

FuTMaN

**THE FUTURE OF MANUFACTURING IN EUROPE
2015-2020**

THE CHALLENGE FOR SUSTAINABILITY

Final Report

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1. **Executive Summary**

- The FuTMaN project¹ sought to assist the European Commission for FP6 in examining what technological, knowledge and organisational capabilities might be required by European manufacturing, if it was to remain both competitive and sustainable by the year 2020. Particular attention was to be paid both to technological priority areas and to any policy changes required.
- Three cross-cutting approaches to exploring the problem were adopted. **Scenarios** were developed to provide imaginative, coherent views of the threats and opportunities which manufacturing might face in the years to 2020. Three broad strands of manufacturing were studied – **Materials, Transformation Processes** and the **Structure of Industry**. Four sectoral case-studies were undertaken in the **Automobile Industry – Personal Cars, Measuring, Precision and Process Control Instruments (MPPCI), the Semiconductor Industry and Basic Industrial Chemicals**. In addition, a separate integrating study examined the implications which **Governance, social attitudes and politics** might have on the transformation of industry.
- The **Scenarios** were not predictions, but sought to establish what common, robust traits European manufacturing must acquire or possess, in the event of a variety of possible futures coming to pass. Four individual scenarios were developed, based on the extent to which socio-economic attitudes and governance became either more individualised or more collectivised. Taking two contrasting examples, *Global Economy* was the most individualised, ungoverned scenario: under it global competition is cost-driven, with R&D helping to sustain leading-edge products. But the uptake of nanotechnology disappoints and progress on sustainability and the environment is incremental. In contrast, the *Sustainable Times* scenario contains both a high degree of acceptance by individuals of the need for sustainability and sophisticated public pricing mechanisms to cope with “externalities”. Some pointers as to how European manufacturing might become robust enough to cope with such apparently contradictory futures emerged later in the study, as the experts in the broad strands and the case studies identified four pressures which manufacturing would have to adapt to in all circumstances. These were **Time** (conflation), **Knowledge** (intensification), **Costs/competitiveness** and **Resource use/Sustainability**.
- Experts consulted in the **Materials** report identified 27 high potential materials technologies. Three potential technology development paths were identified i.e. *Specialisation, Convergence* and *Integration*. The *Specialisation* technology path is the present position, *Convergence* would add pluri-disciplinary thinking and new interfaces with industry, while *Integration* would call forth a new paradigm of technology priorities, R&D organisation and interfaces with industry. The US is more advanced than Europe on technological priorities and on R&D

¹ Appendix 1 contains a list of the FuTMaN partners.

organisation, while Japanese research has a long tradition of a better interface with industry. For Europe to move to move up from the *Specialisation* to the *Integration* technology path will require both substantially increased investment in real and in financial resources and a re-structuring of research practice and organisation.

- The **Transformation Processes** study covered all manufacturing design, planning and production processes (including disassembly and re-manufacture) as it affected both Traditional Manufacturing and Electronic Manufacturing. Traditional manufacturing would require new styles of team leadership and greater adaptability from all team players. Electronic manufacturing would require more research-related resources and a clearer identification of manufacturing's core competences. The report confirmed that Europe has a strong manufacturing base rooted in a well skilled workforce, a good and comprehensive infrastructure and a strong cohort of competitive companies – particularly in the provision of productivity-enhancing manufacturing equipment. The report went on to make five policy recommendations viz. cross-cutting and competing technological trends should be geared towards sustainability, sustainability should be made an effective driver of manufacturing innovation, manufacturing itself should become more pro-active in process improvement, continuous improvement in skills and competencies, and Europe must build on its capability to service a diverse range of markets without falling prey to fragmentation.
- The **Structure of Industry** report concluded that “*human capital will replace physical capital at the core of competitive advantage*”. This suggests that enterprise, incorporated in the whole of the labour force and not simply in its managers or its entrepreneurs, will be the main bulwark against the commoditisation of products made in high-labour-cost/high-value-added economies such as the EU. The report identified three key influences on the structure of manufacturing. Firstly, *servation*, or the need to incorporate a greater service element into the product, both during design and during after-sales. Secondly, pressure towards *closed loop* systems, in which waste outputs from one process are used as an input to other processes. And thirdly, the growth in *virtual enterprises via B2B*, which will radically alter the organisational structure and the competitive positioning of firms.
- The four **Case Studies** provided an interesting mix of the differing capabilities and challenges which different sectors of European manufacturing possess or are exposed to.
 - ◆ The Automobile Industry is one of the EU's major success stories. In Japan, Carlos Ghosn's matching of products to markets and his views on the shortening of product life cycles provide headlines for non-auto manufacturers in Europe. The automobile case study identified seven drivers of change: three were related to demand, two to resource inputs, and two concerned the production process. Unlike the scenarios, the case study experts did not see individual car ownership being ousted by some servation-type concept such as “mobility services”.

- ◆ The Measuring, Precision and Process Control Instruments (MPPCI) sector is comprised of a small number of large firms and a large number of small firms that either collaborate with the large firms or service niche markets. Developments in demand and technology are forcing a much greater degree of adaptability on the sector, particularly in relation to modularisation of product design, concurrent engineering and simulation. Nanotechnology and the spread of sustainable practices will increase pressures/opportunities on MPPCI in future. Policy must help the sector upgrade its knowledge base and its capability in networking and in innovation.
 - ◆ Products produced by the Semiconductor Industry are high-value/low-bulk and thus prey to competition from low-wage Asian countries. The case study considered that opportunities exist for Europe to consolidate its current capabilities and to establish itself as a prominent player in emerging technologies, which will challenge the current dominant technologies. However policy measures will need to support measures to improve the industry's attractiveness, to develop entrepreneurship, to commercialise new technologies and to exploit niche markets.
 - ◆ The Basic Industrial Chemicals sector faces strong pressures towards commodification, with little scope for adding value through customisation or servation. The main technology trends identified for the sector concentrate on the impact of new materials, new catalysts and improved processes. Expert views on the future fall into two groups. One sees the future as incremental with gradual improvements in materials and processes and the second view sees a more rapidly increasing shift towards bio-processing and green chemistry. There was also a North-South division of opinion on environmental issues. The industry is very concerned to better its reputation with citizens. It advances a number of policy recommendations in relation to regulation, innovation, education and realistic visions of sustainability.
- The report on **Governance** looked at the increasing dispersion of power and authority beyond the apparatus of the state. Indeed The EU's White Paper on Governance in 2000 looked for a greater downward distribution of governance, to allow more participation in decisions leading to major technological change and also to allow for a greater diversity in European culture and society. In future major developments or decisions in relation to manufacturing will probably have to be taken within a "*socio-technical constituency*", perhaps using some "*transition framework*" so as to allay disquiet in the move from the old to the new. The report outlines research in a number of areas which might secure a better insight into how this might be achieved.
 - FutMaN sets forth a bold agenda for sustainable manufacturing to 2020 – echoing perhaps the Lisbon Declaration of 2000. And the experts consulted under FuTMaN's many elements considered that such a great hope could be realised: there were no insurmountable social or technological barriers. **However it would mean the development and adoption of new paradigms of production and consumption. These in turn would require a quantum leap in resources to**

enable manufacturing to research and implement these paradigms, and also a willingness and capability by Europe's leaders to persuade its own people and the rest of the world that sustainability was worth pursuing seriously. Neither of these conditions is in place at present. Great change can deliver great rewards, but in the process usually incurs great disruption. The main fear underlying FuTMaN is that European manufacturing, its customers and their political leaders, may be dissuaded from making the great efforts required to reach long-term sustainable development because of the medium-term disruption this would cause to individuals and to society.

- The United States' growth as a *hyperpower* since 1990 has been paralleled by a divergence in values between the US and Europe. Baseline economic forecasts to 2015 suggest a growing increase in the US's hyperpower status and an increase in the EU's dependency. Only if the EU throws off the lassitude of the 1990's and replaces it with the economic and social vigour it displayed during the 1960's, can sufficient resources be made available to turn the FuTMaN programme into reality.
- FuTMaN made six overall recommendations for policy viz.
 1. **Manufacturing must attract and hold on to able people:** A repeated theme in many areas of the study was the concern expressed about the possibility of shortages in adequately qualified and skilled personnel. Demographic trends of ageing raise the first fear in this regard but the perceived unattractiveness of manufacturing industry as a career poses a bigger problem. Solutions require collective actions by all parties.
 2. **Continue building European systems of Innovation:** In addition to optimising the harmonisation of standards, FuTMaN looked continuously for policies to strengthen entrepreneurship through broader education curricula.
 3. **Networking takes time. Be Patient:** The new instruments of FP6, integrated projects and networks of excellence all have a long learning curve.
 4. **From Specialisation to Integration in New Materials:** The Integration technology path of materials development will require a multidisciplinary skills base among S&T personnel, new organisation forms for S&T, for education, and for interaction with industry. Above all it will need strong economic growth among Europe's core economies in order to provide the necessary financial resources.
 5. **Sustainability needs Champions both from Manufacturing and from Governments:** Manufacturing acknowledges its need to be pro-active in this area, but it cannot do it alone

- 6 **“Transition Management” may allow for improved governance.** Recently developed concepts like “transition management” may provide a process for dealing with the combination of slower incremental developments and rapid disruptive dynamics, which would better allow manufacturing and its policymakers to systemically cope with change.

2. Issues

2.1 FuTMaN's Aims and Approach

The FutMan project supports the European Commission for FP6 by examining key factors affecting the competitiveness and sustainability of European manufacturing industry over the next 20 years. FutMan sought to:

- “Develop a major prospective mapping of those critical capabilities and competences – technology, knowledge and skills, organisation and business capabilities - which are necessary to underpin a sustainable and competitive European manufacturing industry in the future,
- “Focus on the technological priority areas of nanotechnology, new materials and future manufacturing systems,
- “Isolate the changes required for success at the micro and macro levels of manufacturing and to integrate these changes into broad guidelines for policy”.

Three cross-cutting approaches to exploring the problem in parallel were adopted viz.

- **Scenarios** were developed to provide imaginative, coherent views of the threats and opportunities which manufacturing might face in the years to 2020.
- Looking at manufacturing in general, three broad strands of manufacturing were studied – **Materials, Transformation Processes** and the **Structure of Industry**.
- Looking at manufacturing in practice, four sectoral case-studies were undertaken in the **Automobile Industry – Personal Cars, Measuring, Precision and Process Control Instruments**, the **Semiconductor Industry** and in **Basic Industrial Chemicals**. The case-study approach aimed to integrate and focus insights from the scenarios and from the broad strands.

A separate integrating study examined the implications which **Governance, social attitudes and politics** might have on the transformation of industry. In addition, the whole approach to the study was iterative; positions were proposed, tested, discussed and amended - both formally in workshops and in interviews with outside experts - and informally and more frequently in contacts between the partners themselves.

2.2. Context 2020 – Building on the Scenarios

*Two roads diverged in a wood, and I
I took the one less travelled by.
And that has made all the difference.*

Robert Frost.

The poet Robert Frost’s well-known triad on the choice of path through life can also provide a useful starting point for considering scenarios on the future evolution of European manufacturing. In both cases the intermediate terrain and the eventual destination is far from clear, and the more obvious and popular route may not prove the most rewarding. However, unlike the poet’s charting of the one, true route, the FuTMaN scenarios have a much less ambitious task i.e. to set out what common, robust traits European manufacturing must possess or acquire, if it is to successfully traverse a number of possible routes through the wood!

