments, as this is perceived to be crucial in the development of the knowledge base and networked enterprises.

1 Fostering structural change: an industrial policy for an enlarged Europe; COM(2004) 274 final.
2 It can be estimated that up to 80% of innovations are driven by customer requirements.

3. MANUFACTURING IN EUROPE TODAY

The European Union is home to more than 26 million companies. The number of manufacturing businesses (classified as NACE D[3]) is about 10% of this total, i.e. around 2.5 million, of which 99% are SMEs. European manufacturing activity today represents approximately 22% of the EU gross national product (GNP).

Global comparisons show that Europe has been, and continues to be, successful in maintaining its leadership in many sectors – but this position is challenged on two fronts. On the one hand, EU industry faces continuing competition from other developed economies, particularly in the high-technology sector. On the other, manufacturing in the more traditional sectors is increasingly taking place in the low-wage economies, some of which are already looking towards higher-value-added segments.

A diverse Community

It should be noted that there are marked differences between individual EU Member States. Following its enlargement in 2004, the Union has absorbed a group of countries with relatively low-wage economies, yet with considerable technological experience.

The ten central and east European (CEEC) new member states and applicant countries – i.e. eight of the countries that acceded in May 2004, together with Bulgaria and Romania – account for 21% of all manufacturing jobs in the region comprising their own territories and that of the original 15 EU nations. Excluding Bulgaria and Romania, their employment share is 15%. The largest employers are the food and beverages industry, textiles, basic metals and fabricated metals industries, as well as mechanical engineering.

Using purchasing power parities, the same ten countries account for about 11% of total European manufacturing production. However, their share is larger in industries such as wood products and furniture, non-metallic minerals, and food and beverages. In contrast, the former EU-15 has greater strength in paper and printing, chemicals, machinery and equipment, as well as in electrical and optical equipment.

Manufacturing productivity growth in the ten CEEC countries has outpaced that of the EU-15 by more than six percentage points per annum over recent years, and the process of productivity convergence is bound to continue. But, in contrast to Western Europe where manufacturing employment has remained relatively stable, productivity catch-up in the acceding countries has been associated with persistent job losses.

Even in Western Europe, continuing productivity increases are starting to cause a decline in direct employment – mirroring job losses in US manufacturing over the past 20 years. In fact, in the 1990s, manufacturing's share of employment fell at least as fast, if not faster, in Western Europe than in the USA according to a US Government report on manufacturing in America – see BOX p12. However, growing numbers of jobs in the associated services is likely to compensate for this loss in direct employment.

In the automotive industry, for example, the direct labour content of car manufacture represents a relatively small proportion of total employment generated by the sector. Apart from the production of raw materials, tools, etc., the remainder stems from the provision of services from supply of fuel, spare parts, consumables and accessories, to maintenance and repair, insurance, in-car entertainment and communications, on-road catering and special interest publishing.

It can be envisaged that, in the shorter term at least, the transfer of more labour-intensive production to the CEEC could help to redress their present situation, while preventing the migration of employment opportunities beyond Europe's boundaries.

3 Manufacturing sectors are classified according to sub-sectors, ranging from clothing and textiles to machinery, from wood-related products to leather and footwear, from pulp and paper to chemicals, from electronics to aeronautics, from instruments and control systems to motor vehicles.

European strengths and weaknesses

A number of European strengths and weaknesses can be identified:

Strengths

- European industry is modern and competitive in many areas. A long-lasting industrial culture exists, with large networks linking suppliers, manufacturers, services and user companies;
- Leading-edge research capabilities are available across Member States, leading to high levels of knowledge generation and a reputation for scientific excellence;
- Some 99% of European businesses are SMEs, which typically exhibit greater flexibility, agility, innovative spirit and entrepreneurship than more monolithic organisations. In addition, SMEs tend to interact in a manner that lies between strong competition and fruitful co-operation, which helps to foster the process of what has been called 'co-opetition';
- Europe has taken on board sustainable development. Significant investments in environmental protection, clean technologies and environment-friendly production processes have led to new manufacturing and consumption paradigms; and
- Historic and cultural differences between individual Member States and regions bring a diversity of viewpoints and skills that can be coordinated to produce novel solutions.

