Working Document For The MANU*FUTURE* 2003 Conference

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A Note for the Reader

This report has been prepared by an expert group, which was established by DG Research in the summer of 2003 to discuss the future of manufacturing in Europe in a series of workshops. The document synthesises the views of the expert group and also draws on various background and policy documents published on the topic.
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PREFACE

The European manufacturing activity today represents approximately *22 % of the EU GNP*, but is increasingly challenged by the global competitive environment – and in particular by the ever more significant role of Asian manufacturers. During the past three decades there has also been a marked increase in the share of the services sector in EU output. In percentage terms, manufacturing employment continues to decline, currently representing about *18% of employment* in Europe. However, it would be wrong to assume that manufacturing has lost its importance. On the contrary, a competitive manufacturing sector is vital for Europe to achieve its ambitious long-term economic, social and environmental targets.

The present document should be placed in the context of the European Councils of Lisbon 2000 (setting the objectives for a knowledge-based economy and society), of Göteborg 2001 (complementing these objectives with that of sustainable development), and of Barcelona 2002 (targeting funding equal to 3% of GDP for EU investment in research[1]).

An important goal in fighting against the perceived trend of 'decline in manufacturing' is to help generate long-term visions for the development of new manufacturing approaches in Europe. These should promote sustainable industrial growth and an improved quality of life for society as a whole. In this context, research on new manufacturing technology is an important catalyst for industrial innovation. The creation and implementation of the European Research Area is another contributory factor[2].

This reflection document attempts to highlight the '*role of Community industrial research programmes to sustain European leadership in manufacturing*'. It aims to identify the main barriers to innovation, and the major incentives that should be provided by public authorities to help traditional EU industry overcome them, notably through the development of targeted research initiatives on manufacturing.

The MANU*FUTURE 2003* conference launches the public debate. We hope this document will help to stimulate further stakeholder contributions, which are essential in helping us to formulate a successful Manufacturing Technology Action Plan for Europe.

November 2003

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1 http://ue.eu.int/en/Info/eurocouncil/index.htm

2 The European Research Area: Providing new momentum - Strengthening - Reorienting - Opening up new perspectives (COM(2002)565 final – 16.10.2002)

EXECUTIVE SUMMARY

This document is the result of contributions over several months from a number of working groups involved in studying the role of European industrial research in a crucial sector for the future of the EU. It highlights the necessary role of research activities in support of industrial competitiveness and for the reinforcement of scientific and technological bases. In addition, it highlights possible ways to tackle the long-term challenges facing us.

Is there a vision of European manufacturing?

The report opens with a portrait of manufacturing today. What is manufacturing? How important is it in, and for, Europe? How commercially and technologically competitive is it? Where are its strengths, weaknesses, opportunities and threats? And what can be said about investment in research in manufacturing today?

Long-term goals for EU manufacturing industry are then analysed, considering in particular the geopolitical importance of manufacturing in Europe. The need for change, primarily to permit an evolution from resource-based to knowledge-based manufacturing, is expressed. The ManuFuture paradigm is presented, with an emphasis on 'knowledge manufacturing' and on the 'Man-Industry-Society' Value Chain.

Are the actions for research and innovation in manufacturing consistent with this vision?

Experts recognise that the stimulation of innovation in manufacturing is a key issue for the future, but they also note that innovation is a very complex process. It does not only require new knowledge acquisition and new ways of integrating new and existing knowledge; a favourable political, fiscal, financial and competitive environment is equally crucial.

- *The prime driver for generating such innovation, and presenting solutions to the problems that industry is facing, is undoubtedly an increase in research and technological development activities. The road to Manufuture implies the adoption of systemic and disruptive approaches, using ICT, new materials and breakthrough manufacturing technologies as enabling mechanisms. The need for cost reduction, new design paradigms, 'extended product' concepts, miniaturisation and precision engineering, and cleaner, more flexible processes demands more integrative approaches, as well as new organisational research.*

- *A second driver is increased, but targeted, international cooperation in research on manufacturing. In this respect, the experience gained in IMS and EUREKA is particularly valuable. The enlargement of Europe and better relations with third countries will also provide scope for more innovation and sustainable development. However, improvement of the existing instruments available to encourage international cooperation in industrial research should be considered.*

- *The third driver is the provision of better education and training schemes in Europe, able to support the development of new production and consumption paradigms. The setting-up of new educational programmes and training activities should also help attract young people to technological careers. Universities have a key role to play in developing improved multi-disciplinary skills, as well as engendering a spirit of innovation. Integrating research, innovation and educational activities under a common research contract is also seen as an excellent way to achieve a concurrent development of skills and technologies.*
- *The fourth driver is of course a robust operating environment for industrial innovation. This mainly involves a consistent general policy framework and an efficient financial support to all phases of research and innovation. The support of entrepreneurs and the development of innovative SMEs is also seen as a political priority for Europe. Through the recently politically agreed Community patent, EU regulation should help to provide effective protection for intellectual and industrial property rights. However, there should also be a simplification of the regulatory framework, both to help stimulate innovation and to prevent the drain of research and researchers away from Europe.*
- *The fifth driver is the necessary improvement of the competitiveness of European research. A better approach to research and stronger research-industry relationships and interactions, particularly through public-private partnerships, should reduce the time from idea to market. Increased networking will combat the fragmentation and duplication of effort. Development of world-class multi-disciplinary centres and Networks of Excellence will build a better knowledge-base in Europe, as well as attracting and retaining the best scientists. Finally, the setting-up of European Technology Platforms, using the new instruments developed under the Sixth Framework Programme, will permit the elaboration of clearer visions, strategies and actions.*

Let's act together !

The questions presented at the end of the document have the objective of stimulating the development of such visions, of more consistent policies and of joint actions. They cover several policy aspects, including the proposal to form a high level expert group on Manufacturing Technologies to elaborate a European research Action Plan. Further suggested practical actions may include the support of more integrated projects of industrial nature within FP6 and improved links between research activities and financing of innovation.

In summary, the challenge facing Europe is to transform traditional manufacturing industry and create new actors in manufacturing in the medium to long term, while at the same time enabling the EU to maintain leadership in manufacturing-related research.

This requires a large combination of cross-sectoral multi-disciplinary initiatives and long-term oriented voluntary actions.

PART A - Manufacturing: the key issue for Growth and Sustainable Development

1. MANUFACTURING TODAY

1.1. What is manufacturing?

Manufacturing covers the 'Man-Industry Value Chain', responding to human needs by the provision of products, processes and services. In broad terms, manufacturing is '*the general transformation of all resources to meet human needs*' and this is why a smooth relationship must exist between supply and demand. The main elements and interactions are presented in the figure below:

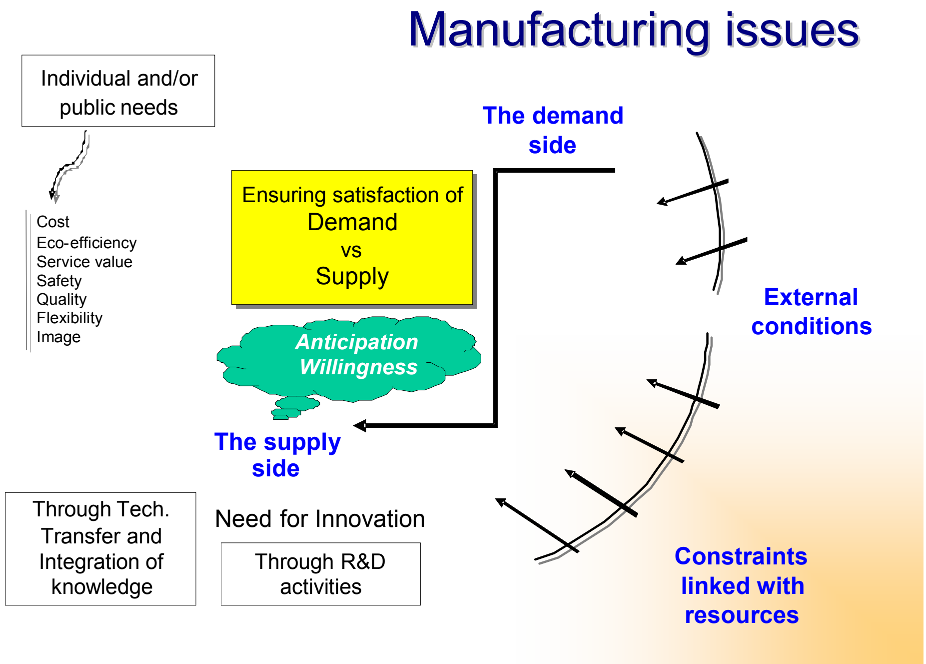

Figure 1

Manufacturing in Europe is characterised by its societal role towards economy, employment and quality of life and by its creativity. Public authorities at regional, national and European level provide significant support to manufacturing research as the industry is currently undergoing radical changes:

(1) the international context is evolving, primarily due to the emergence of new actors in manufacturing and to economic fluctuations;
(2) the need for innovation is increasing, while the complexity of problems to be solved is growing, and;
(3) customers' demands are increasing; in addition, individual needs have to be balanced with the necessity for products and production processes to be safe and eco-efficient.

Manufacturing and manufacturing-related activities play a major role in the economy. This is why 'manufacturing' is so important for European society. It should not be allowed to deteriorate, or simply to move to other parts of the globe.

1.2. Manufacturing in Europe

It well known that, in high income countries, the services sector has been growing more rapidly than industry and agriculture in the last two decades. On the contrary, in the rest of the world, the most dynamic sector has been manufacturing. In other words, the tertiarisation of the richest economies has been accompanied by a gradual shift of manufactured productions towards low and middle income countries. The share of manufacturing in GDP has been falling for all the main country groupings in the nineties (from 22 to 20% in high income countries, from 23 to 22 % in low and middle income countries), with the significant exception of East Asia and Pacific where the manufacturing share of GDP rose from 28% in 1990 to 32% in 2001[3]. Similar trends appear in the data on employment where the share of industry fell from 33% to 28% in the EU.

It must be stressed that the conventional distinction between primary, secondary and tertiary sectors is less meaningful today than in the past. The importance of services as intermediate inputs is increasing in every sector. Moreover, to better satisfy consumer needs, many goods, produced by agricultural or manufacturing enterprises, reach the market only by incorporating a rising share of services to the customer.

Western Europe is home to more than 20 million enterprises, providing employment for 122 million people. In the Candidate countries there are nearly 6 million more enterprises[4]. The number of manufacturing businesses (classified as NACE D[5]) is about 10% of this total, i.e. around 2.5 million. European manufacturing activity today represents approximately 22 % of the EU GNP.

1.3. Competitiveness in trade and technology

A complex interdependence relates the structural transformation of the world economy with changes in the geography of international trade, as represented by export market shares. The EU and the US are still the largest exporters, but their shares have gradually been decreasing in the past three decades (Figure 2). In contrast, Chinese export performance increased strongly in the 1990s, when its world market share tripled.

The structure of manufacturing can be analysed according to different criteria.

For the purposes of this paper, a classification based on technological content is particularly relevant. In the industrialised economies, the share of medium- and high-tech production in manufacturing added value rose from 59% in 1985 to 61% in 1998. The corresponding figures were 42.5% and 49% in developing economies – showing clearly that the North-South technological gap, although still high, has partially been eroded.

Concerning trade specialisation, the EU's strengths are concentrated in the medium- and high-tech. sectors (Figure 3), and are offset by weaknesses at all the other technology levels. Although the broad features of the EU trade pattern have remained stable over the past thirty years, it is interesting to see that the comparative disadvantage in high-tech products emerged only in the '80s, and was almost completely eliminated during the '90s.

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[3] World Bank, world development indicators, 2003

[4] Observatory of European SMEs 2002/No 2 – SMEs in Europe, incl. a first glance at EU candidate countries

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

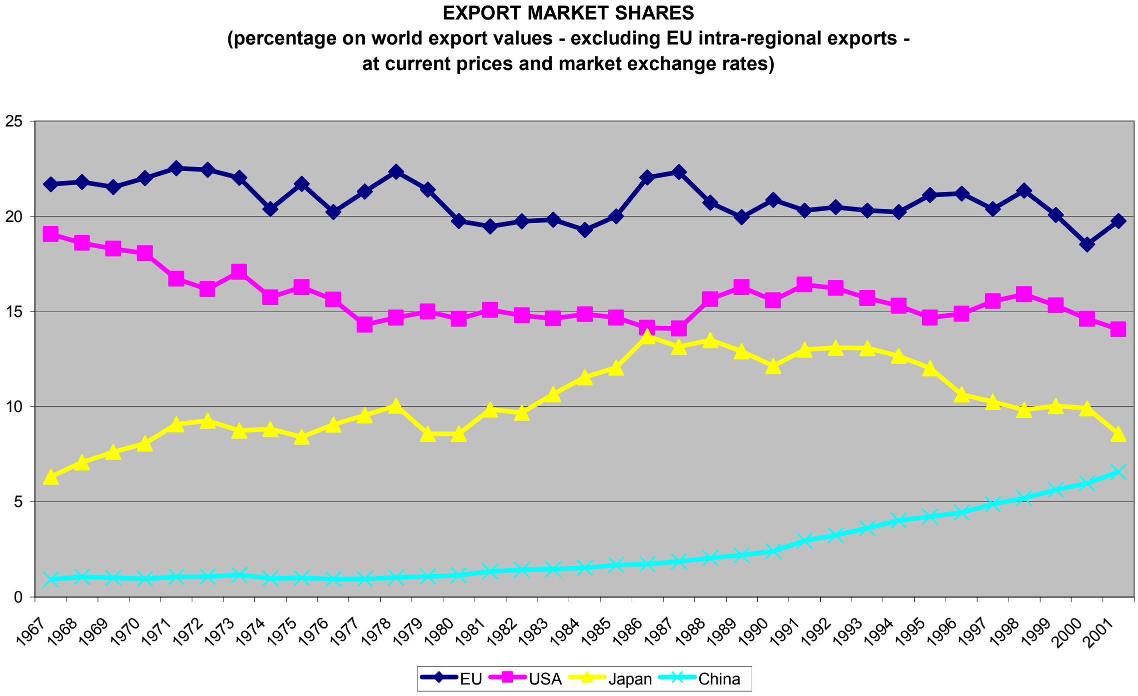

Figure 2 [6]

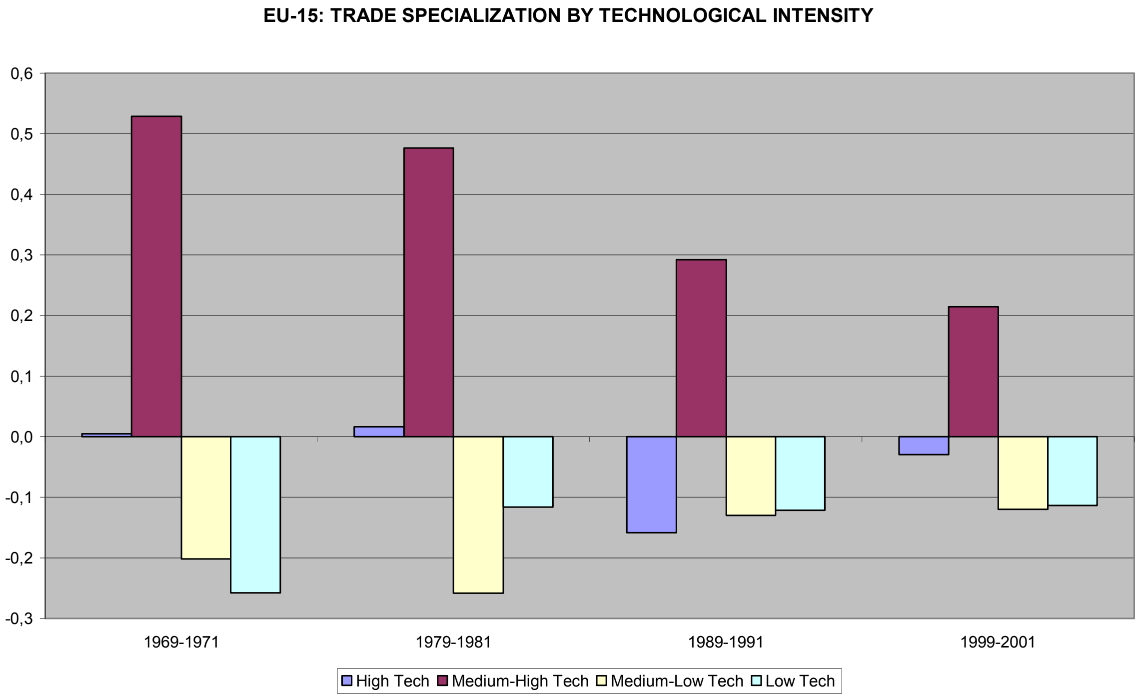

Figure 3 [7]

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[6] L. Iapadre, R. Martana "European Union in the international economy: trade specialization and R&D investment", Working Paper, CNR-ITIA, EPPLAB, September 2003.