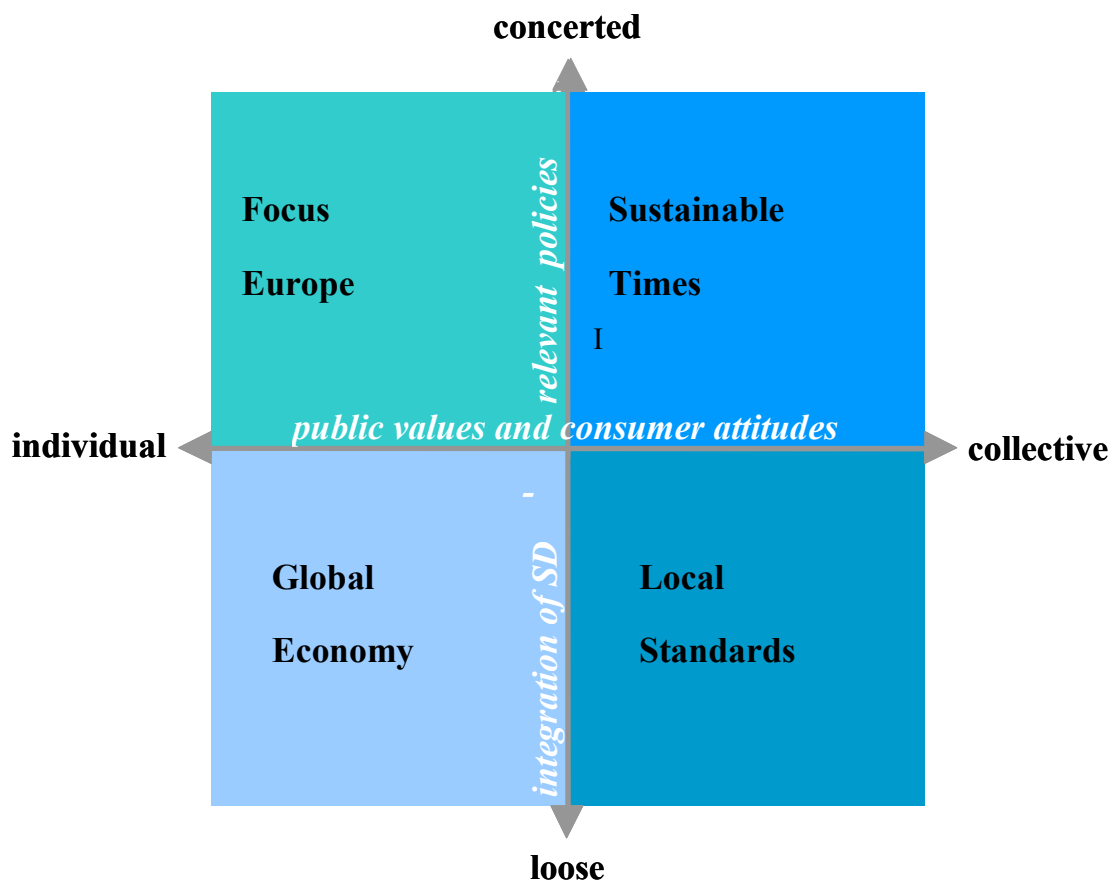
After much discussion and iteration, it was decided to frame the exploration of scenarios for FuTMaN along two broad axes or paths i.e.

- the balance between *public values* and *consumer attitudes*,
- the degree of *integration of relevant policies*.

The interplay between the two axes yielded four scenarios, which were called **Global Economy**, **Local Standard**, **Focus Europe** and **Sustainable Times**.

Fig. 2.1

Four Scenarios for FuTMaN



Before moving on to consider these scenarios, two comments are necessary. Firstly, at this stage, no single scenario has a greater or lesser probability of occurring. And secondly, at this stage, no value judgements are made as to which scenarios are more desirable. The FuTMaN scenarios are explorative rather than normative, and thus each scenario can contain “desirable” or “less desirable” elements, depending on one’s point of view. Thus, viewed through the prism of sustainability, in the *Global Economy* scenario, markets may find it difficult to deliver much in the way of sustainability: while, directly opposite to it, and viewed through a pure market prism, the *Sustainable Times* scenario provides a lesser degree of competition, which could in turn inhibit innovation.

Under the *Global Economy* scenario, individual choice by consumers is preferred and the “invisible hand” of the market will best co-ordinate the policies necessary for economic development and technological innovation. Research and technology is regarded as a key ingredient into sustaining leading-edge progress in globalised markets, but progress in technology is uneven, with Europe lagging behind the USA in mission-funded RTD areas. The uptake of nanotechnology disappoints, global competition is cost-driven and progress on the environment and sustainability is incremental. In terms of manufacturing, there is a much greater focus on product customisation, virtual factories begin to emerge, and modelling increases the efficiency of product and process design. Table 2.1 shows four typical web news headlines during a day in 2016.

Table 2.1. *Global Economy*: News Headlines on 11/03/2016
 futman://scenario.ge2016.news

1. Nanotechnology backers back off! Nanobuild issues liquidity warning
2. USA bullet proofs win shoot out. Nantex vests EU force
3. Where’s the next...sushi bar? CMV shows voice-led car navigation
4. Profits hit new peak at VFS. Soaring demand for digital production tools

Under the *Local Standard* scenario, allegiances unite behind collective public values and consumer attitudes, but congruence in policy is achieved, not at central European level, but at regional level². Influential local citizen action groups go hand-in-hand with a decrease in EU influence on global affairs. Society turns its back on large-scale solutions particularly in the areas of Research and Transport. Companies service markets by adapting large-scale, commoditised products to regional preferences³. But a “hollowing-out” occurs in those sectors of European industry which are prone to commoditisation; this may particularly occur in basic chemicals, where production is located either at a few big European harbour complexes, or outside Europe. Web news headlines under this scenario, on a day in 2016 might include the following.

² “Regional” here = < nation state but somewhat > feudal lordship.

³ Such markets are neologically described as “multi-glocal” i.e combining the “global” and the “local”.

Table 2.2.

Local Standard: News Headlines on 11/03/2016

futman://scenario.ls2016.news

1. EU – Troika signs industrial co-operation pact with Eastern states.
2. Lack of EU co-ordination harms competitiveness.
3. Digital production in Europe of the Regions. Coping with complexity
4. EU chemical industry takes flight? New technology, new locations?

The *Sustainable Times* scenario contains a generalised acceptance at both citizen level and at the level of governance that sustainable development issues should be taken from the clouds of medium-term concerns and grounded in policies with immediate effect. Technological and organisational innovation bring about system changes and industry becomes an active mediator of sustainable development. Public policy devises sophisticated and adaptable pricing mechanisms to cope with “externalities”. As a partial reaction, transport devises new forms of mobility services, renewable energy becomes more important, industry “decouples” growth from resource use, bio-resources partly replace non-renewables and new ICT resources are applied in a socially responsible way. Headline web news stories on a particular day in 2016 might include the following.

Table 2.3. *Sustainable Times: News headlines on 11/03/2016:*

futman://scenario.ls2016.news

1. WTO talks on intrusive technology resumed. But 1984 fears may win out!
2. Record bio-feedstock demand for polymers. Bio-based stocks a buy?
3. Big 3 Auto manufacturers agree on fuel cell standards
4. EU accepts Green Production standards for developing countries
5. No-Waste Chips. Electronics industry extends product liability for chips

The *Focus Europe* scenario combines a high degree of congruence in development and innovation policies with a highly individualised set of consumer preferences. At the macro level, this is a risky strategy, since Europe’s views and policies on sustainability are not shared by the United States and by the big economies of East Asia. The judgement is finely balanced; will the certainly increased cost of environmental compliance on European manufacturing in the short-term be more than offset by the possibly larger European capability of producing more sustainable products in the medium-term? This scenario favours the latter hope rather than the former fear. European manufacturing rises to the challenge and carves out a world-leading position in environmental technology. There is a revival of the European electronics sector, near zero-emission cars are developed and hazardous materials and

processes are phased out of industry. Table 2.4 shows typical web news headlines for a day in 2016.

Table 2.4. *Focus Europe*: News Headlines on 11/03/2016

futman://scenario.fe2016.news

1. EU's Cleantech wins 350bn. environmental technology deal in China
2. Semiconductor Boom in Europe. EU leads in clean-chip products
3. ITS network in Rome. Clean cars and ICT make <i>Eternal City</i> live again

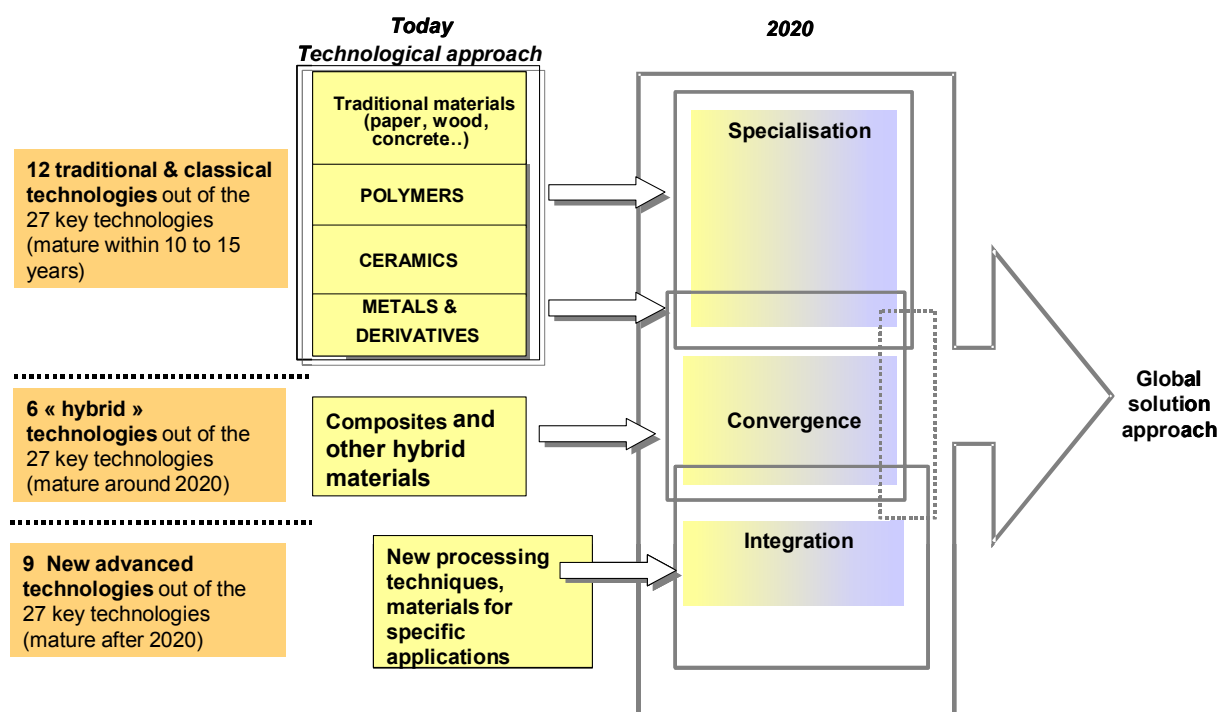
2.3. Thematic Results:

Insights are gathered from the three broad strand studies, from the four case studies and from the governance review.

2.3.1. The Materials Strand:

Traditional “natural” materials technologies such as paper, wood etc. were considered in the study. However, they did not feature in the critical technologies identified. After an iterative process of consultation with experts, 27 high potential materials technologies were identified. Three different technological development paths for materials were identified as shown in Figure 2.1 below:

Figure 2.1. Technological Development Paths for New Materials



The baseline technological path – **Specialisation** – expects growing specialisation of traditional materials technologies. It would be located within either the *Global Economy* or *Local Standard* scenarios. Two alternative technology development paths – **Convergence** and **Integration** would be located respectively within the *Focus Europe* and *Sustainable Times* scenarios.

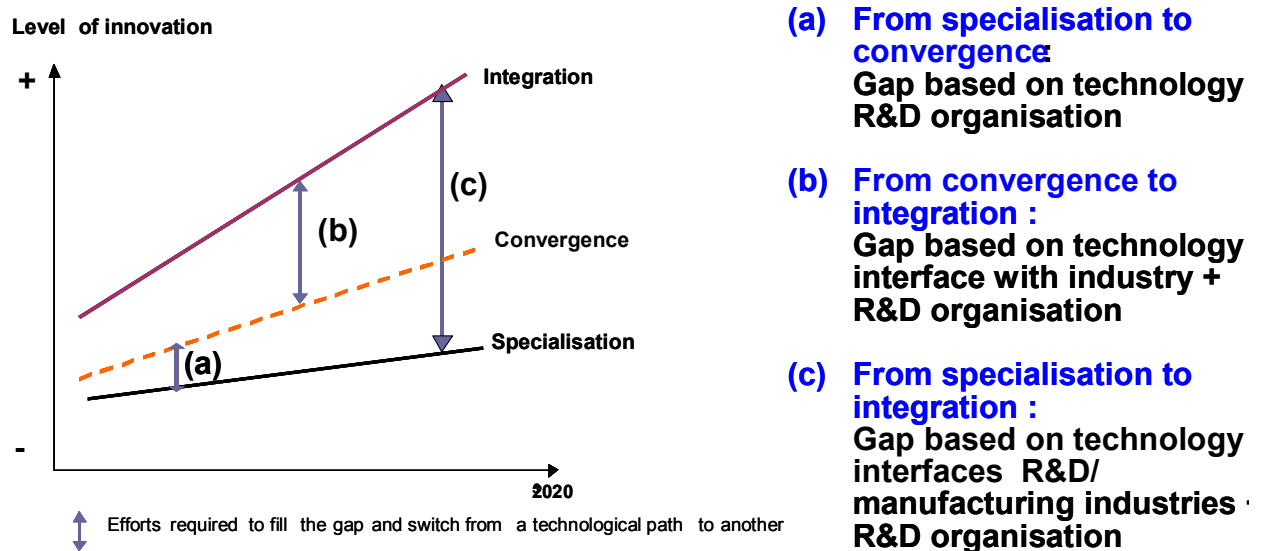
Each of the three technology paths can be characterised by 3 critical factors :

1. Technology priorities
2. R&D organisation

3. Interface modalities with the industry.

Depending on the degree of individual development of, and interaction between, these factors, a growing gap emerge between the technological paths over time.