Weaknesses

- Productivity growth in European manufacturing industry as a whole has been below US levels in recent years. Investment in ICT and new technologies is still too low, and has not so far led to the desired productivity gains; and
- Innovation activity is too weak. The EU does not suffer from a lack of new ideas, but is not so good at transforming these into new products and processes. Industry's analysis is that this is due to the framework conditions for manufacturers operating in Europe.

To build on these strengths, to fight the weaknesses and turn them into opportunities for growth, the EU needs to:

1. Continue to invest in research and innovation to remain ahead in providing the products and process technologies that the rest of the world desires, but cannot necessarily develop for itself;
2. Capitalise on its enabling technologies to increase the already high level of factory automation and productivity, thereby overcoming the labour cost disadvantage;
3. Protect discoveries and intellectual property so that, even when the more mundane aspects of manufacture are exported, profit continues to flow to the innovators; and
4. Develop framework conditions that stimulate innovation, entrepreneurship and therefore growth and employment both directly and indirectly.
5. Companies, in particular SMEs need to significantly enhance their capability to pull through innovative technologies to assist in their move to high-value added innovative product market strategies.

Research and the application of research results in the form of commercially exploitable innovations are central to realisation of the MANU*FUTURE* vision. The Barcelona Council of March 2002 stated that "overall spending on research and development (R&D) in the EU should increase and approach 3% of the gross domestic product (GDP) by 2010". Commitment and investment from both private and public sources are vital if the EU is to reach this goal.

Drivers for change

Principal drivers for change in the whole European economic environment are:

- **Increasingly competitive global economic climate.** The context in which manufacturing companies work in the future will depend even more on flexibility and speed, as well as on localised production. Manufacturing is also likely to become increasingly service intensive. This service orientation of manufacturing and the

increased customer demand will have consequences for the organisation of production, supply-chain management and customer relations. Furthermore, there is a continuous increase in foreign direct investment in manufacturing outside Europe;

- **Rapid advances in science and technology**, specifically in the fields of nanotechnologies, materials science, electronics, mechatronics, ICT and biotechnology. The development of new production processes based on research outcomes, and the integration of hitherto separate technologies exploiting the converging nature of scientific and technological developments, may radically change both the scope and scale of manufacturing;
- **Environmental challenges and sustainability requirements.** The manufacturing sector will also have to comply with stricter environmental regulation in the future, which should further stimulate the adoption of energy- and resource-saving technologies;
- **Socio-demographic aspects.** Manufacturing in 2015 to 2020 will be called upon to provide solutions meeting new societal needs and the demands of an increasingly ageing public, having an impact on mobility, size of the labour force, and on customer requirements. At the level of the labour supply, the manufacturing and research sectors will be confronted with the retirement of the current large age groups, while innovation might require completely new sets of skills – the availability of which, in both manufacturing and research, could become a critical factor;
- **The regulatory environment, standards and IPR.** Stricter environmental and safety regulation will no doubt lead to changes in manufacturing. The intellectual property rights (IPR) system might have to respond to changes in an innovation process that is increasingly based on knowledge sharing and networking. The adoption of new technologies in manufacturing will also depend on the availability of industrial standards and testing procedures; and
- **Values and public acceptance of new technology.** Recent debates on genetically modified food and stem-cell research highlight the need to take ethical concerns into account when science and new technology are being adopted and exploited. At the same time, it should be noted that this could lead to Europe falling behind in some areas of technology.

Asia – competitor or partner?

Asia, and China in particular, is becoming an increasingly potent force in the global marketplace. But, although the exodus of less-skilled production jobs to lower-wage countries is inevitable, many experts foresee positive benefits for the world economy as a whole.

According to Henry S Rowen – a senior fellow at the Hoover Institution in the USA – writing in The International Economy[4], "(China's) manufactured goods exports rose during the 1990s at a 15% annual rate to about $220 billion in 2000. On one estimate, China now makes 50% of the world's telephones, 17% of refrigerators, 41% of video monitors, 23% of washing machines, 30% of air conditioners and 30% of colour TVs. Many companies in the USA, Japan, Taiwan and elsewhere are moving operations there. Jobs are shrinking in Mexico's factories as work shifts to China. The building space of foreign contract manufacturers grew from 1.6 million square feet (0.16 million m^2) in June 1999 to 5 million square feet (0.5 million m^2) two years later."