[7] L. Iapadre, R. Martana "European Union in the international economy: trade specialization and R&D investment", Working Paper, CNR-ITIA, EPPLAB, september 2003. The source of data is the CHELEM database, produced by the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII), Paris, France. The 71 CHELEM product categories have been aggregated into 4 technological groups following T. Hatzichronoglou, "Revision of the High-Technology Sector and Product Classification", STI Working Papers 1997/2, OCDE/GD(97)216, Organization for Economic Co-Operation and Development, Paris, 1997

As far as R&D investments in the different sectors and technologies are concerned, significant differences can be observed. Among the 15 EU countries, there are also wide differences: from 2.1% in Spain to Sweden's 11.3%. The following table indicates the allocation of these expenditures to different manufacturing sectors in Europe, the US and Japan.

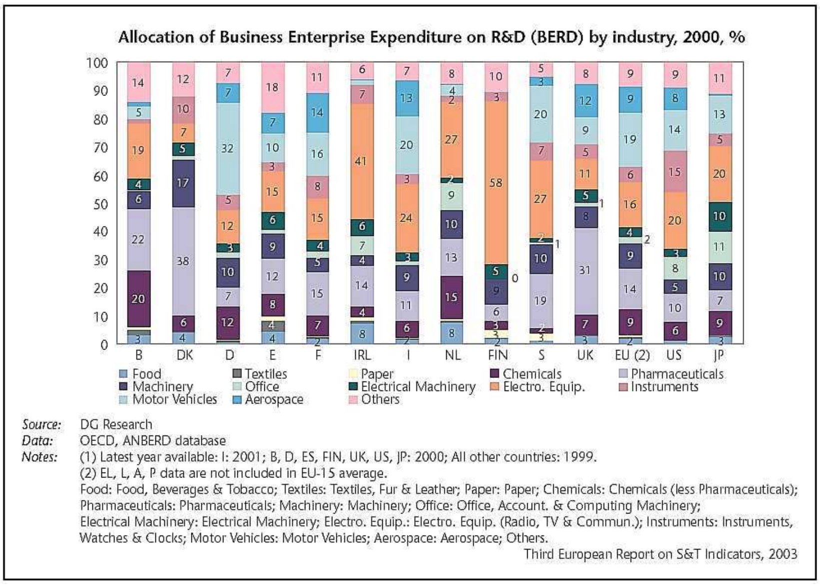

Figure 4: Allocation of business enterprise expenditures on R&D

Considering business expenditure related to added value, the share for manufacturing R&D in Europe (5.7%) is below that of the US (7.8%) and Japan (8.4%). However, if high-tech patenting is used as an indicator of technological competitiveness, the EU has a substantial lead over the US and Japan in materials technologies[8] and is today quite strong in the field of manufacturing. Also based on the patent situation, as shown in Figure 5, Europe's areas of technological specialisation are mechanics and processes, while its weakest specialisation areas are electricity/electronics and instruments.

NB: The current available analysis generally compare the EU with the US and Japan. However, it is felt that further analysis is needed considering the emergence of other Asian and Pacific actors in many fields of manufacturing.

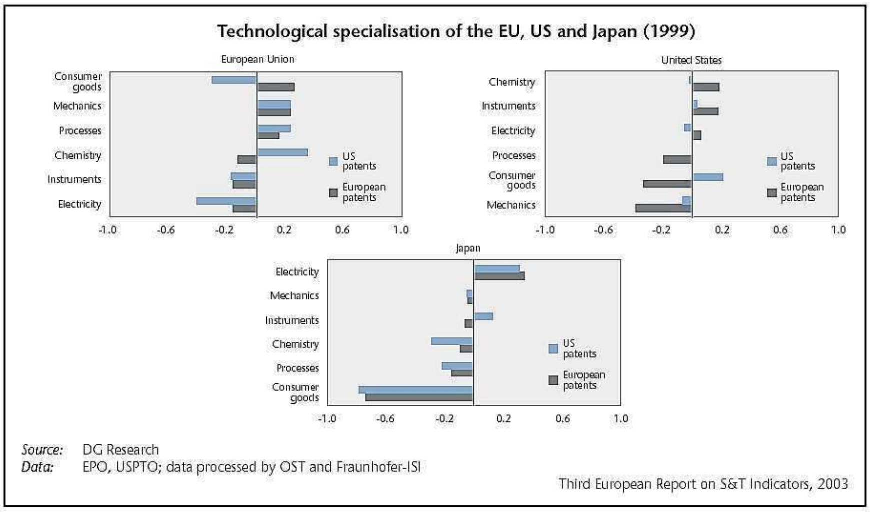

Figure 5: Technological specialisation.(Source: Third European Report on S and T Indicators)

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[8] 3rd European report on Science and Technology Indicators

1.4. EU manufacturing industry: strengths, weaknesses and threats

In most sectors, global comparisons show that European manufacturing industry has been, and continues to be, successful in maintaining its leadership. However, this position is menaced on two fronts. On the one hand, EU industry faces continuing competition from the other developed economies, particularly in the high-technology sector. On the other, low-wage economies are increasingly threatening the more traditional manufacturing sectors.

It should be noted that, while even today there are marked differences between the individual Member States, the industrial landscape of the EU will change considerably following its enlargement next spring. At that time, the community will embrace a group of countries with relatively low-wage economies, yet considerable technological experience.

The implications for industrial policy have been discussed in a Commission Communication 'Industrial Policy in Enlarged Europe'[9], which identifies a number of strengths and weaknesses of European industry:

Strengths:

- European industry is modern and competitive in many respects. Most sectors have made significant efforts to upgrade their production infrastructures and integrate new forms of organisation;
- A long lasting industrial culture exists, with large European networks, linking suppliers, manufacturers, services and user companies;
- Europe has taken on board the sustainable development dimension. Significant investment in environmental protection, clean technologies and environment-friendly production processes have led to new manufacturing and consumption paradigms; This could give a strong impetus to EU industry, offering the potential to expand and/or create new markets;

Weaknesses:

- Productivity growth in European manufacturing industry as a whole has been below US levels in recent years; Increases in ICT and new technology spending over years seems not yet to be translated into productivity gains;
- The Commission's competitiveness reports of 2001 and 2002 have identified insufficient innovative activity and weak diffusion of new technologies as key determinants for low productivity growth;
- EU tends to specialise in medium- to high technology and mature capital-intensive industries, while competitiveness in some of the highest value-added segments of the economy is less encouraging;
- Structural problems in the European economy remain, e.g. fragmentation of research activities, obstacles to geographical mobility and pervasive skill gaps for many categories of worker.

Although a traditional characteristic of Europe has been a good high-level education system, and the average time spent under education by the working population has increased steadily, the EU is currently under-performing the US and Japan. Spending on education as a percentage of GDP has been in steady decline, potentially leading to a weakness in the long term. Threats also exist with countries such as India.

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[9] Industrial Policy in Enlarged Europe, COM(2002) 714 final

Another characteristic of European enterprises is that the majority are SMEs (93% micro-enterprises, 6% small, less than 1% medium and only 0.2% large). On average, a manufacturing enterprise provides employment to 16 persons. This characteristic can be related to opportunities (flexibility, innovative character) but also to weaknesses (e.g. smaller export impacts: SMEs export only 13% of turnover, whereas large enterprises gain 21% of their total turnover from abroad). Furthermore, as far as research is concerned, SMEs are more interested to short-term activities, rather than longer-term commitments.

Finally, while the pursuit of new production paradigms might involve significant disruption, failure to break the current pattern gives rise to equally serious threats for European industry:

- Competition with low-wage countries in labour-intensive, mass-consumption products will be more and more difficult for EU manufacturers;
- European companies could increasingly resort to delocalisation if the region's environment for business and innovation is not sufficiently favourable[10].

1.5. Investment in RTD in manufacturing today

"Investments in research and technology are responsible, depending on the sectors, for between 25% and 50% of economic growth…"

1.5.1. The European programmes and initiatives are almost 20 years old

To face the various challenges, public support for research and innovation in manufacturing technology has steadily increased in Europe since the late 80s. This effort has tended to be more focused during the latter years, directed towards emerging new technologies such as 'nanotechnology'. The table below (Figure 6) indicates the amount of EU public support given to research on manufacturing technologies during the various EC Framework Programmes:

	FP1 (84-87)	**FP2 (88-91)**	**FP3 (91-94)**	**FP4 (95-98)**	**FP5 (99-02)**	**FP6 (03-06)**
Programme acronym	Brite	Brite-Euram I	Brite-Euram II	Brite-Euram III	Growth	NMP
EU funds	185 MECU	620 MECU	748 MECU	1617 MECU	2700 M €	1300 M €

Figure 6

In FP6, specialisation can be illustrated by the NMP priority, devoted to 'nanotechnology and nanosciences, multifunctional knowledge-based materials, new production processes and devices'. A similar focus has appeared in the priority 'aeronautics and space' – a domain that was previously included in the GROWTH programme, but which is now the subject of a specific priority.

[10] Although there is no consensus that delocalisation would be a serious threat, an indication of the volume is given in two studies carried out by Deloitte & Touche in the Netherlands ('Made in Holland', I and II), which identify that one in five companies with more than 50 employees is planning substantial relocation of production capacity within the next two years. In 2003, 20% of the companies surveyed indicated that this has in fact occurred during the past two years;

Complementing FP6, EUREKA – a European initiative[11] oriented towards applied research – has since the 80's also defined the manufacturing domain as one of its priorities. A EUREKA 'umbrella', entitled Factory, is active in this field. The basic purpose of this umbrella is to stimulate R&D projects dealing with the future development of production. It involves the integration of technology, human resources, management and organisation in order to respond to market needs, as well as social and environmental concerns. Figure 7 positions EUREKA (Factory) activities vis-à-vis the Framework Programme research instruments, and illustrates a possible interaction model.

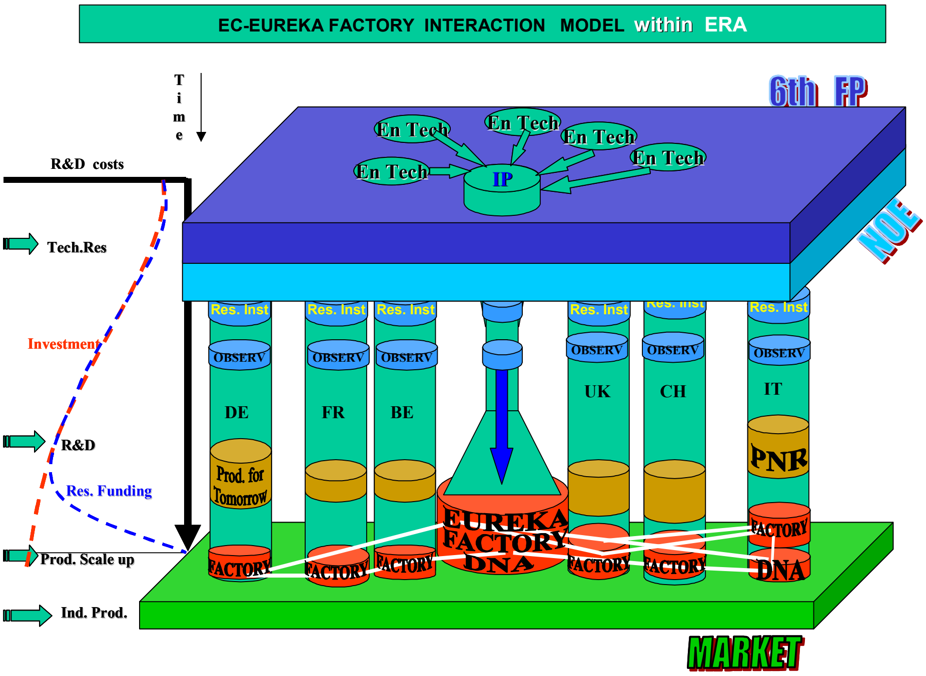

Figure 7

1.5.2. … but, investment in research at EU level is still too low.

Figure 8 refers to all R&D expenditures (government and business enterprises) and shows them as a percentage of GDP in the EU (◆), Japan (☐) and USA (△) between 1992 and 2002. The gap is important!

If we also look into the structure of the expenditures between public and private sectors (Figure 9), we find that enterprises in Europe are clearly not investing enough in research. This raises many potential problems linked to the sustainable competitiveness of the European manufacturing sector in an increasingly complex and globalised environment.

A significant investment in research would help to sustain not only competitiveness but also employment – as evidenced by the Netherlands where, between 1994 and 1998, 8% of fast-growing firms created 60% of employment growth[12].

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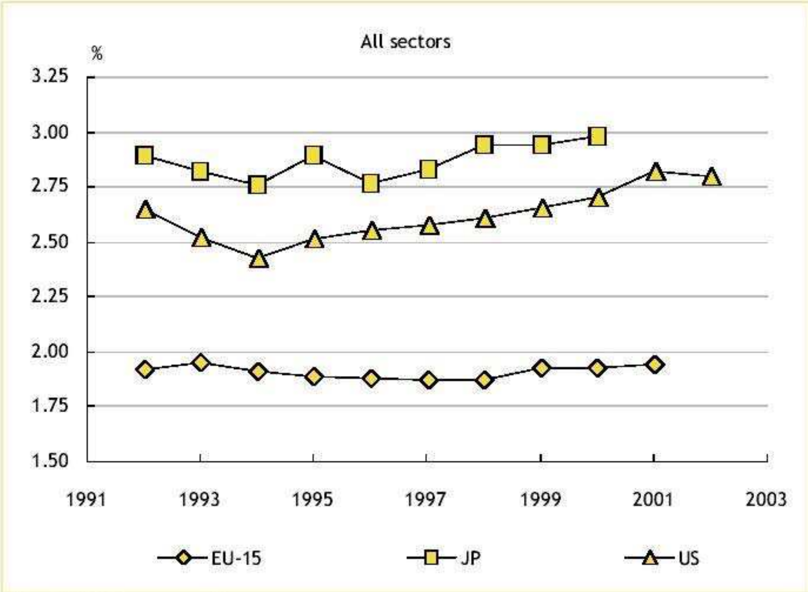
[11] EUREKA was founded in 1985 to strengthen the global competitiveness of European industry by promoting Europe-wide co-operative R&D. 33 European countries and the European Union are now members. Each EUREKA project involves partners from at least two Member Countries and aims to develop advanced civilian products, processes and services for the world market.