Figure 2.2. Growing Gaps between Technological Paths



The *Specialisation* technology path was the consensus view of the experts. Its emphasis on the *status quo* is reinforced by a strong EU academic culture of separate scientific disciplines and by the relative weight of traditional materials in manufacturing. However this incremental path allows for continuity without major technological ruptures, and its perceived low level of uncertainty can accelerate social and public acceptance. Interface with the industry is mostly organised through technology transfer.

Key materials technologies identified by the experts included Polymers, Metals, Ceramics and New Concrete. With regard to R & D organisation, the study cautions that under this technology path, EU-supported integrated research networks can be hampered by “administrative partitions within disciplines”. In general the *Specialisation* technology path will have only a modestly positive environmental impact: under this path, manufacturing selects new materials, to deliver primarily agreed quality at lower initial cost, with perhaps some positive ameliorative impacts on the environment as a bonus.

The *Convergence* technology path introduces lateral, pluri-disciplinary thinking both to developing new goods/products and to their process of manufacture. Convergence is already underway, and is supported by EU technological policy. Hybrid materials can be

- *Traditional Composite Materials.* In terms of applicability and relative importance these matrix materials range down from Polymer-based composites, through Ceramics-based, to Metals-based.
- *Other hybridised materials,* probably in the areas of bio-materials, sandwich materials and opto-electronic materials.

Convergence will result in new hybrid disciplines. Pluri-disciplinary curricula, interfaces and networks of excellence should be supported by national governments and the EU. This calls for changes in R&D organisation with the recognition of pluri-disciplinary “specialities. Interface with the industry uses both technology and skills transfers.

The *Integration* technology path pays homage to *Bauhaus* thinking at its purest i.e. Function will determine the Form not only of materials but also of their process of manufacture. A new paradigm will emerge, driven by the generalisation of nanotechnology and buttressed by substantial investment in R & D. Its impact on manufacturing will involve

- a customised production process which integrates innovative design, materials technologies and production processes.
- Just in Time (J.I.T.) and Just in Place production.
- Miniaturisation of production, energy savings and energy storage.

In general, this technology path seems to be the most desirable regarding sustainable factors and technological innovation opportunities.

To advance along the *Integration* technological path will require a large increase in EU investment in areas of materials technology in which the EU possesses an actual or a potential comparative advantage.

- As to resources provided by central authorities, in the 6th RTD Framework programme to 2006, the EU will invest \$320m. p.a. in nano and associated sciences, two-thirds of US federal funding and less than 80% of the Japanese level.
- As to comparative advantage, the experts surveyed considered that the EU’s relative scores in 27 key technologies were weak compared to the US. It is first in only 2 materials technologies in “*scientific and technical position*” and first in only 1 key materials technology in “*industrial and commercial*” position.

Strictly speaking in terms of technology, the EU’s R & D weakness *vis-à-vis* Japan is not crucial. However, beyond technological aspects, this technology path is mostly based on a multidisciplinary R&D organisation and new interfaces between R&D and industries, resulting in an integration of end user requirements upstream in the value chain through project-based platforms.

With regard to scientists, the *Integration* path requires two new competencies :

- The ability to work with other scientists, technologists and marketers as members of a project team; this raises both education and training issues.
- The capacity to be part of these project teams and then to come back to their original disciplines; this concerns R&D organisation and scientists evaluation.

The US is more advanced in these two dimensions, whereas Japan has a long tradition of a better interface with industry than Europe.

Compared to the US, the report considered that EU research in materials technologies lacks scale, integrates the actors in the value chain less well, is more technology-transfer oriented as opposed to project-based, and generally is confronted with more suspicion from society.

If Europe does not react in the short term, it could become “*locked-in*” to the specialisation path and could face a growing gap with Asia and the US, which would become more and more difficult to fill. Already these two regions are moving towards the integration technological path whereas Europe has tended to favour the specialisation and convergence technological paths.

Figure 2.3. Materials Technology Paths: the Challenge for Europe

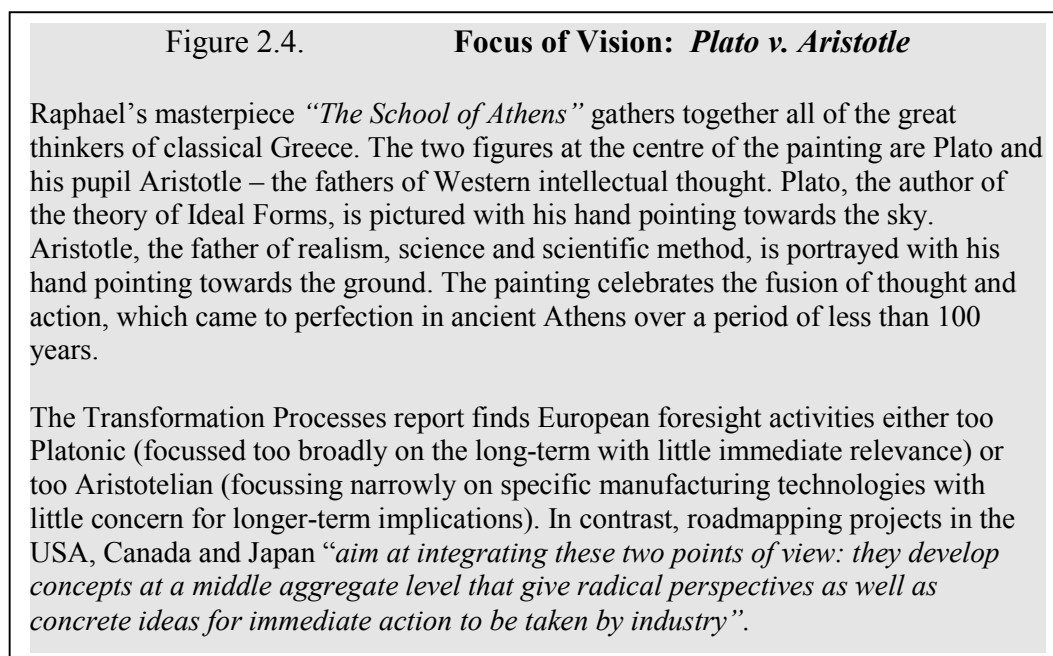
	Technology Priorities	R&D organisation	Interfaces with manufacturing industries
USA	N°1 on all the advanced materials technologies	Flexibility of R&D through agency financing and call for proposals	Project mode already used
Japan	N° 3 in most of the advanced materials technologies	Strong tradition of market lead R&D : weaker science base	Strong tradition of market lead R&D
Europe	N°2 on most of advanced materials technologies ...	Tradition of strong specialisation of scientists Emergence of NoE & IP	Developed technology transfer mode

The policy agenda to turn around these key success drivers in the EU’s favour is weighty.

2.3.2. Transformation Processes:

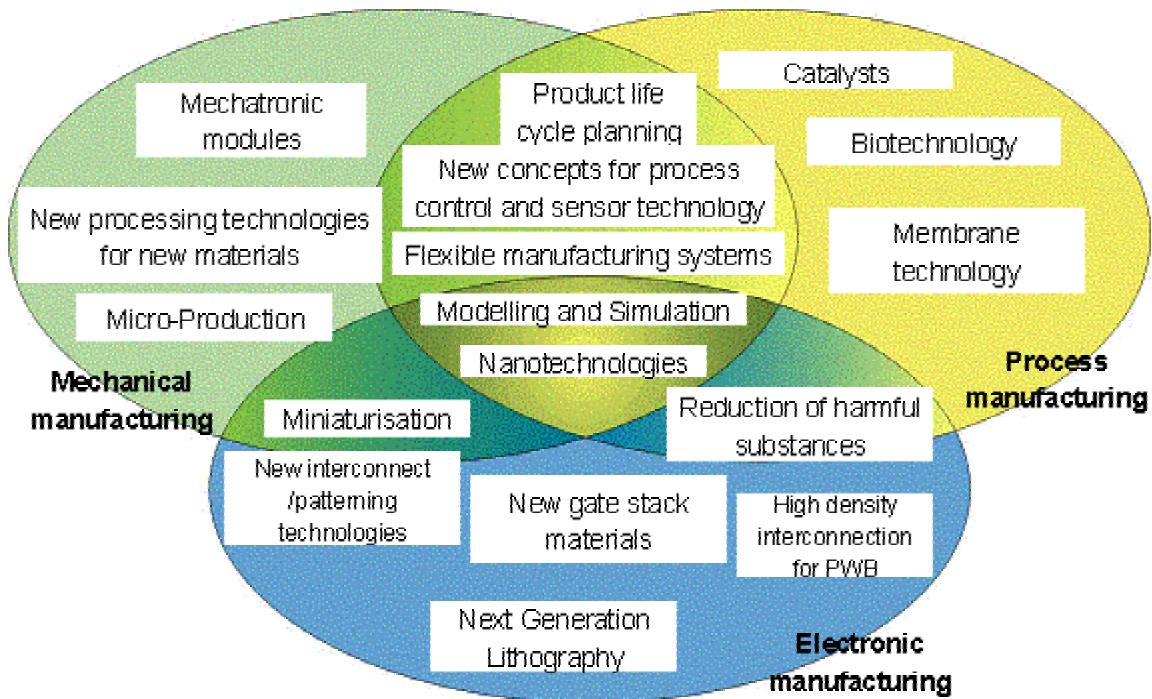
This study of Transformation Processes covered all manufacturing design, planning and production processes including disassembly and re-manufacture. It honed in on two areas - **Mechanical and Process manufacturing**, representing Traditional (or Mainstream) Manufacturing, and **Electronic manufacturing** representing Hi-Tech Manufacturing.

At an early stage, an interesting criticism of foresight-type studies in Europe arose on the focus of vision of such studies. Fig. 2.6 suggests that this is an age-old problem, which each society must in turn attempt to resolve viz.



Accepting this challenge, the strand report set forth its vision in Fig. 2.5. of how the various trends in Mechanical, Process and Electronic Engineering might intersect.

Figure 2.5 Intersection of trends in Manufacturing Fields



In traditional manufacturing, the following trends emerged.

Table 2.5. Technological Trends Identified for Traditional Manufacturing

1. New processing technologies for new materials
2. More complex relationship between materials design and manufacturing planning
3. Miniaturisation of devices and procedures
4. Mechatronic modules – and the need for new types of knowledge in manufacturing in order to integrate mechanics, electronics and IT.
5. Nanotechnology
6. Modelling and Simulation. As with mechatronic modules, new types of knowledge will be required.
7. Reducing the environmental impact of manufacturing
8. Product life cycle – extended to include Planning and Re-cycling
9. Flexible manufacturing systems – to retain high-value manufacturing in the EU
10. Process integration – reducing process steps and re-structuring the process chain.
11. New concepts of process control and sensor technology
12. Intelligent manufacturing/ Near net-shape processing
13. Continuous process improvement and development
14. Catalysts and Membranes , especially in the chemical industry
15. Biotechnology and biofeedstock – perhaps 10% of fuels and plastics bio-based by 2020.
16. Non-fossil hydrogen
17. Substitutes for Toxic and Hazardous substances.

Foresight studies for the USA and EU show similar technological trends. Japanese studies in addition reflected particular societal pressures which are more intense in Japan i.e. those concerning energy, ageing, space.

On diffusion of manufacturing technologies, results from Germany show

- Large firms (employing 500+) are more intensive users of all types of new technology and
- Diffusion rates vary by technology, with for example teleservices showing a rapid take-up but with the take-up of software modelling being slow.

Within electronics manufacturing, technology is the main method of increasing **the capability to produce new products quickly**. And for new products, the price of the technology that will bring them to market is of secondary importance.

“In the semiconductor industry, there is never enough production capacity to produce leading-edge products, and there is always more than enough capacity for yesterday’s technology”

Andy Groves of Intel.