However, as Rowen goes on to observe, "...those who argue that Chinese manufacturing is going to dominate the world soon, if ever, are missing some basic facts. Perhaps their most important oversight is neglect of its manufactured imports, which are almost as big as its exports, about $180 billion in 2000." Machinery imports are particularly important to produce the goods exported. The result for China in 2000 was a positive balance of manufacturing trade of about $40 billion: an amount that is less than one percent of total world industrial production.

Factors that will keep China from sustaining a large manufacturing trade surplus include a growing domestic market, which will continue to generate demand for imports, and lagging technical competence that will take some time to redress.

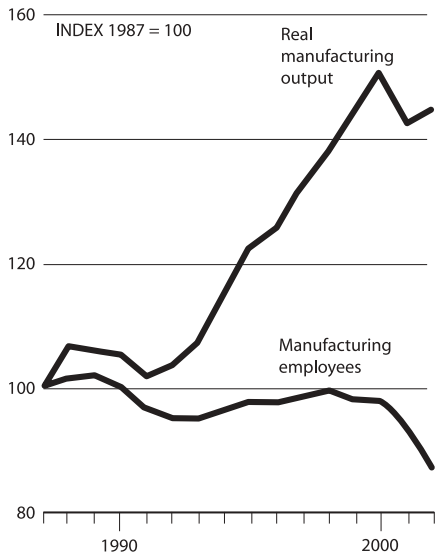
India also envisages the prospect of seizing a substantial share of global contract manufacturing business, which is currently estimated to be close to $149 billion and is expected to grow to $500 billion by the end of the decade.

4 'Will China take over world manufacturing – Last Word'; The International Economy, Winter 2003

USA revisits industrial policy

MORE STUFF, FEWER PEOPLE

Even when factories boomed over the past 15 years, employment trended down.



Source: 'Will "made in USA" fade away', Fortune 24 Nov. 2003

In March 2003, the US federal government launched its own Manufacturing Initiative, expressing the belief that manufacturing is the key to competing and winning in a global economy. In a report entitled *Manufacturing in America*[5], it states: "Manufacturing is an integral part of a web of inter-industry relationships that create a stronger economy. Manufacturing sells goods to other sectors in the economy and, in turn, buys products and services from them.

"Manufacturing spurs demand for everything from raw materials to intermediate components to software to financial, legal, health, accounting, transportation, and other services in the course of doing business. According to the Bureau of Economic Analysis, every $1 of final demand spent for a manufactured good generates $0.55 of GDP in the manufacturing sector and $0.45 of GDP in non-manufacturing sectors.

"A healthy manufacturing sector is critical... for other reasons as well – innovation and productivity. Innovation holds the key to rising productivity, and productivity gains are the key to both economic growth and a rising standard of living." (And, although not specifically mentioned in this publication, the latter are prerequisites for being able to afford the social and environmental dimensions of sustainable development – i.e. development that meets the needs of the present without compromising those of future generations.)

As a result of increasing productivity, the USA has seen a decline in manufacturing employment over a number of years. A recent study by the US National Institute of Standards and Technology nevertheless underlines the benefits of improved manufacturing productivity to other sectors in the economy. It emphasises "the substantial dependency of services on manufacturing firms for technology" and the "critical role" manufacturing plays in stimulating growth in the services sector, which now makes up more than 70% of the US economy.

4. THE MANU*FUTURE* APPROACH

As a response to the dramatic changes expected in both the scope and scale of manufacturing, MANU*FUTURE* will be promoting a research oriented strategy that will advocate science & technology based growth for the European manufacturing industry supporting the development of global competitiveness, sustainable development and high value added employment. Europe cannot afford to fall behind in science and technology.

The dimensions within which manufacturing enterprises operate are also subject to major change. Manufacturing is evolving from local satisfaction of local needs to production patterns able to respond flexibly to global demand. In parallel with this trend, the timescale of product conception and development is shifting from the long to the shorter term – and ultimately to a near real-time response.

In addition, manufacturing is likely to become increasingly service-intensive. This service orientation and the increasing customer expectations will have consequences for the competitive organisation of production, value-chain management and customer relationships, as well as the service elements themselves.