[12] 'Entrepreneurship in the Netherlands, Innovative entrepreneurship. New policy challenges!' Ministry of Economic Affairs and EIM, February 2002.



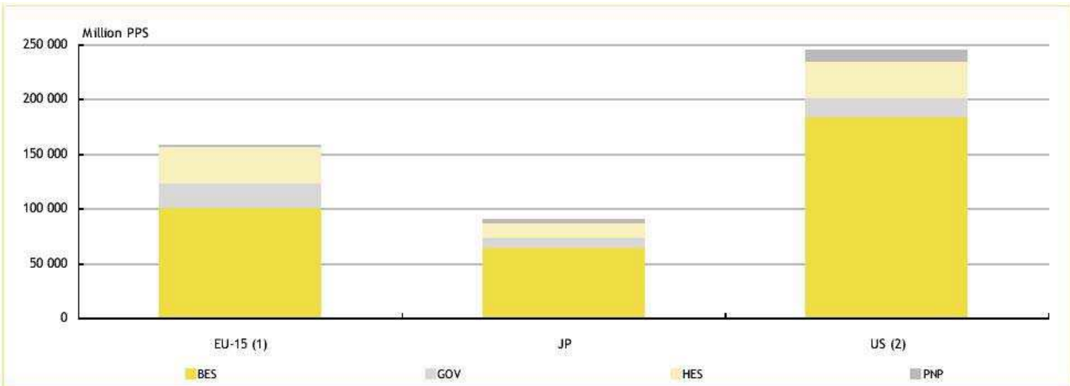
(1) EU-15: Eurostat estimates.
(2) JP 1990-95: overestimated or based on overestimated data.
JP 1996: break in series with previous year for which data is available.
(3) US: excludes most or all capital expenditure; 2001 and 2002: provisional data;
2002: OECD Secretariat estimate or projection based on national sources.

Sources: Eurostat – R&D statistics, OECD – MSTI 2002-2.

Figure 8: R&D expenditures (government and business enterprises) as % of GDP

The graph (Figure 9) shows clearly why, in the Barcelona European Council, the heads of state set an objective to increase investment to 3% of GDP by 2010, in order to bridge the gap with the other regions.

Apart of proposing to redirect public spending towards research and innovation, the '3% action plan' places the onus mainly on the business sector, and especially on the manufacturers. It implies also progressing jointly, improving public support to research and innovation as well as framework conditions for private investment in research.



(1) Eurostat estimates.
(2) All sectors – provisional data;
BES and HES: excludes most or all capital expenditure;
GOV: federal or central government only.

Sources: Eurostat – R&D statistics, OECD – MSTI 2002-2.

PNP – Private Non-Profit Sector (Top of chart), HES – Higher Education Sector,
GOV – Government Sector, BES – Business Enterprise Sector (Bottom of chart)

Figure 9: R&D expenditures (2000) in PPS – Purchasing Power Standard

2. LONG-TERM GOALS FOR EU MANUFACTURING INDUSTRY

2.1. Manufacturing and geopolitics

Two elements – wealth creation and employment – place manufacturing more and more at the core of geopolitics. As already stated, manufacturing activities are an essential part of nearly every regional economy. Nevertheless, manufacturing (and the related employment) is under pressure in the EU due to many factors, ranging from the need for continuous innovation to continuous productivity gains, from the current macroeconomic conditions to the globalisation of markets or from the relocation of enterprises to the emergence of new competitors.

A crossroads lies ahead of us. Which direction should and will Europe choose? And how will it resolve the paradoxes that policy should be simple yet embrace complexity; that policy should sustain diversity yet offer some uniformity; that policy should allow for the creation of new businesses yet preserve the traditional and necessary industrial base?

It is a fact that the future of manufacturing in Europe could differ greatly, depending on whether economic factors alone are considered, or if more emphasis is given to societal parameters. The Lisbon Strategy and the various EC communications show the route that Europe should follow:

… the path towards a thriving, world-leading manufacturing industry that addresses the needs of a sustainable society in an increasingly interconnected world!

A strong transformation of industry and of the industrial environment is necessary to cope with the various challenges, but any action should ensure that both 'knowledge' and 'manufacturing capacities' remain in Europe, since these are the keys to European independence, wealth creation, quality of life and employment prospects.

2.2. The need for change

… a matter of survival …

If the manufacturing sector is to survive over the next two decades, it will have to undergo dramatic changes in technological, environmental, economic, and social terms. The **principal drivers** of these changes are:

- an **increasingly competitive economic climate**. The context in which manufacturing companies will 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 **servation** of manufacturing will have consequences for the organisation of production, supply-chain management and customer relations.
- **advances in science and technology**, specifically in the fields of materials science, electronics, information technology and biotechnology. The development of new production processes based on research results, and the integration of hitherto separate technologies, may radically change both the scope and scale of manufacturing. Nanotechnology and new energy technologies (e.g. fuel cells) could offer prospects for a wide range of product and process innovations.
- **environmental challenges and sustainability requirements**. The manufacturing sector will have to comply with stricter environmental regulation in the future. Markets, too, may demand more environment-friendly materials and products. To realise efficiency gains, manufacturers should adopt energy- and resource-saving technology. It should be also noted that 'new technologies' offering remedies to current environmental problems, could also create new ones…

- **socio-demographic aspects**. Manufacturing in 2015-2020 will be called upon to provide solutions meeting new societal needs and the demands of an ageing society. Concerning the labour supply, the manufacturing and research sectors will be confronted with the retirement of the current large age groups. Radical innovation might require completely new sets of skills, the availability of which, both in manufacturing and in research, could become a critical factor.
- **the regulatory environment, standards, and IPR.** Stricter environmental and safety regulation may facilitate change in manufacturing industry. 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 to ensure reliable and interchangeable devices.
- **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 is being adopted and exploited.

The FutMan Scenarios (2015-2020)[13]

The Futman study developed a scenario analysis with the aim to offer imaginative pictures about possible socio-economic developments and future technologies that are likely to shape the European manufacturing sector over the coming years. In the ***Global Economy*** *scenario, the free market has been considered the most effective way to allocate resources. Technological change in manufacturing is likely to concentrate on realising productivity gain in a globalised economy. If one assumes more powers of regions and local interests in the Future, such as in the* ***Local Standard*** *scenario, manufacturing may concentrate on the introduction of new centralised production technologies to cope with the complexities of supply-chain management. In the* ***Sustainable Times*** *scenario, characterised by consumers who adopt mores sustainable consumption pattern, manufacturing may strongly focus on service provision and exploitation of renewable material and energy technology. New export opportunities for innovative and sustainable technology are portrayed in the* ***Focus Europe*** *scenario, where Europe pushes ambitious mission-orientated manufacturing technology programmes.*

The Futman study concludes that the interplay of a variety of key drivers will contribute to shaping the future landscape of manufacturing in Europe. The FutMan scenarios indicate that success will depend on successful alignment of the technological, organisational, and societal factors that are required for 'system changes'. The scenarios further suggest that the obstacles to progress towards sustainable manufacturing seem to be located mainly in the cultural, political and market arena, rather than in a lack of technological opportunities.

[13] The Future of Manufacturing in Europe 2015-2020: The Challenge for Sustainability – DG research

2.3. From resource-based to knowledge-based manufacturing

- A critical step in preparing for the future is the laying of an underlying socio-technological foundation, through integrated actions between research, education and innovation, carried out by industry, academia, and public institutions. Decision-makers must be guided by a clear vision of manufacturing in the next decades and an understanding of the fundamental challenges that must be met to realise this vision.

The following statements reflect visions in manufacturing, which the conference may confirm, extend or adapt.

- Manufacturing is the key element of the value chain. However, it should be considered from a holistic perspective. The future of manufacturing is indeed linked with the realisation of benefits for the final customers and society in general; companies should view their respective individual evolution in this context. For example, if industry is able to deliver a customised product in few days, it is clear that the major part of the value chain will be in Europe, with obvious consequences for employment.
- Future manufacturing will be confronted with a society-driven, high-value-added environment. Mass customisation will remain an important paradigm, which brings the benefits of customised manufacture – individually tailored products that better satisfy the needs of the customer – to mass production.
- The extended manufacturing enterprise must therefore comprise all functions that together generate and service customers' and society's needs in connection with the manufactured product. Logistics, finance, maintenance, end-of-life treatment, data management and R&D are all parts of the value chain.

Manufacturing in 2020

The planning, co-ordination, operation and maintenance of manufacturing operations in 2020 will maintain and reinforce the need for skilled human capital. The integration of human and technical resources will be crucial in enhancing productivity and workforce satisfaction in Europe. R&D, design engineering, manufacturing, marketing, and customer support will become progressively more integrated, so that ultimately they will function concurrently as virtually a single entity linking customers to innovators of new products.

New corporate architectures will emerge. The assets of an innovative company will move from physical machinery to more intangible property. Ultimately the form and identity of companies will be evolving towards virtual structures that will come together and vanish in response to a dynamic marketplace. However, these 'integrating enterprises' cannot function without 'materials enterprises', albeit far fewer of them, that are processing raw and recycled materials into finished engineering materials.

Apart from the continuing and progressive improvement of the 'top-down' approach to micro/nano-manufacturing, a 'bottom-up' approach towards self-assembling systems can be envisaged in the longer term (2020 and beyond). The availability of new materials will also facilitate the production of more easily customisable products and will therefore be the basis for sustained innovation in traditional sectors.

The vision for future manufacturing is that more and more organisations will have to adopt an agile mindset in managing relationships to find world-class customer and supplier partners. In this context, manufacturing businesses will have to make continuous reassessments of their core strengths and competencies. Companies will need to increase their focus on high-added-value products and technologies, yet at the same time broaden the total service spectrum within which these are brought to market.

A new type of industrial manufacturing actor will also appear in the value chain, its role being 'the creation, transformation and management of knowledge' (complementary to transformation and management of physical matter). This underlines the need for the role of universities and research centres to change in the years to come, if they are to support the transition from resource-based to knowledge-based economy.

2.4. The MANU*FUTURE* paradigm

… towards European leadership! …

A new mode of knowledge generation is emerging in the form of a knowledge-supply network. Hence the key opportunity for future manufacturing may be seen as the efficient integration – within appropriate domains – of knowledge demand and supply networks to attain strategic competitiveness and sustainability. The great challenge facing us is to foresee how this global 'fabric' may develop, implementing the Research-Industrial Innovation Value Chain and combining national interests with global advantages.

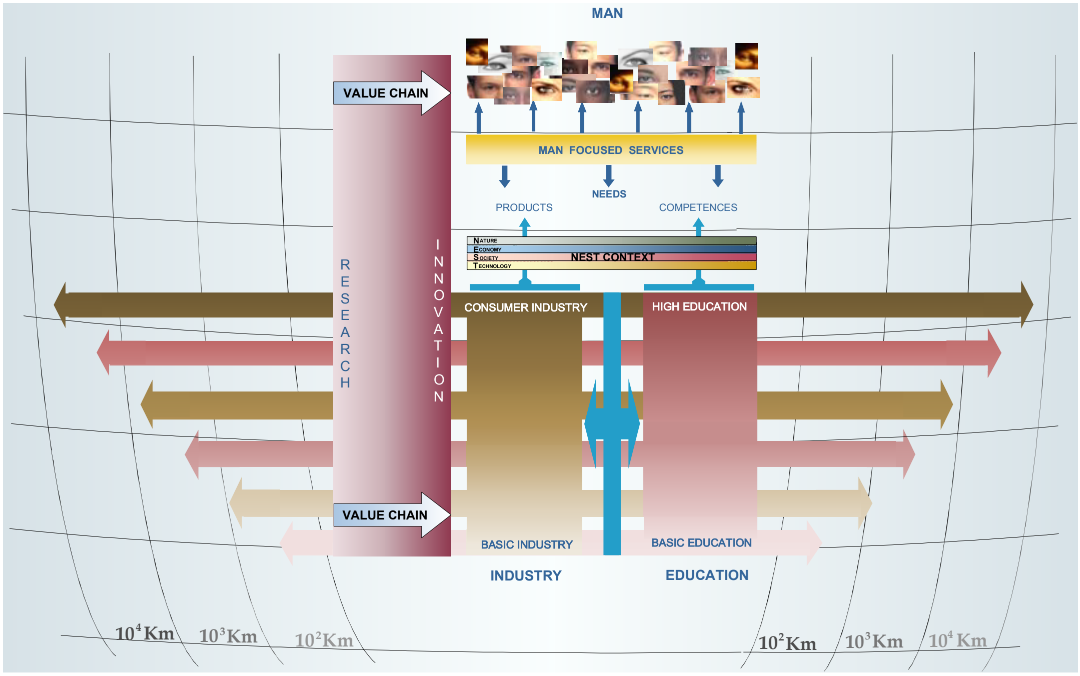


Figure 10: MANU*FUTURE paradigm: globalising knowledge-based manufacturing.*

The above concepts can be distilled to a paradigm we shall call MANU*FUTURE (see figure 10)*, based on:

- The value chain linking 'human and societal needs' to both the industrial and education systems;
- The value chain linking research and industrial innovation, that helps and drives the evolution of the Man-Industry Value Chain;
- The networks of enterprises and universities, research institutes and centres, continuously 'manning', integrating and managing the above globalising value chains, within a changing natural, economical, social and technological (NEST) context.

European leadership will rely on the Manu*future* paradigm considering that the generation of knowledge (K Generation) involved will depend on RTD activities as well as best use of the special European cultural heritage and environment (such as for design).

Such conditions can enable a 'renaissance' of European manufacturing.

2.5. Creating the right environment for innovation and employment

What drives innovation in products and processes?

- The ***innovative spirit*** promoted by company culture, giving everyone possibilities for self-fulfilment is the strongest driver for creating a *learning innovative organisation*[14]
- ***Customer requirements*** are according to several recent surveys driving up to 80% of the cases leading to major innovations. The areas of innovation are concentrated to *products and teamwork between customer and supplier*.
- ***Investment in research*** allowing companies to fulfil their innovation potential including changing the image of manufacturing to one of high-tech, clean, safe and service-oriented, maintaining sufficient employment in the manufacturing sector, creating an environment that improves skills and stimulates creativity, ensuring public acceptance of new technology.

However, innovative spirit, customer – supplier partnership and research will not provide every required solution. Progress in these areas should be integrated with other innovation-related actions such as those dealing with regulation or entrepreneurship, as well as with better education.