Table 2.6. Manufacturing Technologies for the Electronics Industry

<i>Semiconductor</i>	1. Lithography – the current chip production technology, soon to reach its limits.
	2. Next generation lithography , the next mainstream chip production technology. But which of 6 possible processes will prevail?
	3. Interconnect/patterning facilitates the transmission and control of messages within a chip. How will this develop?
	4. Front-end processes to provide better connections to mobile electronic consumer products
	5. Equipment . Might new devices reduce the extremely high cost of wafer fab plants?
<i>Printed Wiring Board</i>	6. High-density interconnect , driven partly by mobile electronic products’ need for boards with higher density and smaller scale.
<i>Electronic assembly</i>	7. Packaging . Performance requirements for chips vary, with telecoms requiring miniaturisation and high performance, while aerospace requires high performance in a harsh environment.
	8. Final assembly . As in the car industry, electronics manufacture will increasingly assemble modules rather than individual components, and will seek to simplify

	the assembly process of final electronic products.

What are the skills and competences required in Traditional Manufacturing?

- **Teams and Leadership:** *“However it can be concluded that the ability to work in teams with people from different cultures and disciplines is one of the core-competencies of future manufacturing personnel. It was also mentioned that future teams need new kinds of hierarchies and leadership....It is expected that the ability to fulfil varying tasks in different projects will be more important than classical leadership abilities.”*
- **Adaptability:** *“Especially interviewees from Scandinavian countries stressed the importance of cultural awareness for success in global manufacturing. They expressed the view that small countries are more apt to these challenges as they are used to adapting to different cultures. Furthermore, it was mentioned several times that global manufacturing is demanding international thinking”.*

Fig. 2.6.

Adaptability and Development

Lessons from the Periphery

1. Classical economic development theory considered that small, peripheral countries were at a significant disadvantage compared to large, central economies. Remote countries within the EU, like remote regions in a country, were likely to fare less well than core countries within the EU, or capital cities within a country. To partially offset this, the EU provided development aid under Social, Regional, Cohesion and Structural Funds. Such funding helped to initiate and increase the pace of development in poor, peripheral countries such as Ireland. But it cannot explain why the economies of two peripheral countries – Finland and Ireland – have had more robust growth than core countries' economies in recent years.

2. The key to both countries' success seems to be in their greater adaptability to international developments. Following the collapse of post-Communist Russia, Finland succeeded in re-focussing its economy, helped in no small measure by Nokia's leadership in mobile telephony. During the 1970's and the 1980's, Ireland had been particularly reluctant to adapt domestic policies to the global changes following on from the first and second oil crises, and its economy suffered as a result. Over twenty years ago an Irish development strategist clearly distinguished between the strategy appropriate for a large country (an elephant) and that appropriate for a small country (a flea).

"The logic of the elephant is power. The logic of the flea is hustle. Ireland must hustle"

From 1987, Ireland began to hustle, abandoned previous Canute-like policies to change the world to suit its needs, and instead adapted those policies to better suit world needs. It became the favoured bridgehead for US hi-tech investment into Europe, mainly because of an Irish managerial capability to mediate between their USA owners and their EU/Asian customers. Within a decade, Irish income levels had grown to exceed the EU average. To those who are convinced that Ireland sold its soul for a mess of (post-imperial) pottage, the country's simultaneous out-performance in the arts, and indeed in football, must surely disappoint. For example, record sales by Irish artists (U2, Cranberries, The Chieftains etc.) last year placed Ireland fourth in world record sales, after the USA, UK and Canada.

4. Can the success of peripheral economies provide guidance for core economies? Yes, but only if core economies stop consoling themselves that the outperformance of peripheral economies is due to proximate causes (concentration on mobile telephony in the case of Finland, a low corporate tax regime in the case of Ireland), rather than efficient causes, such as adaptability.

The world economy is not yet Darwinian, but it is getting there! Policymakers in core EU economies are facing an ageing workforce, confident in the power of their past achievements, and not willing to be hustled into sudden change. However, a persistent failure to adapt to change in the globalised economy will cause stagnation. This has occurred in core EU economies in recent years. Core EU economies now need to hustle.

Electronic Manufacturing requires skills and competences in two areas:

- A. In new Technologies, which do not yet have
 - enough scientists/researchers
 - enough money invested or
 - enough collaboration in research.
- B. In the organisation of manufacturing,
 - one must define core competences and invest in them.

The experts' judgements on Europe's manufacturing capability in terms of transformation processes were mixed. Europe was seen as possessing strong positions in car manufacturing, machine tools, opto-electronics and chemical engineering. High quality was seen as a key strength of European manufacturing, although over-engineering was seen as a weakness among some German companies. The USA was seen as being ahead in IT competence. Europe is seen as deriving strength from its current high level of education and training. Fears were expressed that this would diminish in future due to demographic change, reduced investment in education and a lack of enthusiasm for S & T among European youth. There was a similar even-handed judgement with regard to manufacturing's relationship to the environment. Europe's current environmental performance scores strongly, but fears were expressed that the cost of compliance threatened competitiveness. In general Europe, compared to the USA was seen to be weaker in technical innovation, in time-to-market and in technology transfer to industry.

Five major concerns arose from the report on Transformation Processes viz.

- **Cross-cutting and competing technological trends to be geared towards sustainability:** Technology mapping has shown developments with high potential for reducing environmental impact or enabling improvements in social sustainability. Areas cross-cutting different kinds of transformation processes such as sensor technology, modelling and simulation, product life cycle planning, intelligent control, miniaturisation of products and devices, and nano-manufacturing should be given particular focus. Specific actions need to be taken to ensure the diffusion of innovative concepts and sustainable technologies into a wide range of users – particularly SMEs.
- **Making sustainability an effective driver for manufacturing innovation:** While the concept of sustainability is generally accepted at the level of management boards, the real impact on day-to-day decision-making is limited. Thus, optimisation with respect to sustainability is not taking place as early in the product and process design stages as necessary. Concepts for manufacturing new materials with environmentally benign processes using regional resources and applying the intelligent co-operation of man and machines are required in European manufacturing.

- **Bringing manufacturing into a more pro-active role:** In its struggle to cope with reduced time to market, increasing product variety and volatile markets, manufacturing is in danger of being assigned a purely reactive role. There has been considerable investment in New Product Introduction processes, particularly from a Product R&D viewpoint, but insufficient investment in the associated Total Manufacturing Process Systems. Manufacturing needs to be encouraged to develop relevant innovative solutions encompassing the sustainability dimension. This will foster a vibrant self - sustaining European-based manufacturing capability.
- **Continuous improvement of skills and competencies:** Severe concerns about a future lack in Europe of competent young people to engage in manufacturing call for increased efforts in education and promotion of life-long learning. Transferable skills are considered more crucial than specific technological knowledge. Co-operation and networking (across companies, sectors, (scientific) disciplines and cultures) will become key competencies at both individual and corporate levels.
- **Overcoming Fragmentation, but maintaining Diversity.** Play to Europe's strengths in terms of increased servation and a wide range of manufacturing equipment. Can a model for customising sustainability for manufacturing be drawn up from Europe's experience?

2.3.3. Structure of Industry:

One of the most useful insights from the Structure of Industry strand was its conclusion that *“human capital will replace physical capital at the core of competitive advantage”*. This represents a sea-change from the neo-classical view of the factors of production in manufacturing. Traditionally there were four - Land, Labour, Capital and Enterprise. Land is irrelevant in a post-agricultural society, while Capital for manufacturing (machines for production + liquid capital) has become commoditised in an electronic age. Globalisation threatens to commoditise Labour, not simply in the production of goods, but now also in the production of easily-packaged services⁴. This leaves Enterprise, as embodied in Human Capital, as the main source of European competitive advantage. But the manner in which enterprise must be deployed in firms has also changed. Traditionally, the super-normal exercise of Enterprise by an individual (Henry Ford) or by a group of individuals (Hewlett and Packard at HP, Groves and Moore at Intel) proved the key to initiating and sustaining competitive advantage: leadership was handed down from the top of the pyramid. In a post-Fordist world, enterprise must be distributed through a flatter, more flexible organisational structure of manufacturing. Hence enterprise, incorporated in the whole of the labour force and not simply in its managers or its entrepreneurs, is the only

⁴ *Business Week* (3rd February 2003) reported on how a new round of globalisation was sending “upscale jobs offshore”. They included basic research, chip design, engineering and financial analysis.

bulwark now against the commoditisation of the product offerings of high-labour-cost/high-value-added economies such as the EU.

Arising from that, two questions arise in relation to education, training and work.

- Have information and communication technologies “*hollowed out*” many of the “hand-eye” skills in manufacturing i.e. measuring, setting out, shaping and assembling? Must the operative now control the manufacturing process by thought rather than by deed? Is the Knowledge Economy enforcing a change in kind rather than in degree in the skills of its labour force?
- Is the mass higher education model of the USA better suited to the New Economy than the classic vocational training models of central European economies? Certainly the mass higher education policy of Ireland and its ability to gel with incoming New Economy enterprises is credited as a major factor in the *Celtic Tiger’s* economic success.

The report identified three key future influences on the structure of manufacturing viz.

- “Servation”⁵
- Closed loop systems, in which waste outputs from one process are used as an input into other processes.
- Virtual enterprises via B2B

“Servation” is again a *Bauhaus* insight – that Function rather than Form is the source of added value delivered to the customer in developed economies e.g. IBM’s structural shift from product manufacturer to service provider.

Case study interviews suggest that an interdisciplinary and multidisciplinary approach will become essential for developing and introducing new technologies. And as technology-driven differences become easier to imitate, “causal ambiguity” i.e. smokescreens, will become important. However, these can only delay pursuing competitors: maintaining a competitive lead will require change management to be embedded in the right sort of organisational structure.

Changes in the supply chain through B2B will influence *competitive positioning, strategic choices and organisational structuring* of firms. The supply chain will also be influenced by *demand factors, closed production loops and increased customisation*.

⁵ or extending the physical product offering to include value-added services prior to physical manufacture at the design stage, and/or post-manufacture at the after-sales stage.

2.3.4. Synthesis of Strands

The three broad strand reports on Materials, Transformation Processes and the Structure of Industry cover topics, which are to a very high degree linked to each other and where developments in one area in most cases are dependent on parallel development in others. Accordingly, progress in materials will allow and/or require new transformation processes, which, in turn, can enable further development in materials, and all this will ultimately be geared towards the demand of new industry strategies that are emerging for future manufacturing. These strategies will often decide the technologies that will make it from the laboratories and move on to production. It should be remembered that regulations and policies can play an important role in influencing these strategies and, thus, industry choices. Hence, the symbiosis, in which these trends live and develop, is inevitable and vital.

Customisation

The context in which manufacturing companies will work in the future will depend even more on flexibility, speed and servation. Customisation will be driven far in many areas with product ranges not only aiming at varying income groups but at groups with different age, culture, gender, lifestyle, religion etc. Product differentiation has already begun and the producers are convinced about the continuation of this trend. For example, only a few years ago, Nokia had five different mobile phones on the market and today as many as 35. Likewise, Volvo does not make any cars for stock for the European market but only on a direct customer request. Even though technology push certainly has a substantial impact as a driver, “adaptability” is a key competence. The ability to offer different customers what they want in a quick and reliable fashion at low cost will continue to grow in importance.

Competitiveness through co-operation

In order to combine flexibility, speed and cost in a positive way, organisational structures and practices, and technologies have to develop in parallel. On the former, we will see more of vertical integration but also of outsourcing with global optimisation of the supply chain, and co-operation with research institutes, suppliers, customers and other players. Competing companies in Europe must learn to co-operate in a different way than has been the case until now if they wish to cope with global competition. The problem solution strategy will encourage companies to enter into partnerships when suitable for business and to leave when opportunities dissipate. The virtual factory, linked through the Internet, will allow global constellations also including smaller companies. A close contact with clients and their industries will be of utmost importance both in terms of production and R&D.

Flexibility at a low cost

Moreover, a general approach to accomplish flexibility at a low cost is to work with modules and platforms, at different levels of the supply chain and with respect to products as well as to manufacturing equipment. Final assembly will often take place at the latest time possible and also as close to the customer as possible. It is foreseen that the role of final assembly will in one way be less important due to the decreasing number of components (but instead better and more intelligent and flexible components) to be put together. The important question will be who can produce most products out of these fewer but more complex components. The described approach favours local production with not only local assembly but with local suppliers, all in

order to keep unnecessary transportation time and cost to a minimum. This could lead to a vision of 2020 with for example small scale car manufacturing sites producing 5.000-10.000 cars/year where most basic parts come from nearby suppliers and during the final assembly, components chosen by the customer are added.

Adding value added by servation

A core response to changing customer profiles and market demands will be seen in servation. Whether the products sold are increasingly sophisticated or not, additional services, operational management and maintenance will be provided for example in the form of contracts guaranteeing functionality. The product will be a pre-requisite for the initiation of the business process. Ultimately, the product's ability to provide customised solutions will be the central selling point. For example, a client could pay for a clean stack or a painted part rather than being provided with a specific chemical product. This would allow for a greater scope for creativity in finding the most efficient way of fulfilling customers' needs.