The options for adapting to the new conditions are illustrated in Figure 1. Here the first scenario represents the status quo,

5 Manufacturing in America: A Comprehensive Strategy to Address the Challenges to U.S. Manufacturers; Department of Commerce, January 2004 (http://www.commerce.gov/DOC_MFG_Report_Complete.pdf)

Figure 1: Scenarios for MANU*FUTURE*

where the companies are trying to gain competitive advantage through mass customisation, high quality and short time-to-market. However, concentration solely on short term advantages will jeopardise the competitiveness in the long term. Even for less research-intensive enterprises, there will be clearly a need to move towards scenario 2, in which production is matched to the demands of customers enjoying a wealth of choice in a globalised marketplace. This will apply equally to enterprises supplying niche markets and to those serving large customer bases.

Research-intensive organisations may already be working towards technological leadership as a way to innovate new products (scenario 3), but they must combine the technological approach with the adaptation to new market conditions in order to reap maximum benefit from their innovations (scenario 4). Naturally, scenario 4 requires long term, high-risk investments and is therefore a challenge especially for the smaller enterprises. However, the risks of "short-termism" and "business as usual" are even higher.

Setting research priorities

In a region as diverse as the EU-25, individual countries will inevitably be setting off from different starting points. To accommodate their differing requirements in the medium term, it will be important to maintain a balance between research activities aiming at incremental advances and those targeting breakthrough innovation. In the longer term, however, the weight of support for co-operative research must shift towards initiatives capable of achieving radical breakthroughs. If the EU manufacturing sector is to survive and prosper over the next two decades, organisations must adjust to the new scenarios: a process that will inevitably involve dramatic or disruptive changes to established practices.

Innovating production

The traditional structure of manufacturing industries is constructed upon the three pillars of land, labour and capital. The challenge is to move towards a new structure, which can be described as 'innovating production', founded on knowledge and capital. The transition will depend on adoption of new attitudes towards the continuous acquisition, deployment, protection and funding of new knowledge.

Change will occur in six main areas:

1. From resource-based to knowledge-based manufacture

In order to avoid competition based purely on production cost, European industry needs increasingly to concentrate its capabilities on high-added-value products and technologies offering a broadened service range that fulfils worldwide customer requirements – not only in terms of product satisfaction, but also in meeting environmental and social expectations. Increasing the knowledge content of manufacturing will lead to more economical use of materials and energy.

It will also produce more intelligent devices incorporating services that meet users' real needs. Future consumers will be able to purchase mobility, rather than buying a car; home comfort rather than a boiler.

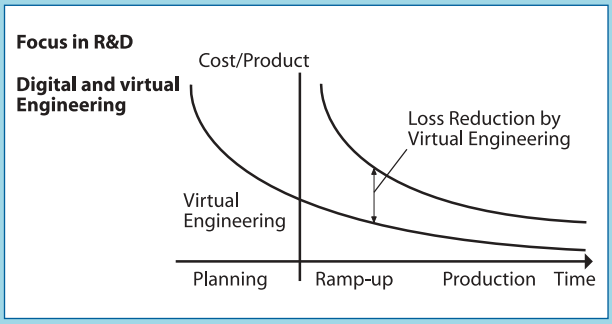
The scientific engineering knowledge content of manufactured products was estimated to be around 5% in 1945 and has grown to some 16% now. The target for 2020 should be at least 20%.

In order to ensure continued competitiveness, production research must focus on radical transformation of the fundamental processes of manufacturing so that they become:

- **ADAPTIVE** – responding automatically to changes in the operating environment. They will integrate innovative processes, overcome the existing process limitations through intelligent combinations, and handle the transfer of manufacturing know-how into totally new manufacturing-related methods.

- **DIGITAL** – involving the use of a wide range of planning tools, software and ICT to integrate new technologies into the design and operation of manufacturing processes. Modelling and presentation tools for complex products will be used to create a scalable virtual representation of an entire factory that includes all buildings, resources, machines, systems and equipment. Planners and designers can use the information from such 'digital factories' to obtain dramatic time and cost savings in implementation of new facilities.