Challenges for EU manufacturing industry can be summarised as follows:

- **Expanding highly skilled organisations and fostering an innovation culture in industry:** The answer is to support the development of a high-tech industry, based on an effective, knowledge-based workforce. There is a need for effective approaches to innovation and for best organisational methods in businesses;
- **… based on an increased knowledge of industrial processes, and of life-cycle parameters of manufactured products:** The aim should be to help develop long-term visions, compatible with sustainable development and the growth of industrial activities in Europe, based on effective collaborative research activities;
- **… supported by schools and universities:** Improved education and training schemes, easier mobility for researchers and engineers; and stimulation of an entrepreneurial spirit are all desirable. Life-long learning should not be forgotten, considering the demographic changes in Europe in the years to come;
- **… better infrastructures:** Such infrastructures should help industry, in particular SMEs, to implement new technologies and organisational practices. Europe-wide networks that give access to innovation possibilities are required, thereby stimulating implementation of paradigm shifts in industry;
- **… and a framework conducive to entrepreneurship:** Adaptation and simplification of the legal and regulatory environment, especially with respect to intellectual property rights, and the provision of easier access to finance would be important ways to motivate innovative enterprises;

Great potential exists if European, national, regional and private efforts can better be co-ordinated and integrated. To engender continuing success, changes of emphasis in Community research must 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.

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[14] A **learning organisation** is skilled at five main activities: (a) systematic problem solving in working groups or networks, (b) experimentation with new approaches, (c) systematically learning from own experience and past history, (d) systematically learning from the experiences and best practice of others (benchmarking) and (e) transferring knowledge throughout the organisation

PART B - The road to MANU*FUTURE*: five drivers

The following chapters define the roles of research, international co-operation, education and information dissemination in stimulating the transformation of the manufacturing industry. Of course, these activities should go hand in hand with the development of a consistent policy, regulatory and financial framework at EU level to promote a favourable environment for high-added-value industrial and research activities in Europe.

- **Increased research and technological development**

  Observation, reflection and long term actions …

- **International cooperation in manufacturing research**

  Working together …

- **The key role of education and training**

  To enable moving towards
  'sustainable production and consumption'…

- **Need for a stimulating operating environment for industrial innovation**

  A consistent general policy framework
  and efficient financial support…

- **An increased competitiveness of European research**

  Better, Cheaper, Faster …

3. THE FIRST DRIVER: INCREASED RESEARCH ACTIONS AND RESEARCH INFRASTRUCTURES

Observation, reflection and long term actions …

3.1. Looking ahead

Research and innovation are key factors in paving the way towards a MANU*FUTURE* of high-tech, flexible, clean, safe, highly skilled and society-driven organisations.

Observation and reflection are the basis of foresight activities. In recent years, the world has become more complex. Today more than ever, acquiring an informed view of the possible paths for the evolution of European manufacturing industries is vital input for policy-making and the formulation of industrial strategies.

It is important to better understand the evolution of markets, of society's and customers' needs – and, above all, to identify the bottlenecks and try to eliminate them.

The following table (ref. 11) shows the evolution of demand for research, and the response of the research community, during the industrialised era. There is an evident move towards increasingly integrated approaches to the solution of more and more complex problems.

Paradigm	**Craft Production**	**Mass Production**	**Flexible Production**	**Mass Customisation and Personalization**	**Sustainable Production**
Paradigm started	~1850	1913	~1980	2000	2020?
Society Needs	Customised products	Low cost products	Variety of products	Customised products	Clean products
Market	Very small volume per product	Demand > supply Steady demand	Supply > demand Smaller volume per product	Globalisation Fluctuating demand	Environment
Business Model	Pull *sell-design-make-assemble*	Push *design-make-assemble-sell*	Push-Pull *design-make-sell-assemble*	Pull *design-sell-make-assemble*	Pull *Design for environment-sell-make-assemble*
Technology Enabler	Electricity	Interchangeable parts	Computers	Information Technology	Nano/bio/mat-erial Technology
Process Enabler	Machine tools	Moving assembly line & DML	FMS robots	RMS	Increasing manufacturing

Figure 11: Evolution of demand for - and response of - industrial research

More Europe-wide foresight studies are necessary. These would aim at developing a long-term vision for EU manufacturing industry, associated with integrated approaches encompassing new manufacturing technologies, biotechnologies or information technologies, as well as social sciences and humanities, including the cognitive sciences.

3.2. Embracing systemic and 'disruptive' approaches

Because manufacturing involves a complicated mix of people, systems, processes, and equipment, the most effective research has proved to be multidisciplinary and grounded in knowledge of manufacturing strategies, planning, and operations. One can already verify that the combination of manufacturing and production technologies with information technologies and biotechnologies has an impressive synergetic potential.

Some enabling technologies may be catalysts for further 'technological revolutions' and can therefore be regarded as 'disruptive': leading to radical changes in industries' innovation processes. This will soon be the case for nanotechnology, nanoscale precision engineering, and environmental technologies, which possess real potential to originate discontinuities e.g. in products/services, production routes or education.

The table below (ref. 12) summarises future manufacturing challenges and the required responses, as identified in recent roadmap studies:

Manufacturing challenges for 2020[15]	IMTI roadmap[16]
Achieve concurrency in all operations.	Lean, Efficient Enterprises
Integrate human and technical resources to enhance work-force performance and satisfaction.	Customer-Responsive Enterprises
"Instantaneously" transform information gathered from a vast array of diverse sources into useful knowledge for making effective decisions.	Totally connected Enterprises
Reduce production waste and product environmental impact to "near zero."	Environmental Sustainability
Reconfigure manufacturing enterprises rapidly in response to changing needs and opportunities.	Knowledge Management
Develop innovative manufacturing processes and products with a focus on decreasing physical dimensions.	Technology Exploitation

Figure 12

The Commission-funded FutMan study took a somewhat different approach by investigating three broad strands: materials technologies, transformation processes and structure of industry. Although the high-level manufacturing challenges are not identified as a single list, a convergence can be noted between this and the studies quoted in the above Figure. Many of the avenues for research are crosscutting areas, i.e. they are applicable to several sectors or domains. This is the case for 'adaptable and reconfigurable manufacturing systems', 'information and communication technologies', and 'modelling and simulation'.

Enabling technologies

An enabling technology is one that underpins significant developments in other technologies and opens up several fields of application with an effect on many industry sectors. At the same time, due to its pervasive effect, an enabling technology is bound to have a profound impact on society, industry, policy, products and processes, as well as on the life of every individual. The EC RTD+I Framework Programmes are supporting such multi-sectoral approaches.

[15] An international Delphi survey "Visionary Manufacturing Challenges for 2020" commissioned by the US National Research Council in 1998

[16] The US Integrated Manufacturing Technology Roadmapping Initiative "Manufacturing Success in the 21st Century

Further European research roadmaps should be established. Rather than trying to anticipate the advances over a 20-year term, general long-term goals should be established in each technology area, and detailed roadmaps be realised for five-year timeframes. A detailed research action plan based on the major challenges and priority technology areas for manufacturing should then be developed.

It is already possible to present with some confidence a number of key enabling technologies for the manufacturing of the future. The following examples (Figure 13) emerge from three prospective studies envisaging a 2010-2015 horizon:

Manufacturing Challenges for 2020	IMTI manufacturing processes & equipment roadmap	FutMan discrete parts and process manufacturing
Adaptable, integrated processes & systems readily reconfigurable	Knowledge repositories & validation centres	New processing technologies for new materials
Manufacturing processes that minimize waste and energy consumption	Intelligent design & process advisors	Miniaturisation
Innovative processes for designing and manufacturing new materials and components	Intelligent control systems	Mechatronic modules
Biotechnology for manufacturing	Distributed control across extended enterprises	Nanotechnology in manufacturing
System synthesis, modelling, and simulation for all manufacturing operations	Science-based manufacturing	Modelling and simulation
Technologies to convert information into knowledge for effective decision making	Zero life-cycle waste	Product life cycle planning
Product and process design methods that address a broad range of product requirements	First part correct	Flexible manufacturing systems
Enhanced human-machine interfaces	Innovative breakthrough processes	Process integration
New educational and training methods that enable the rapid assimilation of knowledge	Engineered materials & surfaces	New concepts for process control and sensor technology
Software for intelligent collaboration systems	Freeform manufacturing	Intelligent manufacturing processes / near net shape

Figure 13

3.2.1. The importance of ICT as an enabling technology

It is clear that ICT is underpinning several of the key technology and business areas mentioned earlier. The use of ICT is the answer to the increased complexity of the industrial environment. Today, it permeates nearly all activities of an enterprise. On the shop-floor, information technology has been used in product design and machine control for quite some time. Industrial automation is a good example of the successful migration of ICT into established sectors. In recent years, many traditional companies have also made significant investments in e-business applications, such as supply chain management systems.

The concept of the 'digital enterprise', i.e. a business that maps of all the important elements of its activities by means of information technology tools, gives a unique way of managing the problems and complexities arising from new production paradigms. *Digital enterprise technology* can be defined as 'the collection of systems and methods for the digital modelling of the global product development and realisation process, in the context of life cycle management'.

Five main technical areas can be outlined as the cornerstones of digital enterprises:

- distributed and collaborative design,
- process modelling and process planning,
- production equipment and factory modelling,
- digital-to-physical environment integrators,
- enterprise integration technologies.

However, the management and optimal, or near-optimal, exploitation of the huge amount of available information cannot be imagined without the effective application of the methods and tools of *machine learning* techniques.

The development and application of more reliable and flexible ICT and intelligent decision-support systems will help enterprises to cope with the problems of uncertainty and complexity, to increase their efficiency, and to improve the scope and quality of their supplier- and customer-relationship management.

3.2.2. New materials and new design paradigms also needed

The revolution in manufacturing will not come to pass through increased use of ICT alone. In recent years, advances in materials sciences have led to the development of new products and improved services. New ceramics, polymers, metal alloys, biomaterials and hybrids are increasingly being used in many sectors. 'Intelligent' materials providing new functionality and improved performance further improve the prospects for product and process innovation in manufacturing.

Meeting new demands and product requirements in key domains such as healthcare (e.g. bio-compatible and bio-mimetic materials), the automotive and aeronautics sectors (e.g. lighter and stronger materials), chemicals (e.g. new catalysts, new reaction and process design) and the electronics and ICT industries (more powerful and smaller computers) depends to a great extent on future advances in materials science and new design paradigms.

Reciprocally, the development of cleaner, eco-efficient and resource-saving products is contributing to the development of environment-friendly materials with long life-spans, and composites that are easy to recover, re-use and/or recycle. Renewable materials could reduce resource consumption and contribute to the attainment of sustainability goals.

Finally, the availability of advanced materials is likely to be a prerequisite for the production of smaller, smarter, and more easily customisable products. New materials may not only play an important role for technology development in high-tech industries, but also for sustained innovation in more traditional sectors.

3.2.3. Miniaturisation and precision engineering

Advances in electronics (Moore's law) are due to the continuous innovation in industrial machines. This obviously forms a clear trend for the next twenty years. In mechanical manufacturing, several topics are clustering around the issues of precision engineering and further miniaturisation of devices. Development in this area has already started, and most studies expect the technologies to develop radically during the coming years (e.g. 'Factory on the desk', 'Mini-factory'). The following issues have been identified as posing research questions up to 2020:

- *Machining procedures for micro- and nano- manufacturing* are expected to remain a problematic area until beyond 2015. The objective is to adapt conventional processes like drilling, grinding and cutting to the needs of micromechanical machining. But scaling down to the nano-level presents completely new research questions and design demands. There is also a call for further research in materials science, as material behaviour changes at the micro- and nano-level. Process knowledge that can be used for modelling and simulation will also become still more important.
- *Micro handling and measuring devices and fixtures* will be key systems in dealing with the high demands of micro- and nano-production. While handling and manipulating matter at the micro- and nano-scale presents many problems, the improvement of handling technologies for conventional manufacturing is equally important. The German study 'Machine tool 2010', which looked at future trends in machine tools, particularly stressed this point. Fields such as high speed nanometer positioning, nano-robotics, non-contact positioning and ultrasonic technologies can be assigned to this area of research.
- *Clean room technologies* will become highly important when micro- and nano-manufacturing become established in new fields, as has been the case in the electronics sector.

3.2.4. Integrative approaches, e.g. mechatronics, process control

As already stated, many new solutions will come from the integration of different disciplines, and from new ways of integrating emerging and existing knowledge. Mechatronics is an example of this trend, characterised by the greatest possible integration of mechanics, electronics and computer science into functional units. Manufacturing systems will change with the increasing ability to combine new materials, electronics and mechanical components. Of particular importance for manufacturing will be modules such as 'mechatronic tool holders' and 'active workpiece fixtures'. But even small devices like seals are expected to become increasingly 'intelligent' by the integration of electronic components such as sensors.

Mechatronic modules will become essential parts of production machines. 'Mechatronic production systems', where all the signals from mechatronic components are integrated for complete manufacturing control, are seen as greatly aiding the rapid reconfiguration demanded for flexible and high-speed manufacturing.

Mechatronics and process control are two of the key research areas for the future. It seems, however, that their application is currently limited by a lack of personnel capable of bringing together the different areas of knowledge involved.

3.2.5. *Extended products*

Just as individual enterprises work together in extended and virtual enterprises so also are many products migrating into extended products by combining traditionally separate products and services, responding to demands for new services and embedding new services (frequently information technology based) into traditional products. This aggregation, which we term Extended Products17, consists of tangible core manufactured products and additional intangible service-based components. The development of Extended Products is not only driven by market demands; legislative pressures may also serve to give rise to such products. For example directives from the European Union are shifting the responsibility for 'end-of-life' products from society back to the manufacturers and distributors of the products. As a consequence, new Extended Products concepts have evolved that package end-of-life take-back and associated recycling with the core product. A simplified perspective on extended products is visualised in the figure below that shows seven key considerations with direct impact on the formation of extended products.

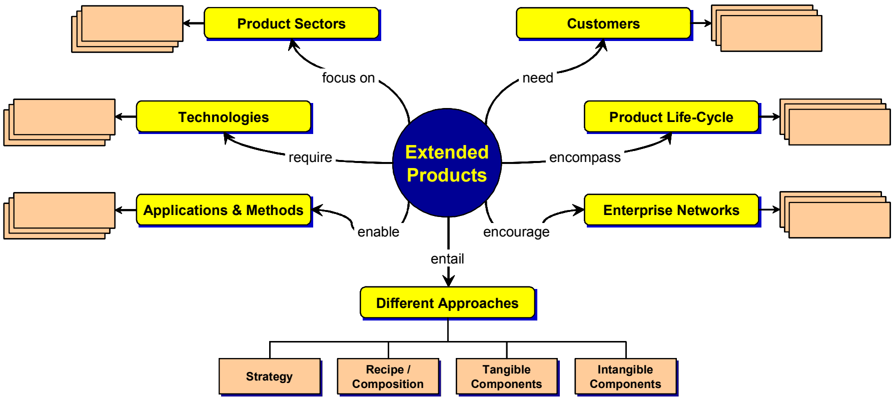

Figure 14: Extended enterprise including product recycling

Just as the term extended enterprise comprises more than a single enterprise, the term extended product comprise more than the core product. The concept behind the term extended products can be represented in the form of a layered model, as follows:

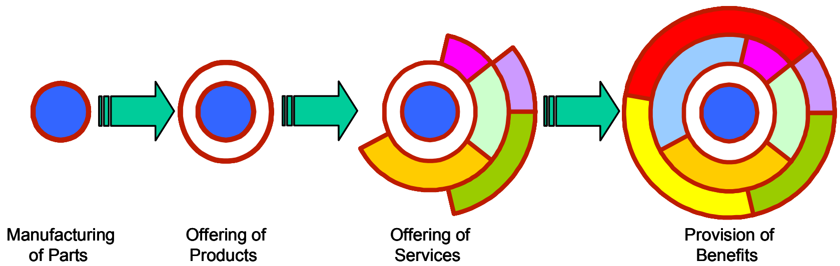

Figure 15: Changing the Focus: from manufacturing of parts to provision of benefits

- The first (inner) ring describes the core product which is closely related to the core function(s) of a product. An example can be the mobile phone which has, as core functionality, the ability to receive and transmit data in a location independent mode.