Speed and flexibility as technology drivers

It is not only the organisational framework, which has to adapt to drivers like flexibility and speed but also the development of transformation processes and, thereby, the same drivers are pushing the materials being transformed. Process integration is seen as one answer to the demand on speed in that it reduces the amount of manufacturing steps needed for a certain product, and likewise, the diversity of each tool in the transformation chain is of great interest. Non-specialised tools, which can be adapted to different functions by programming and be highly automated and integrated with its surrounding stand a better chance to respond to the drivers of flexibility and speed.

Examples of such transformation processes are laser technology, which is fast, flexible and can be highly automated and, thereby, is highly suited for process integration. Hydroforming and pressing are equally flexible. Process integration pushes for near-net shape processing like casting and sintering, which have the additional advantage of being suitable for localised production. In the chemical industry, fewer steps may be required by, for example, combining reaction and separation in reactive distillation or by applying more targeted synthesis paths. The latter will be possible by using new and improved catalysts with higher selectivity resulting in higher yield and less energy input. With process integration gaining in importance, it will be a key competence to chose and combine technologies, which function well together in a complex production system.

In this aspect, the materials used are of equal importance and the available and possible combinations of materials and transformation processes will decide in each case. In general, there will be a strong need for processes that can be adapted to the needs of different materials. The emergence of specific materials with specific functions will lead to an increased integration of material and manufacturing process design.

The choice of materials thus influences the choice of transformation process used and vice versa and can ultimately have an impact on the nature of jobs and their location as well as the organisation of production. If a radically new approach to alternative semiconductor device manufacturing that substantially reduces the price of a

fabrication facility could be developed, the landscape of the electronics industry would change dramatically. Breakthroughs in the area of nano-powders, leading to progress in powder metallurgy, which would further enhance the opportunities for near net-shape processes, is yet another example of how developments in materials, transformation processes and industrial organisation are closely interrelated. One of the first examples to come to mind is the fuel cell where parallel breakthroughs are necessary in manufacturing (technological as well as organisational), materials, systems integration and infrastructure (and possibly in more areas).

Science development based on knowledge in molecular scales

As is clearly laid out in the Materials report, future development in materials can take various paths depending on a number of variables including the socio-economic trends in society. What seems to be certain is that a substantial part of developments to come will in one way or another be based on a deeper understanding of smaller scales, like nano-science. By understanding phenomena at ever smaller levels, it will be possible to predict material characteristics. With the capability to predict material properties and to manipulate material structures, a range of opportunities will arise. We are likely to see materials with increased functionality, special characteristics and extended performance range. The manipulation must not stop at the nanoscale but continue to macroscale to enable the processing and manufacturing of materials with specifically tailored properties.

New materials and improved conventional materials in new applications

Applications of the ability to manipulate materials are expected to be developed in both modifications of conventional materials and completely new ones like hybrid and mixed materials. The potential for nano-composites is high, with multifunctional properties and broad application possibilities. Biomaterials will provide manufacturing with a range of capabilities within chemistry, agriculture and pharmaceuticals. Low-weight and high-strength materials, sometimes further enhanced by special coatings, will be used for example in the automotive industry. Exciting new materials for use in the electronics industry are yet another of the areas which are being investigated. The successor to silicon might be carbon nanotubes or polymers. The potential for polymers, where bulk production may be in place within five to ten years time, is high as the technology could provide low cost materials for the microelectronics industry whose major companies in the world are investing heavily in this area today.

New knowledge on small scale leading to improved and controlled processes

The ability to structure and, thus, control the properties of surfaces and interfaces will have a profound impact on catalysis. New and improved catalysts would allow for new products as well as more targeted synthesis paths with higher selectivity, resulting in fewer synthesis steps, higher yield, less waste and lower energy input. Enhanced performance of materials may also lead to a wider use of sensors in manufacturing industry, both in the control of synthesis and materials structuring as well as in transformation processes. "Active" sensors will be developed which will not only sense but will also respond to what they detect.

Advances in measurement techniques and computational technologies will be necessary to further allow for such control. Traditional quality control laboratories could then be replaced by real-time, continuous, in-process measurement systems,

which would give immediate feedback to the process. This would enhance quality and optimise usage of raw material and energy. Last but not least, it would speed up the overall process as sample preparation will not be needed for routine measurements and the analysis cycle time can thus be reduced. Consequently, it is just as important to continue to develop highly sensitive and precise measurement technologies to be used in laboratories to probe molecular processes, as it is to make sophisticated measurement tools and equipment more robust and user friendly. By doing so, they can be used not only in research laboratories but provide real-time, on-line data in the factory. Processes in the production plant will not only be measured but simulated, automated and controlled in a much more rigorous way than today. Improvements of the interface between production, process and material properties via simulation are a prime research issue.

Simulation of processes, which still today often is based on semi-empirical data, needs to be further developed, make use of existing knowledge in areas like thermodynamics, kinetics and transport phenomena and be able to model fluid characteristics and multi phase systems. To use such programs in an efficient way, far more accurate input data are needed than what exist at present.

Environmental aspects of future manufacturing concepts

There is a range of drivers for environmentally sustainable manufacturing, which may affect any stage of the process, from cutting cost by saving raw material and energy to regulation set by authorities. Such regulations - for example take-back, re-use and recycling as well as emission ceilings - are strong factors which drive the manufacturing industry in its decision-taking and development. Reuse and recycling are moreover pursued for cost reasons and many manufacturers have initiated research projects in dismantling technologies, recycling-friendly design and biodegradable materials. The earlier that materials and transformation processes can be adapted to each other in an integrated design process, the more environmental aspects can be incorporated and dealt with in a proactive way. New concepts of functional material design can therefore be a strong enabler of environmentally sustainable manufacturing. However, their pure existence is no guarantee of their sustainable use and here lies a big challenge for technology policy and R&D funding. From a recycling point of view, multi-material design can be highly problematic. The more different materials there are in a product, the more difficult and expensive are the re-manufacturing and recycling processes. Disassembly considerations should therefore be important concerns when developing and choosing joining technologies.

Distant outsourcing can make tracking and evaluation for life cycle analyses more complicated and can also create problems for reuse and recycling. To solve this, recycling concepts should be developed between several partners. Suppliers play an important role, e.g. by submitting information on their parts but also as initiators of recycling concepts for their modules. Virtual laboratories could help with the co-ordination of manufacturing/recycling projects. It must be remembered that it is not only important to develop new environmentally friendly concepts and technologies but it is just as significant to make sure that the diffusion of already existing ones takes place.

There are several trends in manufacturing which show promising prospects for the environment. A few examples are: new catalysts which result in better use of material

and energy, the control and optimisation of processes enabled by sensors and improved measurement and simulation techniques, near net-shape processes resulting in less waste, more local production with less transport and, lastly, materials providing more efficient energy production, storage and transportation.

Co-operation and communication

The multidisciplinary trends that we see emerging today call for co-operation across all kinds of borders, discipline borders as well as hierarchical ones, between different companies in the vertical chain as well as horizontal co-operation. In turn, this means that comprehension and communication skills across fields will be key issues. To be successful at problem solving, organisations will encourage and give room to multidisciplinary knowledge, ideas and discussions between all kinds of levels; this comes more naturally in flat organisations. The exchange of people between academia and industry would further enhance multidisciplinary knowledge. Moreover, global co-operation and virtual factories stress the importance of taking advantage of cultural diversity. This is something that every company has to embrace.

The question of skills

These “softer” skills should be given more attention at university level, than is the case today. Thus, many of the softer key skills are becoming increasingly homogeneous and generic and, consequently, the workers more readily transferable. This means that companies will have to work even harder to retain their key employees. However, the knowledge society also requires highly specialised skills and a number of industry sectors in different countries are considering actions like sponsoring of programmes at schools and universities, preparing the way for establishing dedicated industry universities and developing schemes whereby certain graduates are given incentives to enter into a particular industry through a high profile fast track scheme that matches the pay and prospects of any other attractive sector.

This is all a response to the expected future lack of a skilled workforce. There are industries, which have problems with their “reputation” and fail to be attractive enough and there are others, which do not have the same problem but still are concerned about the lack of the skills of their future workers. Apart from organising highly industry special education, basic science needs to be made more attractive for young people and the concept of lifelong learning cannot be stressed enough. Vocational training can still today be a difficult issue, due to the unhelpful attitudes of some employers and employees. It is not uncommon for an organisation to concentrate most of its vocational training on a limited number of specially selected people and that is an approach, which may have to “widen” if European manufacturing firms want to be competitive in the future.

2.3.5. Case Studies and Interviews:

To give cross-cutting insights into how the scenarios and broad strands might bear on different strata of manufacturing, four case studies were undertaken in the *Automotive Industry – Personal Cars, Measuring, Precision and Process Control Instruments*, the *Semiconductor Industry* and *Basic Industrial Chemicals*.

The *Automotive Industry* is one of the EU's major success stories. The manufacture of new motor vehicles, vehicle parts and equipment amounts to over 10% of EU manufacturing output; and in 2000, 20m. cars or one-third of global output, were produced in Western Europe. It is the only major sector of manufacturing in which Europe is first in design, output and profitability, with Japan second and the USA

Figure 2.7.

Old Europe goes East

Carlos Ghosn and Nissan

Carlos Ghosn's automobile credentials – *Ecole Polytechnique*, Michelin, Renault – are impeccably “Old European”. When he arrived at Nissan in 1999 only 3 of 48 models were making money and the company had lost \$6.3bn. in that year. In Nissan's Revival Plan, Ghosn persuaded the company to adopt classic Western restructuring proposals – selling assets, closing plants, sacking workers and squeezing suppliers. Crucially, he also deployed his people-management skills to persuade his colleagues that the problem lay within Nissan and not outside it. Handshaking every employee he met, he promised to resign if the company was not profitable within a year. In 2000 Nissan's profits were \$2.7bn. Three years on its operating margin of 10.6% is second only to Porsche's. Internally, English has been made the official language of the company, elevating business imperatives above those of culture (Japanese, French). He has installed 13 cross-functional management teams that cut across the traditionally compartmentalised engineering, finance, marketing and manufacturing departments. While keeping a stranglehold on costs, he has sharply increased investment in R & D and new cars, and hired a new design chief (ex-Isuzu!). He has taken an axe to the long product life cycle of typical car models. By keeping tooling costs low he believes new vehicles can make money almost as soon as they are introduced: he considers that the profits to be milked from the “*cash cow*” mature phase of products are frequently less than the discounts required to retain the market allure of such archaic products.

Ghosn's insights on organisations, on the need for products to match markets in terms of product cost and design, and also on the shortening of product life cycles for consumer durables, should be heeded not only by EU auto manufacturers, but also by other manufacturers operating in high-cost, globally-competitive markets.

coming third. The case study provides important insights that can show other sectors of EU manufacturing how a high wage cost industry can survive and thrive in globalised markets. Indeed, without taking from his huge individual ability as a manager, Carlos Ghosn's turnaround of Nissan⁶ would suggest that Europe can export not simply cars, but also car-making capability.

The automobile case study identified seven drivers of change. Of these, three were related to demand (increased individualisation, changing values and an ageing population). Two related to resource inputs (a reduction in the availability of and possibly in the skills level of young workers, and constraints on oil and other

⁶ Mackenzie, Angus, (March 2003), *If this man joins your company, he'll make you 10 bn. dollars overnight.* Car, (London).

resources). Finally, with regard to the production process itself, two concerns were raised about environmental legislation and globalised production.

Technology trends identified in relation to car manufacturing included Multi-material processing, Lightweight materials, Nanotechnologies especially nano-coatings, Powertrain developments especially fuel cells and Electronics especially *x-by-wire*⁷. Shortened car product life cycles will pressurise manufacturing processes to become faster and more flexible⁸, ICT modelling will move from the experimental to real-time, and the diffusion of technology across the range of automobile-associated companies will have to accelerate. Finally, the level of interdisciplinary teamwork and communication skills will have to improve.

The case study cannot be definitive on how the value chain may be re-structured since diverse concepts such as “*manufacturing close to the market*” or “*centralisation in order to achieve economies of scale*” are emerging in parallel. EU manufacturers have acknowledged Japanese superiority in “*lean production*” systems, and have adopted the use of platforms and modularisation. The European approach to OEM’s⁹ involves networking amongst (almost) equals, while the Japanese is more hierarchical. This results in perhaps more innovation in car component design in Europe, with perhaps more reliability in car production in Japan! The study considers that “*the question of how the core role of electronics is tackled by the different actors in the electronics sector is still open*”. Lest the automobile industry’s commitment to the environment should flag, regulatory imperatives towards best practice exist concerning life cycle and management, water, waste, pollution, VOC’s, and end-of-life recycling. As with all regulation, the desire to secure best presently-visualised use may militate against superior use in future.