Figure 2: Virtual engineering offers increased efficiency

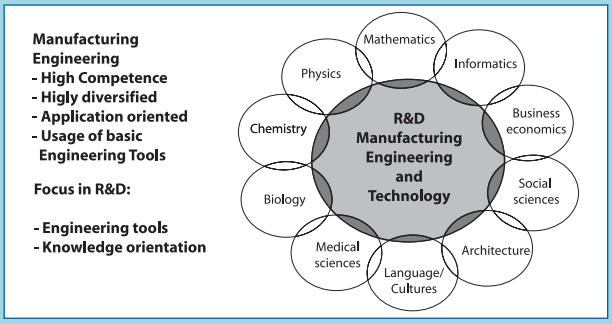


- **NETWORKED** – often operating across the borders of companies and countries. It will thus become possible to integrate processes into dynamic, co-operative manufacturing and value-adding networks. Determining methods for the identification and verification of the manufacturing requirements of all involved parties in a network, as well specifying the necessary processes and ICT systems, will be central tasks for researchers in this field.
- **KNOWLEDGE-BASED** – not only making use of knowledge to optimise specific production resources and processes, but also capturing that knowledge and transferring it via knowledge platforms and competence networks to other areas where it can be employed to advantage. The only way that the new potential of inter-company networks will be realised, or companies be enabled to respond quickly to changes in a dynamic environment, is if the knowledge from all fields of manufacturing is integrated – from manufacturing networks down to the individual components of manufacturing systems.

2. From linearity to complexity

To accommodate the changes foreseen in manufacturing processes, industrial enterprises must also re-examine their organisational structures. Former linear approaches to product and process renewal must be replaced by a 'manufacturing engineering' strategy that simultaneously addresses all inter-related aspects.

Figure 3: Manufacturing engineering – the strategic technology



Nevertheless, it is important for Europe to maintain expertise in the field of traditional manufacturing and to capitalise the knowledge on the traditional manufacturing processes. New technologies could only be developed on the basis of a strong knowledge of the traditional ones. However, significant efforts are still needed to ensure a smooth and efficient transition to knowledge-based manufacturing. It has to be clearly understood how the European manufacturing base can be transformed in the context of low wage, low cost production competition, e.g. from Asia.

It no longer makes any sense to invest in large monolithic mass production plants seeking to make profit from economies of scale. Knowledge-based manufacturing needs flexible enterprises, using parallel networks of suppliers and recruiting the skills necessary to deliver precisely customised products on a timely basis to meet changing demand

Managing the new kinds of dispersed organisation will not always be easy, but it is vital for industry to master the new concept of adding value simultaneously to design, production, distribution and service. This integrated approach to 'manufacturing' will incorporate new knowledge, underpinned by horizontal enabling technologies, into all of the phases – thereby retaining more value, and more employment, within Europe.

3. From individual to system competition

Single companies working in isolation will not be able to respond to challenges of the magnitude that will arise in effecting such fundamental transformation – and even whole countries will find problems in mustering the necessary human and financial resources.

Co-operation is thus essential: it is not appropriate for individual entities to compete against one another for exclusive ownership of the fruits of long-term research. Knowledge sharing and networking across whole manufacturing systems, in conjunction with equitable intellectual property rights (IPR) provisions, represents the logical way for Europe as a whole to gain competitive edge.

The successful businesses of tomorrow will need to:

- Focus their R&D in multiscale networks, drawing on regional centres of excellence and distributed virtual institutes;
- Align with global standards of technology, quality and sustainability;
- Adopt standard ICT interfaces; and
- Participate in open networks of virtual engineering and virtual manufacturing partners employing new business models.

4. From mono-disciplinarity to trans-disciplinarity

Innovation processes centred on single competences will give way to multicompetence and multidisciplinary innovation. In the mid-term, added value will come primarily from an increasing convergence of the three most revolutionary industries: microelectronics, nano-technology and biotechnology.

5. From macro- to micro- to nano-scale

The electronics and biotechnology industries are already well advanced in merging materials design and manipulation with product processing. The progressive reduction of device dimensions, together with the added functions provided by knowledge-based materials, is permitting substantial savings to be made in resource use across the whole swathe of user sectors. But as this shrinkage approaches the nano-scale, established technologies are reaching their physical limits. To take the next steps, breakthrough research will be needed

6. From top-down to bottom-up production

Over a longer timescale of, perhaps, 20 to 50 years, it is to be hoped that scientists will solve the problems of mimicking nature, making it possible to move from today's top-down methods to bottom-up manipulation of individual atoms and molecules.

Hybrid organic/inorganic combinations with hitherto unimagined intelligent multifunctionality could result, and whole new ways found to employ materials with properties that depend on nano-structuring. Examples can be envisaged such as the use of self-diagnosing alloys in bridges and other structures, able to signal fatigue or overloading (e.g. by colour change or variations in electrical resistance) and thus eliminate the need for preventive maintenance.