[17] See 'Strategic Decision Making in Modern Manufacturing' by H.S.Jagdev, A.Brennan and J.Browne, Kluwer Academic Publishers, Boston, USA, 2004. ISBN: 1-4020-7497-2.

- The second (middle) ring describes the packaging of the core functions. In the case of the mobile phone, tangible features can include the packaging or the user interface.
- The outer rings address the intangible assets of the product and the growing importance of services in manufacturing operations. In fact, service providers are often ready to subsidise the 'purchase' of the core product (the mobile phone) to facilitate the use of their networks and their information products.

3.2.6. New technologies for tomorrow's products

Three other significant challenges can be identified for the manufacturing industries:

- due to continuously changing customer demands, product life cycles are decreasing, and, for the same reason, product variants are increasing, leading to smaller batch sizes, and;
- the societal pressure is increasing to decrease environmental and health negative impacts of manufacturing operations.

Addressing these issues necessitates fast and flexible manufacturing systems as well as close integration of product- and production-process development. The various challenges call for strong development of research activities aimed at reshaping industrial organisations.

Considering the holistic approach required, research activities should be developed, mixing basic and applied research, technological and societal sciences, and targeted at all the important steps of the manufacturing processes and of the value and life-cycle chains.

The previous examples have shown how products are evolving. But who knows the future? What will be for example the nature of be the next generation of automobiles? Most probably, fuel cells are likely to replace conventional engines… These possible evolutions place radical new hurdles in the path of the manufacturing sector. For example, existing machine tools are designed to produce motors, gearboxes, crankshafts, etc. How should they be designed in the future to produce electric motors? The required technological competences may be very different. The same applies to the 'bottom-up' manufacturing that may appear in the long term, following advances in nanotechnology and nano-manufacturing.

These examples illustrate the need for robust foresight studies and for the development of new manufacturing technologies, based on research activities at the 'frontiers of knowledge'.

3.3. Moving in the right direction

Leadership means "the art of giving others the envy of doing what you want to be done"
(Vance Packard)

Development of the knowledge and technologies necessary to sustain a real revolution within industry requires an adequate availability (quantity and quality) of research resources and infrastructures. Policy introduced within the ERA makes it possible. An efficient ERA will also be a determinant factor in allowing for better employment (number and skills of employees) in high-technology domains. At the same time, it will greatly facilitate the forging of links between the research and industrial constituencies, and between private and public partners.

3.3.1. Longer term research industry relationships and interactions

As already shown, the EU Framework Programmes have dedicated funds to manufacturing technology and related research activities for more than 15 years. Relations between research and industry were stimulated strongly during the 90s, and targeted at 'problem-solving' approaches. This created a shift towards shorter-term research.

However, the long-term sustainability of European manufacturing industry should be based on radical innovation and the development of new technologies. Consequently, industrial research must also shift towards longer-term visions.

To boost the EU's prominent position, a critical mass of research entities, technology transfer undertakings, incubators and demonstrators needs to be mobilised within the ERA. This should parallel a marked increase in industrial long-term research investment.

3.3.2. Clearer support to industrial research

Industrial participants need to make further efforts to increase their investment in research, following the trend acknowledged during the past 10 years by the OECD (Fig. 16).

Funding \ year	1990	2000
Government	39,60%	28,90%
Industry	57,50%	63,90%

Figure 16: Government and Industry R&D Funding- Source: OECD

The current support by public authorities needs also to be increased. In particular the 'horizontal' measures existing for SMEs – collective and cooperative research – are considered the most adequate instruments by which the SMEs of the manufacturing sector can seek to participate in European research activities. Also the specific "SME IP" of the NMP priority of FP6 constitutes another viable option.

However, another crucial group are the 'midrange' companies (250 - 1000 employees). These companies constitute the bulk of the innovative enterprises which are real drivers of the innovation in the manufacturing sector. They have an annual turnover of approximately € 40 – 150 million, of which about 3.3% is for R&D. Were the European research instrument be more flexible, many 'midrange' companies could be tempted to participate.

The third group consists of very large companies. They employ nearly 30% of the workforce. They are expected to have sufficient capacity to co-ordinate and take leadership in the management of larger projects that are of interest to them.

Lastly, service related companies should not be forgotten since, as it has been shown, the competitiveness of a product is more and more related with its service content.

A clear and consistent strategy is needed in Europe to support the competitiveness of industry and the improvement of its technological base.

The role of research and innovation activities, as well as of research infrastructures, is crucial in this objective. However, actions should be considered as part of a systemic approach aimed at improving overall conditions for sustainable industrial development, with industries of all sizes.

3.3.3. Competence centres on the increase

A preliminary, and by no means exhaustive, analysis confirms the trend towards the development of multi-disciplinary, multi-stakeholder structures around strong scientific nuclei, or at least around regional clusters. One initiative has been launched by Germany, which in 1998 created a number of competence centres for manufacturing technology (CCN)[18]. These have the form of thematic networks on various subjects. Another well-known example is the French Minatec Micro- and Nano-technology Innovation Centre[19] in Grenoble. The centre will comprise a number of platforms (buildings, facilities, laboratories) for teaching, research and technology transfer, as well as aiming to provide a focal point for the concentration of high-tech SME and start-ups.

Production competence centre programmes have also been established in several EU Member States. These can foster innovation and economic development by playing a role in reinforcing R&D capabilities relating to a particular topic, and by improving the links between different actors in the overall innovation system.

Typically, a production competence centre aims to:

- Seek and develop new innovations and technologies
- Facilitate a link between basic research and industrial applications, and perform world-class R&D that supports industrial developments
- Establish new means of collaborating and spreading excellence

Often the centres already operate as a network at the national level, but clearly more could be achieved by networking at the EU level.

Open coordination between the Community, Member States and Associated States is a valuable mechanism for raising awareness among stakeholders, refining strategies of access or linkage and ultimately improving the efficiency and the image of European manufacturing research. The ERA-NET (a scheme supporting the cooperation and coordination of national or regional research programmes) and the FP6 Networks of Excellence would help in the development of a high-performance European infrastructure for manufacturing technology and contribute to the reinforcement of the EU excellence in technological research.

3.3.4. Need for clear strategy and better integrated actions

Following the action lines of ERA, manufacturing research at EU level needs 'reinforcement', 'better integrated approaches' and more 'structuration'. Links between research carried out at EU, national and regional level should be further developed. In particular, the synergy between the EC Framework Programme and EUREKA in the field of manufacturing should be strengthened.

The Commission should be a key actor in looking for synergies between the different schemes available at EU level for cooperation in the field of manufacturing research. EU manufacturing industry should also play a prominent role in this process, trying to develop strategic long-term research and innovation projects, with complementary funding coming from the different public and/or private sources.

To complement this, an EU high-level expert group should be created to look into strategic aspects of future of manufacturing and to follow the resulting activities.

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[18] http://www.kompetenznetze.de

[19] http://www.minatec.com

4. THE SECOND DRIVER: INTERNATIONAL COOPERATION IN MANUFACTURING RESEARCH

Working together …

4.1. EU reaches out to the world

Most research expenditures are likely to have a multiple impact. They allow the constitution of pools of competence in the countries concerned, to produce new knowledge and/or to follow developments made elsewhere. International cooperation is therefore a very important means of acquiring synergy in the common interest.

- At EU level, international cooperation in research started during the mid-50s with the ECSC (European Coal and Steel Community) and the Euratom treaties, stimulating the development of new processes in the steel, coal and nuclear energy sectors.
- Then, during the mid-80s, the European research and technological demonstration programmes and the EUREKA initiative enlarged this international research cooperation to all the other important fields, and to associated countries having signed scientific and technical agreements with the Community.
- Today the EU Framework Programme for research, demonstration and innovation is open to most research partners around the world[20].

It is worth noting that, since 1951, every effort has been made by the International Institution for Production Research (CIRP) to bring together research workers studying the application of scientific methods to production technology[21]:

Also, since the early 90s, the EC has been a partner in the IMS (Intelligent Manufacturing Systems)scheme. This initiative is a multilateral agreement intended to:

- Enhance knowledge-based manufacturing in industry;
- Enrich the quality of life for citizens and improve the global environment;
- Share manufacturing knowledge and transfer it to future generations;
- Increase the participation of SMEs in international collaborative activities;
- Adapt educational and training activities to support knowledge-based manufacturing;
- Contribute to establishing common global norms and standards.

IMS allows targeted research collaboration on manufacturing issues between its member regions[22]. It provides an intellectual property rights management framework for international cooperation activities. Its actions cover development of international research consortia to undertake collaborative R&D projects (including cooperative work on pre-standardisation topics); global, 'forward-thinking' syntheses (e.g., roadmaps, analyses, foresight); and broad dissemination of research results.

Research activities at EU level should continue to attract international partners, not only to benchmark the research itself and to raise S&T standards, but also to promote the spread of EU excellence.

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[20] http://www.cordis.lu/fp6/inco.htm

[21] CIRP's activities are concerned with promoting the highest level of scientific research and, as such, its policies are strictly non-commercial. CIRP members are all internationally recognised scientists and engineers dedicated to common goals. The organisation is fully independent and not restricted to national interests.

[22] IMS regions presently encompass the European Union, Norway, Switzerland, Canada, USA, Japan, Australia and Korea.

4.2. Coping with 'co-opetion'[23]

As far as the international dimension is concerned, it is clear that enlargement of the European Union and cooperation with third countries will in the near future present fresh challenges that cannot be ignored. FP6 is the first action from the EC in which the Accession Countries are considered to be on a par with the Member States. In addition, participants from third countries are in most cases allowed to participate.

A lot of potential exists for manufacturing industry, not only because of new markets, but also because of new technological opportunities. Indeed, the cultures of other countries will bring complementary views to those so far perceived by EU industry.

Also not to be forgotten is the need to modernise the industries of these countries...

The economist's view[24]

There is a widespread concern, especially in more advanced countries, that the 'de-industrialisation' of the economy is a dangerous trend, which should be tackled through pro-active structural policies. The more or less implicit assumption is that the manufacturing sector has some peculiar features. However, the economic rationale for this pro-manufacturing bias is questionable. Productivity gains and technical innovations have beneficial effects on a country's standard of living, independently of the sector where they are achieved.

The rhetoric of competitiveness leads to a vision of the international economy based on the idea that countries should try to defend and possibly enlarge their shares of world production and trade. In other words, according to this view of international economic relations, countries should try to increase their welfare at the expense of the rest of the world. The persistent strength of these mercantilist sentiments has been recently confirmed by the unsuccessful outcome of the WTO Ministerial Conference.

This is a very dangerous policy climate. Last century's economic history shows clearly that any protectionist backlash can only worsen growth prospects in every country. Macroeconomic and structural policies should be targeted at promoting world sustainable development. The necessary reduction in the North-South gap can be achieved only by accepting the idea that GDP and export growth will remain weaker in high-income countries than in the rest of the world. The resulting redistribution of economic activities should not be depicted as a dangerous decline of economic welfare. On the contrary, it should be welcomed as a step forward to overcome global disequilibria.

It should be obvious that a reduction in market shares does not necessarily imply a reduction in the standard of living, if the size of the global economy is increasing. Foreign policies should aim at creating a system of global governance firmly rooted on the value of international co-operation, which is the essential pre-requisite for global progress.

Pro-active industrial policies should be aimed at fostering productivity growth in the manufacturing sector, as well as in the rest of the economy. This is important in order to increase economic welfare in every country, and not to gain market shares at the expense of trade partners, in a beggar-thy-neighbour competition.

[23] 'Challenges between competition and collaboration' - Springler, ISBN 3-540-40165-5 (2003)

[24] L. Iapadre, R. Martana "European Union in the international economy: trade specialization and R&D investment", Working Paper, CNR-ITIA, EPPLAB, September 2003.

Following this path implies the acceptance of large and complex networks. It indicates that companies should accept the sharing of knowledge and 'co-opetition', i.e. co-operation in research and innovation activities, while continuing to compete in the marketplace.

The new modes of innovation and knowledge production will be characterised by collaboration and fair exchange of information. It would be beneficial if such a dialogue were not confined within the EU alone. There are in addition problems of society, sustainable consumption and production, energy and the environment, that are neither specific to Europe, nor to any other geographical region.

Indeed, knowledge management will be a key enabler of competitive advantage! However, the facts show that in recent years the EU has led in scientific output (based on volume of publications) but not in technological output (based on number of patents). This highlights the need for further strengthening of the links between research and innovation, and those between fundamental and applied research – plus exploitation of the synergies to be gained in developing efficient relations between industry, research and education at a global level.

Experts recommend that the Commission strengthen its efforts to develop and enlarge, where appropriate, the necessary international cooperation in the field of manufacturing.

4.3. Opportunities in sustainable development

Clearly, new manufacturing technology may contribute substantially to comprehensive and realistic sustainable development, thanks to the better control of materials, production processes and consumption/use patterns. A particularly promising field is the introduction of more resource-efficient and cleaner manufacturing processes.

Europe is at the lead of such development. Having all the attributes to form the basis of a potential technological and industrial revolution, 'environment-friendly manufacturing technology' is a key field of research, with significant perspectives of societal and economic impacts within a medium- to long-term timeframe.

At international level, collaborative and cooperative research activities in the field of 'clean and safe manufacturing technology' represent a major opportunity, not only for sustainable development as such, but also for new businesses.

Experts recommend that the Commission strengthen its efforts to develop and enlarge, as appropriate, the necessary international cooperation in the field of clean manufacturing and environmental technologies.

4.4. More support for international cooperation

International cooperation is a relatively well-known activity at EU and Member-State level. It benefits under FP6 from about €600 million of EC funding for the period 2002-2006. However, in view of the predicted challenges due to the evolution of the manufacturing actors throughout the world (growing role of Asia), suggested measures are:

- To enlarge the IMS multilateral agreement to new partners in Asia,
- To increase the budget for international cooperation in manufacturing research,
- To include specific modules for international cooperation in the EU research projects,
- To develop more coordination actions at international level, including the possible detachment of Commission staff in specific regions, etc.

5. THE THIRD DRIVER: THE KEY ROLE OF EDUCATION AND TRAINING

To enable moving towards
'sustainable production and consumption'…

A draft Commission communication 'The EU Economy: 2003 Review' argues that rising educational attainment has had a major influence on economic growth in recent years, and notes that further possible benefits might result if education were indirectly to promote technical progress in the longer term. The report also points out that it takes a very long time to realise the full productivity benefits of investment in young people's education, and that the quality of education is as important as the number of years spent in study.