Interestingly, survey respondents do not see car sales being ousted by a “*servation*” concept such as the provision of “*mobility services*”, as envisaged in the scenarios. Could they be proved wrong, as Theodore Levitt famously showed the US railways were wrong, because they thought they were in the railroad business, when in fact they were in the transportation business and cars provided superior transport? Or are the car manufacturers correct in reckoning that point-to-point car transport will endure in spite of increased congestion and gradually-improving public transport services?

The case study engages with this problem in considering three possible trajectories for automotive manufacturing in relation to sustainability viz.

- *End-of-pipe Compliance* would obey the laws on environmental impact, but would not proactively attempt to anticipate legislation with innovative concepts.
- *Life-cycle Orientation* would involve re-cycling and re-manufacture issues right from the product design stage.

⁷ Replacing mechanical systems with electronics e.g. drive-by-wire, brake-by wire etc.

⁸ Laser technology may speed processing, while simulation and modelling may speed design.

⁹ Original Equipment Manufacturers i.e. primary suppliers.

- *Sufficiency turn* would see sufficiency replace (first round) efficiency as the main strategy for consuming and producing.

Whatever its position on sustainability, the automotive industry is ideally placed to function as a test-bed for improving European manufacturing's competitive position in technology fields as diverse as electronics and materials.

The case study ends by summarising two conclusions and policy implications for automotive manufacturing.

- *Competitive challenges* must be overcome with respect to re-structuring supply chains (with a policy need to support networking), the increasing "electronification" of the car (with a policy need to support the development of electronic systems), and the emergence of new propulsion systems and car concepts (with policy reinforcing support for the system innovation character of fuel cell technology).
- *Sustainability and Future Car Production* needs both a strengthening of production modernisation as a self-contained "capacity" within companies, and also improved workforce skills (better knowledge and better communication of that knowledge).

The *Measuring, Precision and Process Control Instruments (MPPCI)* sector provides an example of a sector in which Europe has established strengths while lagging somewhat behind the USA in some promising segments of the market. As a derived demand market, success for firms is intimately linked with that of their customer industries. Many of these have been traditionally cyclical. However, the development of new technologies has opened up many more opportunities to the sector in more stable markets such as pharmaceuticals, healthcare and security.

The industry is characterised by a small number of large firms and a large number of small and medium sized firms that either collaborate with the large firms or service niche markets. The sector's reputation for innovation is quite high and its relationship with research communities has been strong as the sector is an important supplier of equipment.

The rapid development of technology in many fields is broadening the scope for the sector. At the same time it is placing severe demands for adaptability on actors in the sector.

The principal drivers of development in the sector identified by the case study were three related to demand (increased individualisation, heightened perception of risk among the public and requirements of an ageing population), and one related to resource inputs (the availability of the requisite pool of skills and knowledge to support the innovation needed by the sector). Technological development, particularly in nanotechnology, new materials and new production processes would also provide opportunities and challenges to the sector.

Technology trends, affecting the MPPCI engineering sector include increased automation in many activities together with increased integration of real time monitoring, measurement and testing. The response of the sector has been to move from simply providing stand-alone equipment to working with other process equipment suppliers to supply components of integrated facilities and in some cases to supplying, operating and maintaining the functional service their equipment enables.

The future development of nanotechnology will move the sector into the mainstream of production/process equipment provision, as many of the critical instruments needed for production processes will be high precision laboratory-type equipment.

Modularisation of product design, concurrent engineering and simulation and modelling will be essential parts of the sector's stock-in-trade in future. The spread of multi-functionality in individual devices may reduce the number of instruments needed but should increase their overall value.

The sector will have an important contribution to make to the spread of sustainable practices by providing much of the monitoring and control of products and processes and by giving confidence to the public that new technologies such as nanotechnology and biotechnology are being exploited safely.

As a support industry to a wide constituency of users in manufacturing, research and services, the instrument sector will continue to be the source of most new innovations, particularly for SME's who outsource most of their cutting-edge R&D requirements. However, because most expert firms in the instrument sector are themselves small, their own R&D will tend in the future to be collaborative and lean heavily on research institutions, particularly for basic research.

A strong European MPPCI sector will be a prerequisite to support developments in new materials and processes. Current strengths in skills and competencies of the industry's workforce will need to be maintained and replenished. A general strengthening of European innovation capacity and capability will particularly assist the instrument sector. Networking to achieve critical mass in future developments in the instrument sector will be a key to allowing Europe to compete in this sector.

Standardisation, accreditation and certification are important issues for the instrument sector. In future, new opportunities for providing services may emerge, e.g. in analysing data from newly generated metrology networks in the fields of transport, health, environment, etc. More generally, the application of new measurement techniques and systems within both manufacturing and research (and in the areas of transport, environment and health) are likely to produce large amounts of data which will have to be analysed and processed, which should provide opportunities for forward-integration strategies by instrument firms.

Policy actions suggested as particularly appropriate for the MCPPI sector included,

- Support for networking between instrument manufacturers and makers of process equipment as the integration of measurement and control functions into processes

becomes more pervasive. This action will be especially important for SMEs in the sector.

- Support for new research programs, incentives and methods for co-operative working. The further professionalisation of R&D management and the introduction of knowledge management methods should be fostered.
- Development of multi-disciplinary approaches to R&D to exploit its potential in emerging areas such as nanotechnology and new materials is needed. In this the sector shares with other sectors the need to attract and retain highly qualified and competent personnel.
- Intellectual property is an important asset for this sector. SME's need internationally-efficient and streamlined systems of protection to allow them to compete.

The *Semiconductor Sector* case study deals with a classical sub-supply sector, which produces an extremely wide range of components for a wide range of user industries. The products supplied range from mass produced commodity chips to sophisticated complex niche products. Europe buys 22% of the world's output of semiconductors and produces 13%. This represents a very large trade deficit.

With the ubiquitous spread of ICT into all aspects of life, future use of semiconductors is set to continue to grow. Opportunities exist for Europe to consolidate its current capabilities and to establish itself as a prominent player in emerging technologies, which will challenge the current dominant technologies.

Current semiconductor technology is silicon-based and this technology will continue to be the focal point for materials research for another decade. As material limits are reached, the challenge for the industry will be to invent and develop new technologies to extend the capabilities of silicon or to develop new substitute materials. Improvements to transformation processes will help silicon to hold its central role in this industry. These improvements will require expensive R&D but the rewards for companies and countries that can exploit the results will be substantial.

Drivers of change in microelectronics research have traditionally been consumer electronics, military and space applications. In future, computing and telecommunications applications and biotechnology will figure more prominently. While technology push factors will remain important as firms in the industry continually seek first-mover advantages by bringing new generation devices to the market, demand pull factors seeking evermore powerful memory and processor devices for an expanding range of applications will extend the range of user industries. Miniaturisation and ultimately nanotechnology will allow the ubiquitous spread of electronic devices, creating widespread market opportunities. The expectation of a significant expansion of the use of electronics in the automotive sector, as mentioned above, will be repeated in other industries such as aerospace, electrical appliances and medical devices.

Experts interviewed from the sector highlighted the need for a broad range of skills. This skills range extends over many areas of physics, chemistry, and engineering, while much stress was placed on the importance of multidisciplinary capability. This is particularly required for materials research, which holds the key to much of the future opportunity in the sector. The case study also identified the need to attract science and technology graduates to work in R&D and manufacturing in the sector and reverse the trend that has seen top S&T graduates choosing career paths in financial services etc.

Europe will need to increase its level of R&D spending on new high tech sectors generally and on semiconductors specifically. It will also need to improve its productivity levels to remain competitive at a global level. The dominance of the USA and Japan in the semiconductor industry will be difficult to break but building on the solid research base of Europe it is a challenge that can be met. It will require an improvement in Europe's ability to rapidly exploit and commercialise its R&D output.

Environmental legislation and compliance may result in higher prices in the short term for goods containing semiconductors in Europe. The current usage of hazardous material in the semiconductor industry affords Europe an opportunity to lead the world in environmental technology, in design for recycling processes and in the recovery of valuable materials from waste products.

The semiconductor industry will continue to play a significant role in the future of Europe. The European Council Lisbon Declaration of March 2000 set the goal for Europe *“to become the most competitive and dynamic knowledge-based economy in the world, capable of sustaining economic growth with more and better jobs and greater social cohesion”*. Achieving this goal requires an overall strategy aimed at preparing the transition to a knowledge-based economy by better policy for information society and R&D as well as by stepping up the process of structural reform for competitiveness and innovation. The semiconductor industry is in a pivotal position to contribute substantially to this ambitious aim.

Policy action suggested in the semiconductor case study included:

- Improving the attraction of the industry and manufacturing in general for highly qualified and skilled people,
- Supporting the development of entrepreneurship through education and training,
- Support for the commercialisation of new technologies
- Support for the exploitation of niche semiconductor markets through Member State and regional policies.

The ***Basic Industrial Chemicals*** case study covers an industry, which is very large in its own right but is a segment of the chemicals sector. The chemicals sector is a major industrial sector in which Europe contributes 32% of world output and is a larger producer than the USA or Japan. Throughout the 90s Europe's chemical production

grew faster than that of either Japan or the USA. The basic industrial chemicals segment represents about 38% of total chemical output.

This industry depends heavily on oil and gas for its raw materials. For basic low value-added product producers, access to and prices of oil and gas dominate decision-making and strategy formulation. Experts interviewed expected this area of production to progressively move out of Europe into the Middle East, Russia and North Africa so as to be close to the sources of raw material, and as these countries adopt strategies to exploit their natural resources. Europe can still play a role in this development since the technology for this segment of the industry is shared by the USA and Europe largely.

For higher value-added products the impact of raw material prices is less critical and volumes tend to be lower. Product differentiation is an important feature of demand and so flexibility and adaptability of processes and scheduling are more important to suppliers in this segment. Innovation in new processes and new materials will provide a competitive advantage to firms and Europe's strength in R&D can be turned to advantage here.

The main technology trends identified for the sector concentrate on the impact of new materials, new catalysts and improved processes. New materials will be particularly important in polymers, with for example bio-polymers, bio degradable polymers and polymers for use in electronics leading developments. New sources of feedstock to replace oil and gas based sources, e.g. bio-feedstocks from agriculture, will make critical contributions to sustainability. In the medium and longer-term nano-structured hybrid materials will meet the need for materials with lower weight and greater strength for industries like automotive and aerospace. Nanotechnology will also provide improved catalysts in the longer-term future while biotechnology will meet this need in the more immediate future.

New process technology will also play an important role in the basic chemicals industry of the future. New membrane technology, micro-reaction technology and plant intensification will be prominent contributors to cleaner and more environmentally acceptable chemical processing. Developments in information technology will allow the industry to model and dynamically simulate product and process design and operation.

Expert views on the future fall into two groups. One sees the future as incremental with gradual improvements in materials and processes and with little change among the main players other than an increase in concentration through mergers, or possibly through strategic partnerships. The second view sees a more rapidly increasing shift towards bio-processing and green chemistry. In this situation innovation will be the key and interviewees have expressed concerns about a shortage of risk and venture capital for advanced process innovation. This issue will be particularly critical for small innovative spin-off companies originating in the research community.

Market trends predict a continuation of the move towards customisation and higher quality of products combined with a shortening of product life cycles. Traditional customer industries such as textiles are leading in this area. Some experts interviewed felt the chemical industry is still not sufficiently innovative to meet these demands.

The concept of servation or the supply of product services rather than of products solely is not yet a significant factor in the basic chemicals sector. Some moves in that direction have been attempted and may be a viable way for some of the industry to be more creative in meeting customer needs. However, a significant segment of this industry will continue to supply commodities in bulk.

A significant debate on environmental issues surfaced in the interviews with experts. This debate is complicated by what appears to be a North-South divide on these issues also. Environmental issues are clearly seen to be significant drivers of change in the industry. Industry's concern is expressed as a fear that stringent environmental regulation in Europe, if not implemented in other regions of the world, will result in reduced competitiveness within Europe and the relocation of large sections of the industry. Experts from other areas such as academia argue that the expected costs of these regulations need not be as severe as industry predicts and that the opportunity for innovation would give European chemicals firms longer-term competitive advantages.

European consumers are perceived to be also somewhat split on these issues with Nordic and northern European consumers more aware of and prepared to pay the prices associated with the introduction of more environmentally-friendly products and processes, than those in the South. This debate will be heightened with the enlargement of the EU. Co-ordination of policy between Member States will be very necessary in this area if the basic chemicals industry is to continue to thrive in the future.