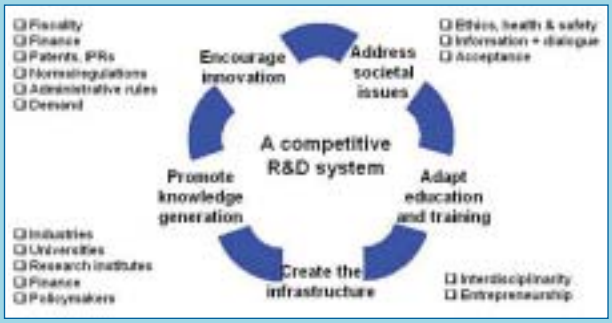
Although radical transformation of the industry must be the long term objective, it has to be ensured that Europe continues to be competitive in the mature manufacturing areas, where the driver is no longer radical innovation, new patents etc., but rather a continual improvement and gradual application of new technologies, and last but not least where competitiveness is secured through lean management and other well known, but underutilised principles.

The capability of defining a shared long term vision would provide continuity and stability to the different actions decided by the stakeholders' interests and priorities. It is within such an approach that, the short term RTDI activities, carried out by the industry, would be consistent with the vision and would contribute to the achievement of its objectives.

5. CREATING THE CLIMATE FOR SUCCESS

The main thrust of the MANU*FUTURE* initiative will be to promote intelligent and advanced concepts of competitive and sustainable manufacturing that speed up the rate of industrial transformation and secure a major share of world manufacturing output in an increasingly competitive knowledge-driven global economy.

Figure 4: Factors for competitive manufacturing R&D



Encouraging innovation

Strong governance of research will be vital in order to maintain stability and unity of purpose. Traditional industries cannot simply be expected to abandon established practices and bring in the new. Without appropriate fiscal encouragement and financial support, they will be reluctant to bear the risk of undertaking long-term initiatives that offer uncertain prospects of a return on the investment.

Political leaders must take the initiative in establishing framework conditions that motivate individuals and enterprises, encourage the sharing of knowledge, and promote public awareness and enthusiasm. Great potential exists if European, national, regional and private efforts could be better co-ordinated and integrated, with a view to rationalising and simplifying of the legal and regulatory environment – especially with respect to IPR, the harmonisation of standards and the provision of easier access to finance for motivated innovative enterprises.

To engender continuing success, changes in the emphasis of Community research should nevertheless be accompanied by more involvement of industrial partners in research and innovation activities. Equally critical is a stronger contribution from start-ups and technology transfer centres, as vectors for industrial breakthroughs and for change in the image of the traditional manufacturing industry.

Addressing societal issues

Manufacturing in 2015 to 2020 will be called upon to provide solutions meeting new societal needs and the demands of an increasingly ageing public. At the level of labour supply, the manufacturing and research sectors will be confronted with the retirement of the current large age groups, while innovation will require completely new sets of skills – the availability of which, in both manufacturing and research, could become a critical factor.

If industrial success is to lead to increased employment, a key requirement will be for effective communications highlighting the achievements of European manufacturers and underlining the attractions of careers in the emerging knowledge-based sector.

Questions of ethics, health and safety all assume high priority in the creation of a sustainable economy. Recent debates on genetically modified food and stem-cell research, for example, highlight the need to take ethical concerns into account when science and new technology are being adopted and exploited. (At the same time, it should be noted that this could lead to Europe losing ground in some areas of technology.)

Stricter environmental and safety regulation will inevitably lead to changes in manufacturing, stimulating the adoption of energy-saving, resource-saving and cleaner technologies. The role of research will be to deliver the materials, processes and technologies that enable the new requirements to be met without loss of competitive advantage.

Every effort should also be made to raise general awareness of the implications and importance of manufacturing in Europe to the Lisbon strategy. Educating and persuading the public to adopt sustainable patterns of consumption would permit a truly ecological use of technology – with everyone enjoying a life-style of elegant sufficiency, while living within self-imposed limits.

Promoting knowledge generation

In order to stimulate knowledge generation and ensure efficient transfer of its benefits to the manufacturing sector, a new value-adding approach to innovation must be nurtured in which the mutual benefit of an intimate collaboration between the academic and industrial communities is clearly recognised[6].