5.1. No progress without a skilled workforce

In terms of employment and added value, manufacturing is one of the largest industrial sectors in Europe. However, the problem today is that the majority of the jobs available in EU manufacturing is for skilled or highly skilled personnel. There are fewer and fewer opportunities for unskilled or even semi-skilled workers. Skills shortages in the areas of expertise needed by manufacturing industry therefore have a significant impact on European companies and, as a consequence, on economic growth and employment. The issue must be seen as critical for the medium to long-term potential of manufacturing industry in the EU.

It is perhaps surprising for many to see that, despite high unemployment rates in most of the European countries, the shortage of skilled workers at all levels represents a problem to many companies, which cannot fill certain vacancies. There is, indeed, a significant and growing shortage of high calibre apprentices, qualified workers, technicians, engineers and researchers in most European countries and sectors. For companies to maintain and increase their innovative potential, it is essential to have access to a highly skilled, committed and adaptable workforce.

What are the factors at play?

In the short-term perspective it is necessary to increase the available skilled workforce in order to bridge the existing gaps. However, what can be done about this in practice?… Any action must focus on making optimal use of the best the people that the labour market can provide. An early opportunity to replenish the reservoir of skilled personnel may be offered by the enlargement of the EU, and by more flexible immigration policies for skilled workers from other countries. This should, however, be seen as only a partial solution.

In addition, with respect to the Candidate countries and the developing world, it will be necessary to avoid a brain-drain that could destabilise the respective regions, economically as well as politically. A further challenge is to ensure that there is more opportunity for employees to have longer careers. This requires a reversal of the existing trend for people to take early retirement, particularly if they have acquired, developed and maintained the skills that are so important to manufacturing industry. This is extremely important at a time when the service content of manufactured products is increasing and forms an integral part of manufacturers' offerings.

In this context, it is vital to ensure that the conditions exist to foster life-long learning.

In the longer-term perspective, the more important steps are:

- To reinforce formal scientific education from primary schools up to university level, as well as informal education at all ages, in order to increase scientific, technical, and holistic literacy among Europeans;
- To adapt existing national educational structures, making them more flexible to cope with the ever-changing conditions on the labour market. This needs to be done through a better coordination between national and regional authorities and industry;
- To open up many more universities and higher education institutions to foreign students who could play a key role in helping to fulfil the future needs of the European manufacturing industry. This tradition has been lost in many countries (often to the benefit of the USA) and needs to be reinstated;
- To ensure that there are enough teachers in general educational and vocational schools, plus professors at universities, who are sufficiently highly qualified and have the ability to teach pupils in the required subjects (a major concern is the ageing population of teachers in Europe; more than 60% are over 40 years old);
- To (re-)develop and permanently adapt the apprenticeship/vocational schools' curricula to reflect the needs of manufacturing industry. The loss of the apprenticeship tradition in many sectors and countries is at the root of the problems we face today. This will need concrete action at a national or regional level;
- To develop new concepts for international cooperation in order to meet skills gaps and launch a debate on formal and informal industrial education in Europe, together with life-long learning as a means of keeping up with the pace of change.

5.2. Can manufacturing be made more attractive to the young?

The establishment of a European Education Area is underway in the framework of the 'Bologna' process. It will allow a clearer European dimension in university curricula. Although it might positively affect the quality of education in Europe, concern remains that the appeal to young people of technical and scientific studies will not be increased. Interest in science and engineering is not sufficiently awakened and encouraged in schools.

For too many people, manufacturing industry also presents little appeal as a career. The images of the workshops of the past still remain, although these have long since been replaced by modern production facilities. It is therefore important that efforts be made at all levels to give a positive image of technological courses and of working in manufacturing industry.

The development of educational curricula has not kept pace with the growing complexity of industry and the economy, and even less with the rapid development of new technologies. Studies are often too lengthy and too general. It can be argued that that manufacturing is a subject that cannot efficiently be handled inside a university classroom. Addressing this problem emerges as a strategic challenge for manufacturing-related education in Europe. Integrating the factory environment with the classroom concept seems to be the only way forward. To this end, the *teaching factory* concept emerges more strongly than ever as the required breakthrough.

It is also important to broaden the appeal to women of working in manufacturing. More effort needs to be made to attract women to technical jobs, which have too often been dominated by male employment. Here again, the cooperation of all parties involved is essential, including industrial-research partnerships.

Experts suggest that further structuring actions should be *undertaken. Closer links should be established between universities and industry. Such links could establish joint graduate degrees, postgraduate industrial training, industrial real-life-oriented courses, as well as manufacturing departments and/or universities driven by industry. An initiative at EU level could certainly have a catalytic effect, by developing the framework for the pilot implementation of the 'teaching factory'.*

5.3. Education must become multi-disciplinary

Universities should be able to attract the younger generation towards industrial careers, particularly in manufacturing, by encouraging them to participate in the discussion on science and technology and their societal impact. Support should also be given to the development of better approaches to science for girls and boys, and to actions concerning a better understanding of the relative attractiveness and social aspects of taking engineering as a career.

According to the findings of FutMan, there is a growing need to expand the technological aspect of education, with an extension to the 'soft skills'. Teamwork under multicultural circumstances is becoming increasingly commonplace, but the educational institutions do not often adequately provide the necessary training and education to foster communication skills across the cultural frontiers.

Furthermore, there is a growing demand for interdisciplinary thinking, reflecting the increasing integration of different areas of knowledge in manufacturing. In the long run, boundaries between disciplines, and even between traditional industries, are expected to become blurred. Addressing these demands will become a challenge for the current education systems.

The FutMan study concludes in particular that the ability to work in teams with people from different cultures and different disciplines will be one of the core competencies of future manufacturing personnel.

5.4. Rekindling the pioneering spirit is a priority

As stated in a 2003 Commission green paper; 'Entrepreneurship is first and foremost a mindset. It covers an individual's motivation and capacity, independently or within an existing organisation, to identify an opportunity and to pursue it in order to produce new value or economic success. It takes creativity and innovation to enter and compete in an existing market, to change or even to create a new market'.

Entrepreneurship is a crucial element for achieving the political objectives set at the European Council Meeting in Lisbon in 2000, where the European Union committed itself to becoming, within a decade, the most competitive and dynamic knowledge-based economy in the world'. It is therefore important to support the development of an innovative spirit within the EU education system.

There is also a real need for higher education in manufacturing to become less closely linked to short-term economical developments. Young students decisions as to which disciplines they should study are influenced strongly by the contemporary situation in the employment market (Figure 17 shows an example from Germany, indicating the number of new registered students in mechanical engineering, electrical engineering and civil engineering in Germany over the past 25 years).

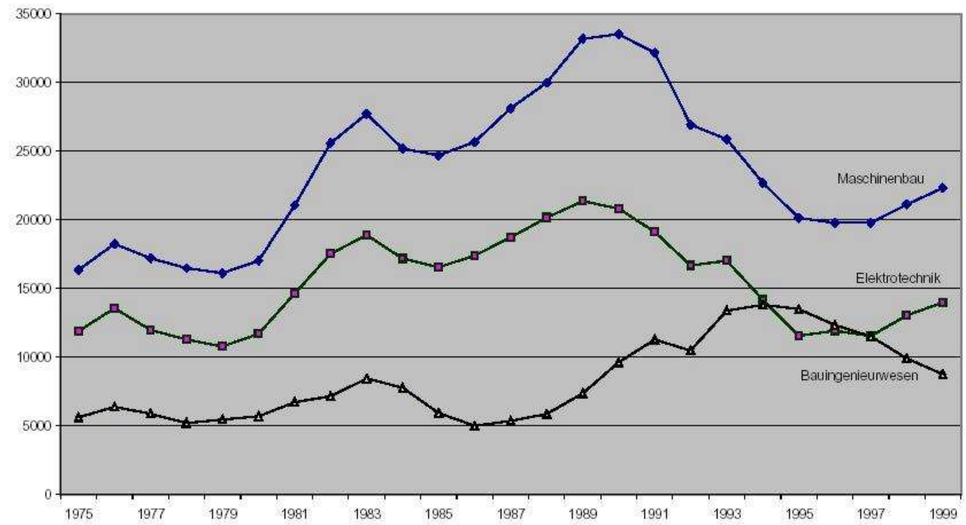

Figure 17 (Source: Federal Statistical Office, Germany)

In parallel, training on management should stimulate existing and tomorrow managers to run their companies with the mix of creativity, inspiration – and even fantasy – necessary to stimulate the innovation required on the way forward.

It is critical to develop further entrepreneurial spirit in Europe, recognising that risk-aversion was a hallmark of the past.

5.5. Research, innovation and education go hand-in-hand

Crucial to Europe's future will be the ability not only to integrate research and innovation activities with education and training, but also to be effective in the formation of future managers, the future workforce and future 'wise' consumers. In addition the 3% objective stated in Barcelona implies a drastically growing number of researchers by 2010 (considering also that many current researchers will be retired at that time…)

How can we ensure the achievement of these three objectives?

The first (*integrating research and education*) depends upon the public bodies that are providing the resources to fund such integration activities. Support can range up to 100% in the new instruments available under FP6. Member States are also called upon to upgrade their various research and innovation instruments.

The second issue (*training future managers as well as consumers*) is more complex, since it involves the awareness, understanding and commitment of people. It is embedded into larger challenges depending on the evolution and governance of western society: topics that are the subject of a green paper recently launched by the Commission[25].

The third issue (*more researchers*) is also very complex. The Commission has recently adopted a Communication[26] on the career of researchers to help facing this great challenge and to face European 'brain-drain'.

It is recognised that public support for research and innovation activities at EU level should permit the development of long-term and more challenging manufacturing approaches, breaking with the traditional use of incremental research schemes, and stimulating young people to choose an engineering and technology researcher's career. The 'training factory' is a scheme considered important to be stimulated.

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[25] Green Paper 'Entrepreneurship in Europe'

[26] COM (2003) 436; 18 july 2003

6. THE FOURTH DRIVER: NEED FOR A STIMULATING OPERATING ENVIRONMENT FOR INDUSTRIAL INNOVATION

A consistent general policy framework
and efficient financial support …

Research and innovation spirit alone are not sufficient conditions for industrial competitiveness and sustainability. Added value comes mainly through entrepreneurial action, so any research policy needs to be complemented by other policy interfaces, related e.g. to competition policy, internal market policy, regional policy, fiscal policy, labour policy, etc. The European Council underlined this view in spring 2003, and the innovation policy in its wider context is elaborated in a Commission Communication 'Innovation policy: updating the Union's approach in the context of the Lisbon strategy'[27].

A consistent industrial policy framework is needed at European level. This, it is hoped, will be the outcome of the recent reorganisation of the European Councils, which now treat industrial aspects together with research and innovation issues.

6.1. Investing in research: an action plan for Europe

The Commission has published an action plan[28] indicating the initiatives required to give Europe a stronger public research base and to make it much more attractive to private investment in research and innovation. The gap in research investment between the EU and the United States is already in excess of €120 billion per year and widening, with possibly serious long-term consequences for innovation, growth and employment creation potential in Europe. The goal is to reach the objective set by the March 2002 Barcelona European Council: to increase the average research investment level from 1.9% of GDP today, to 3% of GDP by 2010, of which 2/3 should be funded by the private sector.

Apart from calling for increased private investment in research, the Communication highlights the need for the improvement of the mix and effectiveness of public-private financing instruments. The respective roles and their complementarity in support of research and innovation of the major financial instruments (the Framework Programme, the structural funds, EUREKA and the financial instruments of the EIB and the European Investment fund) should be reinforced. The need for revision of the Community framework on state aid for R&D and the potential role of public procurement in stimulating R&D are also highlighted.

As already stated, much more can be achieved if efforts are coordinated at EU level. Significant progress has already been made in linking national innovation programmes through the specific innovation-related actions of the Research Framework Programmes. More coordination should be developed between the instruments at EU level and those used at national and regional level (e.g. Interreg). The increasing role of the regions in supporting research activities should especially be highlighted. This requires the development and reinforcement of new coordination schemes, such as ERA-NET.

Apart from fiscal measures, innovation and growth are also related to investments in manufacturing capacities. Figure 18 shows an impressive positive correlation between changes in the share of inward foreign direct investment (FDI) stocks and world exports in the 90s.

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27 Updating the Union's approach in the context of the Lisbon strategy, COM(2003) 112 final

28 Investing in research: an action plan for Europe, COM(2003) 226 final

Countries[29] that could attract foreign investment were successful in export markets, because they captured a higher share of multinational corporations' foreign sales[30]. It is interesting to see that Ireland, whose record in attracting in FDI is known, is also the only high-income country whose export market share rose significantly during the 90s.

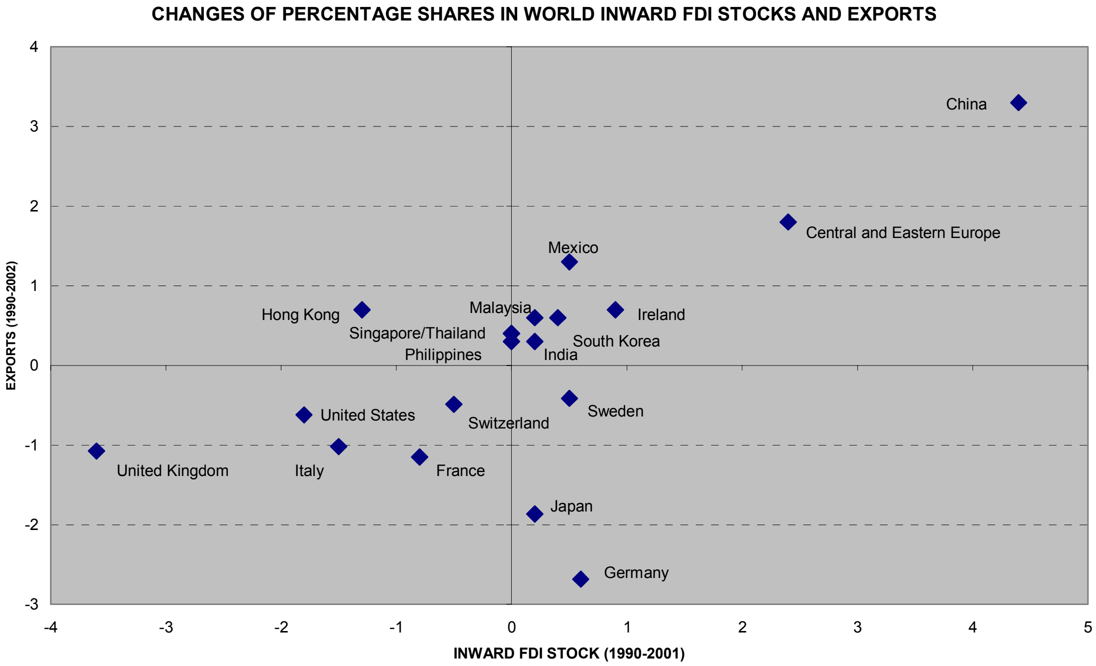

Figure 18 [31]

Experts believe that 'Large Public-Private Partnership' research initiatives can be true catalysers for change!