A major issue for the industry identified in the case study was its **reputation**. The industry is very concerned with the poor perception of the industry by the public and the consequent lack of attraction it holds for the highly qualified and skilled personnel it will need in the future. It also recognises that its senior managers must become better ambassadors for the industry and must do more to make the case for the industry's importance and contribution to the standard of living and quality of life of Europe's citizens. However, to establish its *bona fides* with citizens, the chemical industry may have to develop some chemical process technologies, which, while just breaking even in financial terms, endow the environment with significant benefits.

The report advised that policy action in support of this sector needs to focus on:

- Early and extensive dialogue on issues leading to balanced regulation,
- Support for entrepreneurship through education and training,
- Support to increase the availability of risk finance,
- Awareness promotion of good practice and realistic visions of sustainability,
- Harmonisation of standards in EU and internationally,
- Continued support for the commercial exploitation of new technologies.

2.3.6. Governance:

In political science "governance" implies the increasing dispersion of power and authority beyond the apparatus of the state. The Governance study sought to address effective and appropriate modes of governance in a context of changes in technology and in industrial organisation. National governance describes a wider distribution of power than was normal for sovereign governments. Nowadays power can be distributed up to international organisations, down to sub-national organisations and outwards to executive agencies. Following the work of the German sociologist Beck and others, the report finds that

- Risks in modern society are seen as flowing from conscious choices, rather than from natural hazards.
- Among the adult population in western Europe, the division between "materialists" and "postmaterialists" is currently roughly equal, reflecting the strong gains in environmental concerns since the 1970".

The report would expect, at both political and corporate level, a growing acceptance that "*manufacturing processes should be governed so as to take a much fuller account of their environmental consequences*".

The EU's White Paper on Governance in 2000 looked for a greater downward distribution of governance, to allow more participation in decisions leading to major technological change and also to allow for a greater diversity in European culture and society. In future major developments or decisions in relation to manufacturing will probably have to be taken within a "*socio-technical constituency*", perhaps using some "*transition framework*" so as to allay disquiet in the move from the old to the new.

This points to some key research topics, some of which could be further addressed in future research:

- Much better knowledge is required about the relations between regulations, governance and innovations of the sort involved in the transformation of manufacturing.
- A transition management type of approach to the transformation of manufacturing systems should be tested, but informed by a solid understanding of the underlying "socio-technical constituencies".
- More analysis is required of the links between the risk society (and other macrosocial analyses) and the sorts of value changes examined in the analyses of postmaterialism – and how these relate not just to environmentalist sympathies, but how the discourses and experiences of environmental problems and solutions are intertwined with these elements. Public appreciation of different types of risk and uncertainty is a key topic for analysis.

- There is scope for exploring more deeply the educational repercussions of the above debate. Probably, additional interventions will be required to align education systems to the transformation in manufacturing.
- New modes of interest articulation as they relate to the above phenomena need to be tested, in order to explore the scope for utilisation of new mechanisms of deliberative democracy in the course of transition management.

Specifically in relation to manufacturing in a knowledge-based economy, network-type globalised supply chains in manufacturing require new forms of autonomous governance.

- Centralised control is substituted by distributed intelligence.
- Regulation, IPR's and standard-setting are increasingly defined in the context of industrial-government partnerships.

2.4. Hopes and Fears

The hope underlying FuTMaN is both large and simple. Given developments in the markets that it serves and in the governance within which it operates, can European manufacturing deliver a range of products/services which are sustainable in their economic, environmental and social aspects? In general, the experts consulted under FuTMaN's many elements considered that such a great hope could be realised: there were no insurmountable social or technological barriers. However it would mean the development and adoption of new paradigms of production and consumption. These in turn would require a quantum leap in resources to enable manufacturing to research and implement these paradigms, and also a willingness and capability by Europe's leaders to persuade its own people and the rest of the world that sustainability was worth pursuing seriously. Neither of these conditions is in place at present.

Great change can deliver great rewards, but in the process usually incurs great disruption. The main fear underlying FuTMaN is that European manufacturing, its customers and their political leaders, may be dissuaded from making the great efforts required to reach long-term sustainable development because of the medium-term disruption this would cause to individuals and to society. Unlike Robert Frost, Europe might not take *the road less travelled by, and that would make all the difference*".

3. Policy Analysis

3.1 Context Europe: Europe in an Age of Hyperpower

3.1.1 Differing Power and Values?

Some years ago Hubert Vedrine coined the word *hyperpuissance* or *hyperpower* to illustrate the present dominance of the United States over world affairs. Its impact on the world is greater in scale and kind than that exercised by all previous empires – from the Roman of Augustan times, to the Spanish under Charles V, to the British under Victoria. Coping with hyperpower will be a principal concern in the medium-term, not simply for European manufacturing, but also for European society.

Last summer¹⁰ Robert Kagan argued from a US perspective that America’s strength and Europe’s weakness meant that they no longer shared a common view of the world. His opening paragraph is worth quoting in full.

Fig. 3.1. Kagan on *Power and Weakness*

“It is time to stop pretending that Europeans and Americans share a common view of the world, or even that they occupy the same world. On the all-important question of power — the efficacy of power, the morality of power, the desirability of power — American and European perspectives are diverging. Europe is turning away from power, or to put it a little differently, it is moving beyond power into a self-contained world of laws and rules and transnational negotiation and co-operation. It is entering a post-historical paradise of peace and relative prosperity, the realisation of Kant’s “Perpetual Peace.” The United States, meanwhile, remains mired in history, exercising power in the anarchic Hobbesian world where international laws and rules are unreliable and where true security and the defence and promotion of a liberal order still depend on the possession and use of military might. That is why on major strategic and international questions today, Americans are from Mars and Europeans are from Venus: They agree on little and understand one another less and less. And this state of affairs is not transitory — the product of one American election or one catastrophic event. The reasons for the transatlantic divide are deep, long in development, and likely to endure. When it comes to setting national priorities, determining threats, defining challenges, and fashioning and implementing foreign and defence policies, the United States and Europe have parted ways.”

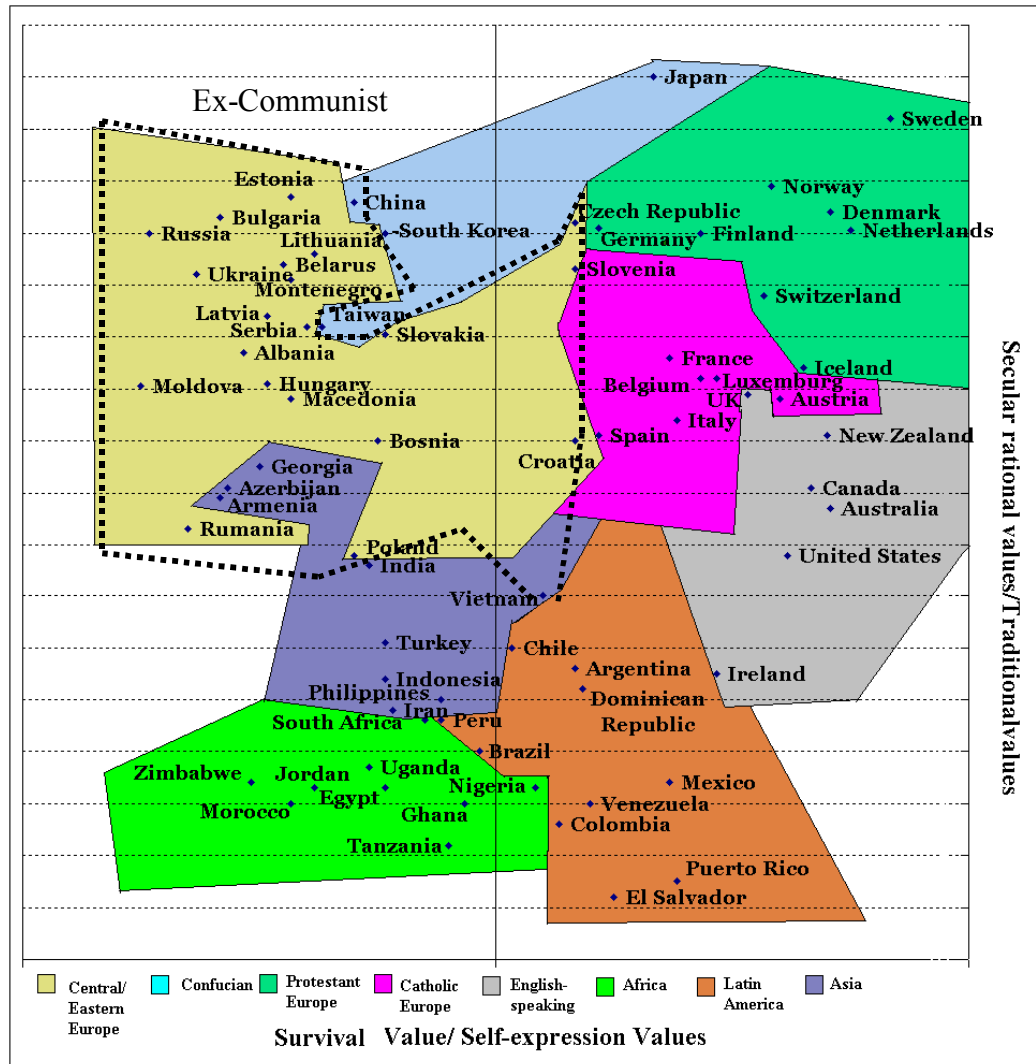
In spite of the invocation of Kant and Hobbes, Kagan’s argument is singular and circular: it is simply a tract on power. The USA has it and uses it, whereas Europe eschews its use mainly because it no longer possesses it. And while his historic examples are of questionable applicability, his assertion that USA and European values are different, and possibly diverging, is borne out by the well-regarded

¹⁰ Kagan, Robert. “Power and Weakness”, *Policy Review*, no. 113 June and July 2002)

University of Michigan's *World Values Survey*¹¹. Since 1981 values held by citizens of up to 78 countries have been arrayed along two axes. The first looks at values in relation to religion, family and country, running from "traditional values" at one extreme to "secular-rational values" at the other. The other axis measures "quality of life" attributes, ranging from "survival values" in poor countries to values of "self-expression" in rich ones.

Fig. 3.2. U. Mich. *World Values Survey*

America's strange place



Source: *The Economist*, January 4th 2003

¹¹ *The Economist*, January 4th 2003. Also available at <http://wvs.isr.umich.edu>

Virtually all countries in Western and Eastern Europe adhere to *secular-rational* values rather than *traditional* values, the notable exception in Western Europe being Ireland. The position of the United States is most interesting. It shares the same position as Western European countries along the *quality-of-life* axis; they agree closely on a broad range of political and economic conditions, which are fundamental to the well being of their individual countries. But in relation to *traditional* values concerning religion or patriotism, America is on a par with Poland or India and differs hugely from values held in Western Europe. And compared to earlier surveys, the United States is becoming more traditional and Western Europe more secular.

This divergence in values is at the heart of the current disagreement between Europe and America concerning the war in Iraq. In the United States currently, patriotism can cement over cracks between liberal and conservative positions on a potential external aggressor, to an extent which the EU can barely envisage. Commissioner Chris Patten's rebuttal of Kagan¹² and his plea to the United States "*not to tear up the global rule book that she did so much herself to write*" (after World War II) fell on deaf ears. European optimists can point out that average values in the United States are comprised of two evenly-balanced groups, divided by religion (church attendance or not), politics (Republican v. Democrat) or geography¹³ (South + Midwest v. West + Northeast): perhaps the pendulum may soon swing towards a more *secular-rational* United States.

However, from a planning perspective it would be imprudent for European manufacturing to expect the United States to shift (back?) towards a more multilateral approach to politics and markets, since it perceives its current approach to be more successful than Europe's; and it seems likely to experience an increase in its economic hyperpower in coming decades.

3.1.2 Economic Outlook to 2015

Historians can add perspective (if not prescience) to economic forecasts: and Prof. Angus Maddison is one of the best of our economic historians. Reviewing the growth in population and GDP from 1950 - 2001¹⁴, Madison decided that for the 2001 – 2015 period the relevant world groupings should be the (developed) West and the (undeveloped) Rest. And within the West he has three subgroups of Western Europe, the USA + others¹⁵ and Japan.

¹² Patten, Chris (2003) *The World in 2003*. The Economist p.62

¹³ In a humorous insight, Michael Moore blamed the commercialisation of air conditioning in offices and cars for the economic shift from the Northeast to the South and for the subsequent mainstreaming of Southern religious and political values. "*If you think about it, the Confederacy has finally won the Civil War – a long-awaited victory won by luring stupid Yankees down there with the promise of 5,000 BTU's and a built-in icemaker*".