The actors in this process are:

- **Universities**, where basic scientific and technical training takes place;
- **Research centres**, in which graduate and postgraduate students can gain confidence and build mature experience in dealing with the real problems of manufacturing;
- **Knowledge-intensive SMEs** (KI-SMEs), which can transform the knowledge produced by applied research into products and services for manufacturing industry; and
- **Manufacturing enterprises**, equipped to incorporate the acquired knowledge into products and processes with the qualities needed to support enhanced competitiveness.

New ways must be found to promote greater interactivity and parallel innovation by breaking down barriers between these partners, giving individual researchers the mobility to contribute their expertise wherever it is most needed.

Knowledge will become increasingly important as a 'product', especially to the SMEs constituting the great majority of the manufacturing enterprise pool. This will require a new approach to IPR – securing knowledge ownership while sharing the results fairly between all the contributing partners.

Thanks to their agile and flexible structures, KI-SMEs will be in a position to undertake subcontracted pre-competitive activities within national and international projects, while remaining close to the manufacturing companies, and saving time and resources for the R&D institutions.

Conversely, manufacturing companies can derive added value from the knowledge created within KI-SMEs. This will enable them to focus on their own core activities, while leaving tasks that require specialised skills to the SMEs that have direct links with universities and R&D centres in so called 'knowledge' or 'teaching' factories.

As a result of their extensive networking, KI-SMEs will thus become important reference points for manufacturing enterprises seeking frontier knowledge and innovative services. They will also form fertile breeding grounds in which personal growth and creative talent are strongly stimulated.

Finally, new ways must be found to promote the percolation of knowledge through the manufacturing fabric – in particular to benefit the very large numbers of European SMEs which cannot be characterised as knowledge-intensive. In this context, actions at national and regional levels play a key role.

6 The important role of companies that lie between the SME definition (less that 250 employees) and large manufacturing enterprises has to be recognised. SMEs are often too small to have the resource to create world-class commercial products and services, and yet large enterprises are not flexible enough. These mid-range companies act as catalysts for innovation with the SMEs. Also, they are large employers, major market thrusts, and add critical mass and create linkages between end users and technology originators.

Adapting education and training

Schools and universities must be encouraged to provide the appropriate types of education and training to develop the skills needed by new generations of 'knowledge workers', who will need to combine technological expertise with entrepreneurial spirit.

Development of educational curricula has not kept pace with either the growing complexity of industry or the economy, and even less with the rapid development of new technologies. Studies are often too lengthy and too general. Furthermore, it can be argued that manufacturing is a subject that cannot be handled efficiently inside a university classroom alone. Addressing this problem emerges as a strategic challenge for European manufacturing education. Integrating the factory environment with the classroom seems to be the only way forward. To this end, it is increasingly evident that the teaching' factory is the required breakthrough.

Facilitating the mobility of researchers and engineers should be an integral part of this process – and life-long learning should be the ultimate goal, considering the demographic changes foreseen in Europe.

With the growing emphasis on lifelong learning, it is essential for industry and educational organisations to form strategic alliances to ensure complete staff skilling as part of human resource development. It is not only in the interest of companies themselves to ensure continual training of their workforces; individuals need to take advantage of regular opportunities to enhance their own skill levels both at work and in their own time. If such training schemes were put in place across the whole of the manufacturing sector in Europe, dramatic results would be obtained with marked increased in the skills and capabilities of the EU workforce.

Creating the infrastructure

Support for the development of networked and easily accessible research, technological development and innovation (RTDI) infrastructures would allow industry, in particular SMEs, to deploy new technologies and organisational practices rapidly and at affordable cost,

The Sixth Framework Programme is promoting broad collaborations through Networks of Excellence and Integrated Projects that provide critical mass and encourage extended networking, and FP7 will build on the lessons learned. Contributions to the MANU*FUTURE* deliberations will form valuable inputs with respect to manufacturing, helping to define the optimal environment in which European industry can thrive.

6. THE MANU*FUTURE* STRATEGY

MANU*FUTURE* is a powerful vision encompassing the complex network linking human and societal needs (demand) to both the industrial and education systems (supply). It is intended as a tool to guide the development of foresight into the strategic future of manufacturing – possibly leading to the formulation of a manufacturing platform as the basis for concerted action to achieve success in the world economy.