6.2. Innovative SMEs are essential

SMEs are key participants in Europe's research effort. The Lisbon objective and the Barcelona target both direct European policies towards the promotion of innovative SMEs (in Europe, 4% of these give rise to the creation of 50% of new jobs). Such companies boost the overall competitiveness of the economy by strengthening the innovation potential of larger economic actors. SMEs are therefore a priority for the European Union in its research activities.

Three key areas are worth elaborating: (1) financing of SME innovation, (2) improving the environment for SME involvement, and (3) the direct support to SME research:

- *Development of the financing of innovation:* The objective is to maximise the leverage on private investments. Under the '2000 Innovation Initiative', €3 billion will have been mobilised via the EIF by the end of 2003. Since 1998, 120,000 SMEs have benefited from support. EIF activities are also directed towards start-ups.

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29 Only countries whose shares changed by a minimum of 0.2 % have been included in the graph.

30 See also UNCTAD, *World Investment Report 2002, 2002 – Transnational Corporations and Export Competitiveness*, Geneva, 2003.

31 L. Iapadre, R. Martana "European Union in the international economy: trade specialization and R&D investment", Working Paper, CNR-ITIA, EPPLAB, September 2003. source *WTO-UNCTAD*

- *Creation of an environment more favourable to innovation:* The legal, fiscal and regulatory environment must support private investment in SMEs, for which IPR is a key issue. Implementation of an EU patent will help, but more needs to be done to reduce the cost for SMEs in protecting their innovation. Public research can provide new services for SMEs through incubators, science parks, etc. A proposal to remove the requirement for prior notification of state aid for SME research will also help.
- *SMEs and the Sixth Framework Programme:* The ERA offers SMEs new possibilities to increase their competitiveness in the marketplace. Since 1994, previous EC programmes have had specific SME provisions, but FP6 goes further with an allocation of almost € 2.2 billion. In a new departure, calls for Integrated Projects specifically targeted at SME-intensive sectors are included, with funding reserved exclusively for SMEs. Under NMP, €40 million were allocated in 2003; while €80 million will be assigned in 2004. Many other efforts are supporting the SME-intensive traditional sectors (for example, the Economic and Technological Intelligence (ETI) action will support their participation in research for the traditional manufacturing sectors).

The message is that there is no 'low-tech industry', only 'low-tech companies' which have not yet realised the potential that technology would give to them… Knowledge creation, and therefore research, is a major contributor to innovation.

6.3. IPR and the problems of Euro-patent

A number of activities can be identified in which the transfer of knowledge and of manufacturing-related technologies is very important, and where 'teamwork' is a vital to success. However, IPR issues can sometimes be causes of conflict, and may seriously undermine innovative potential. A central issue in respect of technology transfer is therefore the matter of 'patents and IPR'. Intellectual property covers industrial property rights as well as authors' rights and other connected rights. While intellectual property can sometimes be a source of financing for R&D (exclusive alliances with industrial partners), there is an attendant risk that over-protection may block innovation.

It should be noted that the European policy referring to patent issues was initiated in 1980 with the creation of the Patent Office. At the same time, the US decided on a dramatic increase in its protection of innovation. Between 1980 and 2003, USA patents increased from 100.000 to 350.000, while in Europe the increase was from 50.000 to 200.000. The lower number of patents in Europe can to a large measure be explained by the complexity of the procedure to date, plus the elevated costs of registration (and translation). A much simpler, cheaper and faster Community patent system is a must. It is vital if manufacturing industry, is to set world standards, develop new products and benefit fully from the economic advantages associated with being first on the market.

The Commission has set out the essential elements for a patent system. The EU needs:

- A unitary Community patent that provides incentives for the creation of inventions, and remedies the current cost-gap vis-à-vis the US and Japanese patents;
- A reliable jurisdictional system, based on a Community court specialised in patent matters and competent to examine the validity and infringement of Community patents;
- An instrument that makes use of – and can coexist with – the present European Patent Convention.

It is fundamental that such a Community Patent should meet users' needs in terms of quality, affordability and legal certainty on the basis of a reliable jurisdictional system. The Common Political Approach of 3 March 2003 is an important development. However, political compromises have moved this agreement away from the instrument that business needs today if it wants to compete with its main trading counterparts (particularly in terms of costs, with the obligation to translate patent claims into all official EU languages).

6.4. Cutting through the 'red tape'

The creation of an *innovation-friendly framework* is important to both the individual and the company to avoid that their planned research investment occur outside the EU: For example, for the researcher, a 'one-stop shop' carrying out all the formalities involved in opening a new business based on his/her achievements, and involving a minimum of bureaucracy, would be highly desirable. For companies, the same is true. The administrative burden in obtaining permits, licences and approvals is damaging. Europe should be committed to reducing these obstacles and minimising the direct and indirect costs of complying with regulations and procedures.

A stable and supportive *macro-economic environment* and an efficiently functioning single market are essential for entrepreneurship. Improving the Research-Innovation Value Chain will be of direct relevance in increasing rewards for risk-takers, the prospect of which is elemental for entrepreneurs. For example, barriers formed by the high penalties associated with failure should be reduced to alleviate hardship and create a culture where it is commonplace to restart a business after failure.

The European employment strategy should focus on '*encouraging entrepreneurship'*. The strong bias towards the supply side (labour supply) in the employment guidelines must be corrected. More attention must be paid to the demand side (job creation). To secure a qualified workforce it is necessary to increase the provision of scientific, technological and management courses throughout the education system. Also, common rules on the mutual recognition of qualifications in the EU should be improved to increase mobility.

Finally, lack of financing can be one of the most significant barriers to the start-up and growth of businesses. A *well-functioning capital market* and appropriate support initiatives are essential to entrepreneurs[32]. The recent EIB initiative is seen as a key factor to boost innovative companies in Europe. The services of risk-capital companies should also be further enhanced.

Public authorities should enhance the European macro-economic environment to stimulate investment in research and entrepreneurship. For example, innovation funds could be set up to offer protection against failures in extremely risky technological projects.

Instruments designed to foster research and innovation should also make provision for the preparation and management of the pre-exploitation phase in parallel with the conducting of research activities.

Research activities should stimulate not only radical technological innovation, but also radical innovation in industrial organisations and in the way research results are exploited and valorised at EU level.

[32] See information on EUROMAPLIVE web site: www.euromaplive.icon-innovation.de

6.5. Matching standards and regulations to real needs

Efficient, sustainable and competitive trade depends upon the imposition of effective standards. These can be *de facto* (such as in the telecom area) or *de jure* (such as in the health domain). In particular, unambiguous quantitative measurements are necessary to demonstrate that products and manufacturing process meet specified functional demands. Standards should be developed with global consensus. This allows more critical mass, reliability and effectiveness, bringing greater benefit to industrial competitiveness and to society in general. The following areas can be identified as most urgent for study and development:

1. written standards, including norms and regulations for a common understanding of terms, descriptions, quantitative and qualitative information;
2. measurements and testing applied to counterfeiting;
3. validated and robust measurement and analysis methods.

From a research and innovation point of view, an important objective is to ensure that regulations remain 'technology-neutral'. Regulation is needed to safeguard citizens against risks: when new technologies are envisaged, their application should be monitored, assessed and –where appropriate – controlled in order to avoid unexpected negative effects. These will probably not arise in the vast majority of manufacturing technology applications. But where problems are anticipated, they should be addressed in an extensive and open debate about the ethical and societal implications that the introduction and use of a new technology may have. It is very important that hazards are properly assessed and governed[33].

In parallel, the manufacturing regulatory framework needs to be simplified. The development of the internal market – a major EU success story – was accompanied by a considerable body of European technical legislation that aims to ensure free circulation of products throughout the EU while striving for higher levels of quality and safety. In recent years, the Commission has initiated a significant volume of legislation in areas such as the environment, consumer protection, employment and social affairs, etc… However, in order to be competitive, companies need a stable regulatory environment and legislation that is as simple and efficient as possible. Although in June 2002 the Commission issued a Better Regulation package, the reality today is that there is a multitude of regulations, sometimes conflicting with each other. The view of trade associations such as ORGALIME (the European federation of national associations representing the mechanical, electrical, electronic and metal articles industries) is that the outcome is a highly complex regulatory framework. If the individual measures were justified at the time they were enacted, together they have become burdensome to the extent that they can stifle innovation.

Research activities should also stimulate the integration of pre-normative research, and collaboration between related stakeholders in FP6 initiatives.

Another desirable step is the establishment of a European regulations observatory, which would advise on the optimisation of the legislative environment in Europe, in a wide industrial and sustainable context.

[33] At European level, the European Parliament's technology assessment network (EPTA) is made up of specialist organisations that advise national parliaments on the possible social, economic and environmental impacts of scientific and technological progress.

ORGALIME point of view

The Commission should:

- *analyse the most important manufacturing sectors, and in particular those which we term as the 'enabling industries' (for example manufacturers of capital goods and their supply chain) which are the industries at the root of much of the progress and competitiveness of other industries. An inventory of existing Community legislation affecting companies in selected sectors would be useful to better understand the effect of this legislation on the competitiveness of manufacturing industry and its capacity to innovate and be able to define in that light new policy objectives and actions.*
- *act to simplify the regulatory framework, in line with the mandate issued by the Laeken summit and the Communication from the Commission (Action Plan 'Simplifying and improving the regulatory environment' COM(2002) 278. In parallel, Member States should likewise ensure the proper transposition of European regulation without adding further requirements at a national level.*

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* *

Considerable improvements need to be made in framework conditions for private investment in research in manufacturing. In this regard, the Commission, Council and the European Parliament must rapidly finalise and implement pending legislative proposals such as those that form key components of an effective intellectual property system as well as optimise regulation of product and service markets in favour of the development and deployment of new technologies, including the identification and removal of regulations impacting negatively on research and innovation in the manufacturing sector.

7. THE FIFTH DRIVER: AN INCREASED COMPETITIVENESS OF EUROPEAN RESEARCH

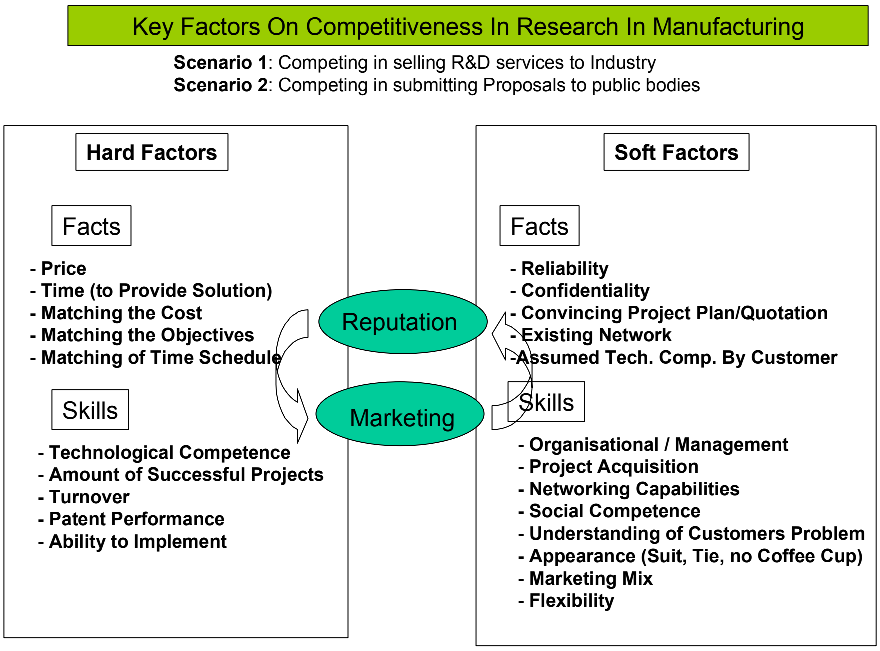
Better, Cheaper, Faster …

Is manufacturing research, today, competitive at world level? Many companies have doubts because of a too long time needed to get support from public sources, because of too much bureaucracy or because the 'top' scientists are not based in Europe. It should also be mentioned that, as the level of education is increasing in the low wage economies (e.g. India now has 1.5 million English-speaking graduates), companies might be tempted to relocate some or all of their R&D activities. If the predictions come true, 'off- shoring' could imply the loss of control of the entire value chain!

7.1. Key factors on competitiveness in research on manufacturing

To estimate the level of competitiveness in research, a common approach is to perform a benchmarking on research institutions, -policies and -regions. Usually the benchmarks refer to number of patents, amount of scientific publications and citations. Other approaches are to benchmark levels of public and private investments in R&D or human resources in R&D by relating researchers to work forces or population. Following the concern of industries relocating their R&D or at least to maintain and improve competitiveness of European research, the above mentioned indicators are not sufficient to estimate the real status and challenges of European research.

If it comes to the point, when industry is willing to spend money on R&D as a provided service, clearly more issues will drive the decisions to be made. Following the experiences of organisations dedicated to applied research such as Fraunhofer, the key factors of competitiveness can be structured in "hard-" and "soft-"factors. Hard factors are covering issues which can be easily measured and determined like costs of research by man month rates, amount of successful finalised projects etc. Soft-factors which are difficult or even impossible to be measured are dealing e.g. with project management skills, reliability as a partner and other issues as shown in the following picture:



Depending on the two different scenarios, the indicated factors will receive a different emphasis. Despite price and time, especially the large number of requested soft skills shows a further challenge for European research to maintain competitive.

7.2. New funding instruments support ambitious objectives

Several complementary objectives should be encompassed to ensure problem-solving, cost- and time-effectiveness, competitiveness and sustainability. The Research-Innovation Value Chain is presented diagrammatically in figure 19.

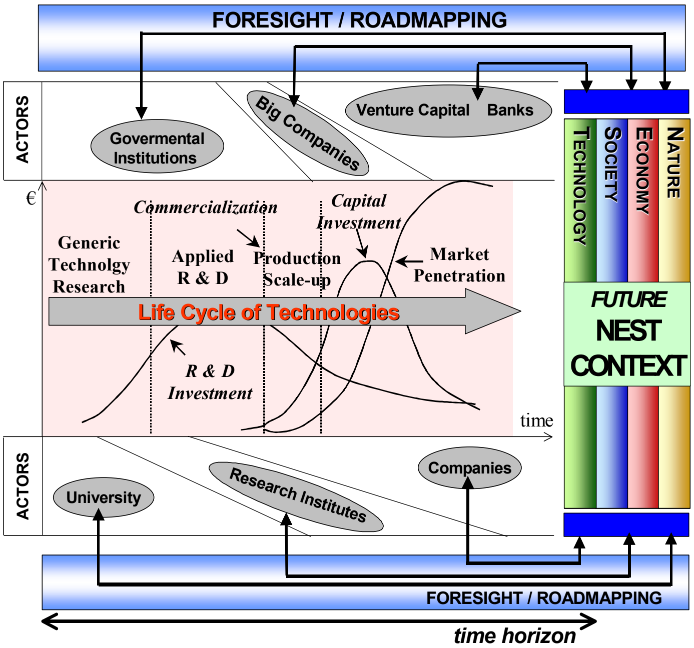


Figure 19: Research-Innovation Value Chain.

The various instruments proposed through the RTD Framework Programme allow the assembly of EU research capacities and strengthened S&T excellence (NE), stronger support for research investment to aid the development of new technologies for radically innovative products and production processes (IP), and promotion of cooperation between research and industrial partners in basic research activities (STREPs). FP6 industrial research actions in the manufacturing field involve, as a principle, a strong presence and interaction of innovative enterprises and research organisations.

FP6 also goes a step further than the previous Framework Programmes by placing the responsibility on the beneficiaries of the research funding to generate innovation from their activities.

Recent Councils have confirmed the importance of research and innovation policies, and of developing an efficient European research community through integration, structuring and reinforcement of related activities. This implies wider scope and ambition than in the past. This should also imply a better 'value for money' and it is one of the reasons why the new instruments developed under FP6 – the Integrated Projects (IP) and Networks of Excellence (NE) – have been designed to support larger scale research activities.

Most notably, three types of instruments need to be highlighted in the manufacturing context:

- IPs and STREPs aim to promote:
  - Real breakthroughs, <u>not</u> just incremental research;
  - Creation of RTD-intensive manufacturing industries and uptake in existing sectors;
  - Revitalisation of industry through disruptive technologies;
  - Transition towards knowledge-based society and sustainable development;
  - An integrated approach covering production and consumption patterns;
  - New approaches to materials science, engineering, production and servicing;
  - Wherever appropriate, the establishment of new forms of cooperation with research organisations, companies and technology transfer centres in third countries, with a view to working together more efficiently.
- The NEs target:
  - Reduction of the fragmentation of manufacturing research in Europe;
  - Lasting integration of research capacities and lasting support to the competitiveness of manufacturing industry;
  - Long-term research objectives as a contribution to advancing knowledge for sustainability, competitiveness and dynamism in EU industry;
  - Spreading the excellence and attractiveness of EU manufacturing research;
  - Integration of education and skills development into the project work, as a means of preparing the future workforce at EU level.

There is also a strong need to develop further an infrastructure that helps industry, notably SMEs, to implement new technologies and organisational practices. This can primarily be achieved through:

- The above-mentioned NEs;
- IPs for SMEs, led by SMEs with R&D capacities and with the possible participation of universities and research centres. Other industries and industrial associations can participate whenever it is either essential or highly desirable in terms of the role of SMEs in the supply chain. Proposed activities should be centred on reinforcement of the SMEs' S&T knowledge, and on validation of innovative solutions within broad international and regional contexts. Results of such IPs should clearly be for the benefit of SMEs. Activities to be carried out should facilitate the shift from less RTD-oriented sectors to RTD-intensive and higher-added-value sectors.

These instruments have the potential to develop world class and breakthrough research activities, spanning from basic research to validation and demonstration activities, therefore breaking the linear approach of research.

7.3. Increased networking to reduce fragmentation in the EU

Thanks to its traditional intellectual entrepreneurship, particularly in science and technology, Europe now has a leading role in several manufacturing-related domains. However its efforts remain very fragmented. Because manufacturing operations are highly competitive, networking is relatively uncommon within industry – apart from the natural supply chain collaborations. Spontaneous networking, even if important between researchers, is not sufficient to sustain the required quality, speed and cost of industrial research activities. Structural initiatives are therefore essential.

With the ERA initiative, the Commission has for the first time tackled the problem of the fragmentation of research in a comprehensive way. ERA should become both the research internal market and a coordination space for research teams.

As an illustration of what is possible, the critical requirement for the exchange of data between researchers in very large quantities and at very high speeds has spurred the creation of the EU-sponsored GÉANT network[34]. This already forms the most advanced international networking infrastructure in the world. Other examples relate to the Networks of Excellence selected during 2003 under the Sixth Framework Programme, which deal with the development of 'European virtual research labs' tackling long-term industrial issues such as 'multi-materials micro-manufacture' (4M), 'nanoscale simulations for nanostructures and advanced materials' (NANOQUANTA) [35]. Other networks are expected dealing with the reinforcement of 'the knowledge community in production'.

Recently the Commission has also launched several initiatives to create Technology Platforms, which are vehicles for the development of common long-term industrial vision and the promotion of coherent research and innovation activities at EU level. The targeted industrial sectors include 'low-CO_2 steel processes' and 'nanoelectronics'.

To reduce the fragmentation of effort and facilitate groundbreaking innovation at EU level, while also assembling a sufficient critical mass to generate quickly important spin-offs, large networks and groupings should be formed around strategic objectives.

7.4. Long-term vision and acting together: a formula for success

Alone, single organisations have little power. The emergence of industrial networks as key actors in a globalised market is a sign of the growing importance of 'knowledge communities'. More important is the willingness of industrial sectors to develop strategic visions for their future, and to adopt consistent approaches to research and innovation. Examples of successful sectors in Europe range from aeronautics to the pulp and paper industry, from the steel to the chemical industry.

The recent initiative of the European Commission on the Technology Platforms opens the way towards more consistent approaches for Manu*future:*

- Technology platform are firstly defined by a common long term vision.
- They should help stimulating a favourable environment towards the realisation of this vision and in particular support joint research and innovation actions of strategic character.
- To achieve these goals, public-private partnerships (PPP) are welcome, with in addition the objective of reducing the time from idea to market and of making Europe the most competitive area in a 'knowledge-creation' society.

Ideas for such platforms range from 'new product design paradigms' to 'textile of the future', from 'nanoscale precision engineering' to 'nanoelectronics', from 'environment-friendly and safe manufacturing technologies' to 'the manufacturing SME of the future'.

Ultimately, Technology Platforms through public-private partnerships (PPP) could contribute to an intelligent answer to the main question of the conference: which vision? How to act together?

The Commission is encouraged to continue with the implementation of the new research instruments, IP and NE, as well as to stimulate the preparation of European Technology Platforms (ETP), to help develop long-term visions and joint initiatives in European manufacturing industry.

[34] http://www.dante.net/geant/

[35] projects currently under negotiation

PART C - Towards a European strategy

Discussions are increasingly taking place at Community level. Topics such as technology, education, governance, organisation, legislation, employment, consumption patterns, knowledge-based society, and especially the global competitive environment, are being tackled. In the various consultations held, broad support has been expressed for the setting-up of a 'Manufacturing Technology Action Plan' (MATAP) for **the Renaissance of Manufacturing through industrial research activities** at European level.

More specific comments included the following:

- A clear EU research strategy should follow from the development of a long-term societal vision of a competitive and sustainable industrial society. Consequently, the research actions at EU level should not be geared to short-term considerations.
- The research action plan should be based on the identification of barriers to innovation up-take, and on ways to resolve them. Recommendations should not be considered in isolation, but as part of a systemic approach. In addition to barriers, attention also has to be paid to the drivers of change.
- Work on the research action plan should involve looking at best practices in terms of relevant national and international research policies and initiatives. The enlargement issues deserve particular attention.
- A research action plan should not necessarily result in a technology push; it should be framed by integrated guidelines to meet the demands of increasingly complex environments in the years to come.
- Innovation takes time to happen; it often stems from entrepreneurial SMEs rather than large companies. The need to focus on SMEs has to be recognised, not only due to their role in innovation, but also because they are the largest component of most manufacturing sectors.
- A 'stepwise approach' involving a continuously updated research action plan is clearly recommended by experts; A first workshop organised in February 2003 was considered as the initial step; The second step in shaping a research action plan has involved a broader discussion among research and industrial actors, as well as users, educators, regulators, consumer representatives, sociologists, etc. A third step will be to broadcast the findings of the studies carried out to date, as well as the conclusions of the 'MANU*FUTURE* 2003' conference in December 2003;
- A fourth and more important step would be to develop and implement a consistent European research action plan, joining European, national and regional efforts, using the opportunities offered by the European research programme and the EUREKA initiative. Such an action plan should be supported by a High Level Expert Group;
- It is proposed that this plan, if possible, should foster and promote 'platforms' for technological, organisational and social innovation. These platforms should of course provide the freedom to experiment with innovative solutions;
- The High Level Expert Group mentioned above should also help in monitoring the various achievements and in advising on the periodic revision of MATAP.

Finally, there is an overriding need for a better connection between experts, civil society and policy-makers for an interactive dialogue underpinning decision-making in medium- to long-term RTD policy and other policy fields.

Research and innovation for future manufacturing

Increased research efforts will be needed to face various challenges for future manufacturing:

(a) to change the image of manufacturing: high-tech, clean, safe and service-oriented

Despite the key role of manufacturing in the economy and our society, its common image – especially among the younger generation – is more one of an old-fashioned, dirty and polluting industry providing insecure, unhealthy employment than that of a sector providing desirable jobs and real sustainable development. This creates a vicious circle: young people do not see their future in manufacturing. Universities have difficulties in getting new engineering students. Companies have difficulties finding the right people and tend either to decrease their expectations and potentially the quality and added value of their services, or look for other investment opportunities elsewhere. 'Flagship' industrial research activities have the potential to change this image of manufacturing.

Research should support new production and consumption paradigms, based on high-tech, cleaner and safer technologies. In addition, the importance of services coupled with manufacturing operations should increasingly be considered, adding another human-friendly dimension to manufacturing and manufacturing employment.

(b) to maintain sufficient employment in the manufacturing sector

Although manufacturing output has grown by 35% in volume terms between 1979 and 2001, employment in manufacturing has declined from 41.6 million to 31.5 million during the same period. Eurostat statistics show that, between 1997 and 2001, manufacturing employment remained quite stable – but, with the recent economic slowdown, the negative trend has resumed. The 'Employment in Europe 2003'[36] report shows more positive figures for net employment in EU15, but there is a huge variation in performance between individual countries. The dilemma is that productivity-boosting measures improve industrial competitiveness, but at the same time tend to decrease employment. In addition, if macroeconomic conditions stifle market growth, productivity increases will result in further job losses.

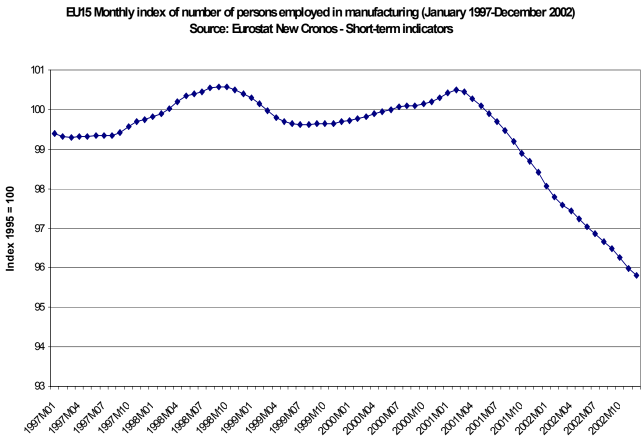


Figure 18

[36] Employment in Europe 2003, Recent trends and prospects, European Commission, DG Employment

It should also be recalled that, during the 90s, particularly fast-growing firms contributed substantially to job creation. During this period, about 50% of new employment was provided by only 4% of high-tech enterprises.

To maintain employment in the manufacturing sector, RTD activities at EU level should:

(1) support the competitiveness of the sector through improved or new manufacturing technologies, with the result of maintaining or increasing market shares;

(2) encourage the creation of new businesses, consequently of new jobs, notably through efficient exploitation of research results and a stronger orientation towards services, and;

(3) promote rapid diffusion of best manufacturing practices.

(c) to create an environment that improves skills and stimulates creativity

There is in Europe an understandable tendency to concentrate on short-term issues and on the preservation of 'tradition', which hinders the development of long-term visions and actions. However, the facts are that ongoing socio-demographic change is likely to confront the manufacturing industry in 2020 with a considerably aged workforce; that radical innovation in the field of new technology, especially nano- and bio-technology, will require completely new sets of skills; and that economic and industrial changes are likely to increase the mobility of labour in Europe.

The availability of the right multi-disciplinary skills and of motivated staff, especially for SMEs, will also become a critical factor in manufacturing. Finally, in investing in the knowledge and information society, Europe needs to take care to avoid the digital divide. The emergence of new manufacturing paradigms should not generate unsustainable 'structural' unemployment.

The challenges for future research activities will be (1) to stimulate long term visions and actions; (2) to help develop the required knowledge in emerging technological fields, stimulating in particular the required international cooperation, and; (3) to forge a strong association between education and training activities to help prepare the future workforce, not only at postgraduate level but increasingly at technician and engineer level.

(d) to ensure public acceptance of new technology

Recent debates on genetically modified food and stem cell research highlight the need for taking public values and ethical concerns into account when scientific advances and new technology are being adopted and exploited. The potential effects of any new technology are by their nature largely unknown. Public concerns regarding those issues could lead to a lack of acceptance that consequently may hinder the implementation of new technology. By the same token, to avoid unfounded opposition, the research sector, industry and government must act to improve public understanding of S&T. The development and adoption of socially robust technology in manufacturing is therefore needed, entailing new approaches to governance and technology development.

It is also important not to lose the societal benefits that have been gained in Europe.

While industry is evolving, the European industrial culture should be retained, i.e. serving society and improving the human dimension in industry. The establishment of participatory mechanisms (including industry, research, government and the public) and reviews dealing with the societal impact of new technologies and of related research actions would help to ensure broad public acceptance and preservation of European values.

8. SUGGESTED ACTIONS

How to make it possible?…

A widespread agreement already exists that:

EU research activities on new forms of manufacture can serve as an ideal means to support the strategies and targets set out at the European Councils of Lisbon 2000, proposing the shift towards a knowledge-based economy and society; of Gothenburg 2001, formulating a European strategy for sustainable development; and of Barcelona 2002, targeting funding equal to 3% of GDP for research throughout the European Union.

However, the Manu*Future* conference and this working document should stimulate discussion on a possible *specific 'Manufacturing Technology Action Plan'* and its initial focus areas. As a first step, the questions that need answering are:

- ***Has this document touched the key issues for European manufacturing? Is the manufacturing evolution path presented in this document realistic?***
- ***Which are the possible actions to ensure that the issue of manufacturing research & technology receives sufficient attention at higher political level?***
- ***If a high level expert group was to be created to develop long-term and strategic visions for manufacturing research, what should be its composition?***
- ***Which are the RTD actions needed at EU level to stimulate the transformation of the traditional manufacturing industry?***
- ***What can be done to improve the effectiveness of EU research in supporting manufacturing industry? Which are the improvements needed in research infrastructures?***
- ***Which are the possible actions to support the ERA initiative in manufacturing context?***
- ***How can public-private partnerships be stimulated in the manufacturing sector, e.g. to establish effective Technology Platforms?***
- ***How can the image of manufacturing be improved and people's interest in manufacturing careers and research rekindled?***

9. THE LAST WORD: INNOVATION IS VALUELESS IF NO-ONE IS AWARE [37]

A good innovation potential is strongly linked with a correct communication to all stakeholders. This will require time and resources…

The Commission invites the readers of this document to contribute their opinions by e-mail, in particular in the context of the questions presented in Chapter 8. A specific mailbox RTD-NMP-Manufact@cec.eu.int **has been created for this purpose. In parallel, a Manu*future* discussion forum will be available at** http://europa.eu.int/comm/coreservices/forum/index.cfm?forum=research
Both the e-mail address and the forum will be operational until February 2004.

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[37] As a service to everybody interested, the Commission has created websites devoted issues concerning manufacturing research and related topics. http://www.cordis.lu/ http://europa.eu.int/comm/research/industrial_technologies/