Implementation of the measures described in this document will enable Europe to expand its knowledge base through world-class research, and to exploit its discoveries to maximum advantage in the development of novel, life-enhancing products and product-related services. By 2020, the EU could be setting global standards in manufacturing efficiency, quality and sustainability. As well as employing state-of-the-art production facilities within the region itself, it would be in a position to export leading-edge processes and resources to the rest of the

world, while retaining ownership of the underlying technologies and intellectual property.

European expertise would enable industry to thrive by being proactive and flexible in facing new manufacturing challenges, absorbing new technologies stemming from all scientific disciplines, and responding effectively to external competitive pressures. Manufacturing would thus enjoy a strong renaissance, and be recognised by the citizens as a provider of health, wealth and well-being. It would be a growing source of direct and indirect employment – and a career path of choice for emerging young talent.

The goal of MANU*FUTURE* is to create a common understanding, to identify top priority research topics for the future of manufacturing in Europe and to include these topics in the EU framework programme for research, other European initiatives such as Eureka, and national or regional programmes while aiming at financial leverage and progress towards the 3% objective.

These activities can be facilitated by the creation of a "MANU*FUTURE* platform". The platform should have more of an horizontal nature than that of other ETPs, as it addresses the entire manufacturing sector, integrating all stakeholders and their needs. Its main role would be to govern research, technological development and innovation (RTDI) efforts aimed at the transformation of the European manufacturing industry at two levels:

- A policy level aimed at continuous development of the MANU*FUTURE* vision and promotion of the Lisbon objectives; and
- An operational level employing a technological approach exploiting all possible synergies arising from the converging nature of science and technologies;

The technological approach should begin by addressing common problems or bottlenecks faced by the sectoral platforms currently in operation or under development.

However, given the diversity of manufacturing activities, the number of actors involved and widely different national and regional needs across the EU, these challenges obviously cannot be met by a single universal solution. Consequently, the MANU*FUTURE* Strategic Research Agenda that will accompany this document envisions a multiperspective approach based on:

- Creating an integrated knowledge-sharing community, with strong links between academia and industry;
- Building a world-class R&D infrastructure;
- Adopting new business models, organisational concepts and working methods;
- Establishing a favourable economic and regulatory climate to encourage research investment and entrepreneurialism;
- Restructuring education and training to reflect the lifelong learning needs of tomorrow's 'knowledge workers'; and
- Increasing public awareness of the value of science, the rewarding career opportunities that will arise in knowledge-based manufacturing and the importance of sustainable production/consumption patterns.

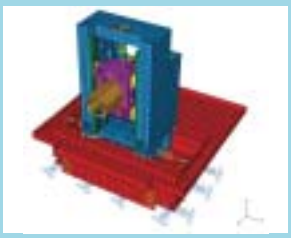
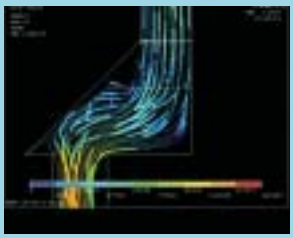
The MANU*FUTURE* Strategic Research Agenda will provide an overall road map that will inform stakeholders, encourage debate and lead to a consensus view on the way ahead.

The vision of MANU*FUTURE* is long-term, but this should not be used as a justification to postpone implementation. A number of implementation plans will therefore be formulated, consistent with the step-wise development of the Strategic Research Agenda and aiming at mobilising stakeholders and resources at the most appropriate levels.

7. GLOSSARY

CEEC	Central and East European Countries
ERA	European Research Area
ETP	European Technology Platform
EU-15	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom
EU-25	EU-15 plus Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia
GDP	Gross domestic product
GNP	Gross national product
ICT	Information and communications technologies
IPR	Intellectual property rights
KI-SME	Knowledge-intensive SMEs
NAS	New accession states
R&D	Research and development
RTDI	Research, technological development and innovation
SME	Small and medium-sized enterprises

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To survive as the mainstay of Europe's economy and employment, its manufacturing sector must continually confront new challenges. In the face of global competition, standing still means moving backwards. The MANU*FUTURE* High Level Group has developed a powerful vision encompassing the complex network that links human and societal needs (demand) to industrial and educational systems (supply). It is intended as a tool to guide the development of foresight into the strategic future of European manufacturing.

http://www.europa.eu.int/comm/research/industrial_technologies/manufuture/home_en.html

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