¹⁴ Maddison, Angus (2002), "The West and the Rest in the International Economic Order", in *Development is Back*, OECD Development Centre, Paris.

¹⁵ Canada, New Zealand, Australia.

Table 3.1.

Baseline forecasts to 2015

	W. Europe	USA + Others	Japan
Population (m.)			
2001	391	333	127
2015	397	369	126
GDP/capita [\$ 1990]			
2001	19,126	27,892	20,722
2015	24,226	36,400	23,472
GDP [1990 \$bn.]			
2001	7,506	9,288	2,638
2015	9,618	13,432	2,957

The demographic projections are those of the UN Population Division and indicate a continuing decline in the rate of population growth in all parts of the world. But whereas Western Europe and Japan will respectively, show little or no growth in population to 2015, the group containing the USA will experience 0.7% p.a. growth to 2015. In a separate forecast, the USA Census Bureau reckons that the population of the USA – currently 100m. lower than that of the EU15 – may overtake the EU15 level sometime between 2027 and 2040. Higher immigration and higher fertility are the reasons for the USA’s demographic out-performance.

In making GDP *per capita* forecasts, Maddison assumed a continuation of 1990 – 2001 rates of performance in Western Europe and Japan¹⁶ and a mild slowdown in the USA “*where the information technology bubble of the 1990’s has burst, and where the capital inflow which financed its trade deficit seems likely to slacken substantially*”.

Not surprisingly the GDP forecasts to 2015 show Western Europe growing at c.1.8% p.a., while the group dominated by the USA grows by almost 1% p.a. more. USA hyperpower increases substantially under the present baseline scenario, as does EU dependency. If the EU wishes to resist and change this probable outcome, three conditions must obtain viz.

- a frank recognition of the relative failure of EU economic policies during the 1990’s, particularly in relation to manufacturing,
- a frank analysis of the reasons for relative underperformance, not only in defined areas such as those covered by FuTMaN, but also at the more general areas of policy and governance,

¹⁶ He does not explicitly refer to the banking and financial imbalances in Japan, which are unsustainable in the long-term.

- a strategy for radical action, based on EU competitive strengths, which would enable the EU to move (initially at least) from dependency on the USA to a position of economic equality.

Undertaking such an analysis and developing such a strategy [*From Dependency to Equality*] is properly the task of the leaders of society within the EU; it is well beyond the remit of the FuTMaN study. However the answer to the following question will prove crucial for the development of manufacturing over the next two decades.

“Can the EU to 2020 display the same economic and social vigour as it did during the 1960’s, or will it repeat the lassitude of the 1990’s?”

The answer will determine

- in general terms which scenario for manufacturing may unfold and
- more particularly, as the Materials study outlined, whether the EU can afford to fund a move up from a basic technological path of Specialisation towards the much more ambitious and rewarding technological path of Integration.

In March 2000 the Lisbon Council declaration articulated the goal of establishing Europe as “*the most competitive and dynamic knowledge-based economy in the world by 2010*”. For this ambitious goal to be achieved, clearly policies must change. It may prove useful to raise a series of questions in the critical growth-enhancing areas of *Human Capital, Productivity and Innovation*.

3.1.3 From Dependency to Equality: Questions arising.

In a Knowledge Economy the quantity and quality of Human Capital, and its deployment, will prove crucial to the EU’s rate of development.

- The quantity of human capital will depend on fertility rates, immigration and outsourcing (or quasi-immigration). Might improved economic performance facilitate an increase in EU fertility rates without an offsetting increase in social pressures? Should the EU increase its immigration rate to match that of the USA? Can the EU accession countries provide most of the EU’s needs in terms of outsourced, commoditised goods and services, or must these be sought globally?
- The quality of human capital will depend on the education/training levels both of new entrants to the workforce and of the existing workforce. How can EU countries increase entry to third-level education so that they begin to match the “mass higher education” regimes of Japan and the USA? How can the existing workforce become numerate in computer/electronic skills?
- Finally, how can the EU better deploy its stock of knowledge so that it meets domestic and global needs more productively? This question covers areas such as

the nature of economic-knowledge activities,¹⁷ the rate of company start-up and virtual and real relationships within and between companies.

The growth in EU labour Productivity during the 1990's was lower than in previous decades and lower than that of the USA. In general terms, this seems to have occurred because of a slower rate of adaptation by the EU to the *New Economy*, in terms of products, processes and forms of organisation¹⁸. The FuTMaN insights should help to reverse this underperformance in productivity.

Compared to the USA, the EU spends proportionately less on R & D, EU industry's share of R & D is much lower and venture capital funding for risky ventures is less plentiful. Partly as a result of this, the EU's system of Innovation is less productive than that of the USA, both in basic and applied research. How can this relative underperformance be reversed?

3.2. Context for Manufacturing

EU manufacturing's view of itself – both in the four case studies and the three broad strand reports – is more positive and forward-looking than the macroeconomic picture would suggest. In addition there was a high degree of agreement on the particular pressures European manufacturing was exposed to, if less agreement on what the appropriate policy responses should be to these by the various levels of governance. Out of the large number of pressing items raised in FuTMaN interviews and research, four broad areas were selected. These were Time, Knowledge, Costs/competitiveness and Resource use/Sustainability.

Table 3.2. Pressures on EU Manufacturing

Pressure	Possible Response
Time	Adapt (for the present) Innovate (for the future)
Knowledge	Acquire from outside Intensify inside
Costs/competitiveness	Improve product offering Restructure/relocate
Resource use/sustainability	Takeback, re-use, recycling Sustainability incorporated into design of products/processes

¹⁷ Prof. Joel Mokyr has recently extended the notion of *codified* and *tacit* knowledge to what he calls *propositional* and *prescriptive* knowledge.

¹⁸ v. OECD (2002), "Strengthening the Knowledge-based Economy in *Science, Technology and Industry Outlook 2002*. OECD. Paris

How well or how badly EU manufacturing and its governance copes with these pressures will largely determine the development path to 2020 of the EU as a whole.

Time conflation may be the greatest single pressure on EU manufacturing today. Customer pressure (in both consumer and industrial markets) demands the speedier availability of products. For example, in the automobile industry, the design stage has been severely shortened by ICT-enabled concurrent engineering. During the production phase “lean engineering” techniques such as Just-in-Time (J.I.T.) are now ubiquitous¹⁹. And in product distribution, the art of transport has been ousted by the science of logistics. Time pressures show no sign of easing and will force EU manufacturing to become more adaptable to present customer demands and more innovative in meeting future demands. Because of its dynamic nature, time pressure presents unique problems for governance policies. If governance limits are set too low or are too uncoordinated – as with the USA preference for minimal regulation or self-regulation – it will prove difficult to incorporate social objectives such as sustainability into the business agenda. However, setting the governance bar too high may hamper the capacity of manufacturing to adapt and innovate in meeting customer requirements. Most governance policies have traditionally been fixed and backward-looking. Is it possible to design governance policies which are flexible, forward-looking and of shorter duration i.e. which achieve their public policy objectives with minimal negative repercussions on manufacturing?

Virtually every expert consulted by FuTMaN considered **Knowledge and Skills** to be crucial to manufacturing’s future. Their responses to pressures from the Knowledge Economy varied from an intensification of their own organisation’s knowledge capability to outsourcing new knowledge through formal and informal networks. And while the “electronification” of knowledge proceeds apace *via* eLearning, eTransmission etc., further research will be required before the path from *data* through *information* through *knowledge* to *wisdom* becomes clear. Economic historian Joel Mokyr²⁰ suggests that, as in the Industrial Revolution, the Knowledge Economy may develop through the continuous interplay between *Propositional Knowledge* (concerning physical laws and material properties) and *Prescriptive Knowledge* (concerning techniques). Whatever the eventual outcome, it would appear that very large scope exists for fruitful policy interventions so as to speed the development of the system of electronic knowledge.

Pressures from **Costs and Competitiveness** apply unevenly over different sectors of European manufacturing. Of the four sectors studied, automobile manufacturing appears the most successful in maintaining its comparative advantage: it has a high capability to improve its product offering and it has re-located some production capacity to lower-cost Accession Countries. In contrast Basic Chemicals produces a high-bulk, low-value commodity product which it is difficult to add value to by using customisation or servation techniques: relocation is sometimes the only method of cost reduction which can be deployed. In the semiconductor industry, products are low-bulk, high-value, and thus prone to competition from low-wage Asian countries. The EU is enriched by having a wide portfolio of competitive sectors in manufacturing. In setting compliance or regulatory measures for EU manufacturing as

¹⁹ In several VW car plants, the length of the working week varies with demand levels.

²⁰ Mokyr, Joel (2003) *The Gifts of Athena*, Princeton University.

a whole, policymakers should be mindful that such measures may weigh more heavily on the competitiveness of some sectors than of others.

Energy-efficient production has been a pressure on manufacturing for a generation. To that are added current pressures for reduced **resource use** and for **sustainability**. Regulations on take-back, re-use and recycling are causing sustainability to be incorporated into the design of materials and processes. Further out, resource conservation will stimulate nanotechnology while new renewable materials and agricultural bio-feedstocks will help sustainability. The challenge for governance policies on sustainability is twofold. Firstly, within the EU to establish a “socio-technical constituency”, which can agree on a common rate of advance towards sustainability in manufacturing. And secondly, outside the EU to persuade other governments, principally the USA, that their own long-term interests will be better served by buying into the sustainability agenda.

4. Policy Recommendations.

In drawing general conclusions from the FuTMaN study, the key questions which need to be answered are:

- (a) Among the many issues identified in the various elements of the study what is important and needs urgent attention to set Europe's manufacturing on the path to continued and enhanced success?
- (b) What do they suggest for EU RTD policy?

4.1. Manufacturing must attract and hold on to able people:

A repeated theme in many areas of the study was the concern expressed about the possibility of shortages in adequately qualified and skilled personnel. Demographic trends of ageing raise the first fears in this regard but the perceived unattractiveness of manufacturing industry as a career poses a bigger problem. Like most of the problems facing any economic activity the solution can only be found by collective action between industry and public policy makers. In the specific area of research where the same general problem arises, the EU and Members States have made efforts to solve the issue. FuTMaN has made some suggestions for additional steps that might be considered in relation to the Semiconductor industry. These suggestions could be generalised for most manufacturing sectors.

4.2. Continue building European systems of Innovation:

A continuation of efforts to reach optimal harmonisation of standards and regulation in many areas impacting manufacturing will provide Europe with conditions in which its industries can use their innovative capabilities to gain competitive advantage. The weaknesses in Europe's innovation capacity are recognised and again in this study the exhortation is repeated to develop policies to support the strengthening of entrepreneurship through broader educational curricula, particularly in conjunction with S&T education, and the attraction of risk capital to support the commercialisation of new technologies. Many existing policy instruments at national and EU level have been striving to meet these needs and in many cases perseverance is what is required because of the long learning curve involved.

4.3. Networking takes time. Be Patient:

The future of manufacturing is expected to be a strongly networked activity and many of the infrastructural supports for such arrangements are under development. The new instruments of FP6, integrated projects and networks of excellence should be tangible contributors to the development of networking in the R&D field. However, it is important to realise that the learning curve for the new behaviour patterns demanded by networking may be long and that patience and long-term commitment will be required. Much has been written on these subjects but to date there is little widespread competence or capability anywhere. The opportunity is there to be grasped.

4.4. From Specialisation to Integration in New Materials:

Clearly Europe will need to move from ‘specialisation’ to ‘integration’ in material development over the next 20 years. To be at the forefront of nanotechnological developments in materials Europe will need to have progressed significantly along this path. This shift in strategy will require the development of a multidisciplinary skill base among S&T personnel. In turn this will require new organisation forms for R&D, new initiatives in education and stronger interaction between industry and research community actors. While this in itself is a major task, which will take many years to accomplish, without strong economic growth in the core economies of Europe to provide the necessary financial resources, supportive policies will not be sufficient for success.

4.5. Sustainability needs Champions both from Manufacturing and from Governments:

Sustainability was a particular focus of the study and the elements of the study have dealt in detail with many aspects of the ideas underpinning the concept. A significant conclusion of the Transformation Processes report is that manufacturing industry in general must become more proactive if it is to play a lead role in achieving sustainability. This pro-activity will be manifest in a range of processes aimed at developing in industry a strong self-sustaining innovation capability. While obstacles to sustainability are mainly to be found in the market and in some policy realms, European industry has strengths, which can be exploited to gain competitive advantage in environmental technologies. However, to avoid imposing a large cost burden on European manufacturing, Europe’s political leadership must become much more successful at persuading other economic regions of the world that an even roll-out of sustainable measures is in everyone’s medium-term self-interest.

4.6. “Transition Management” may allow for improved governance:

A major governance challenge arises as to how societal objectives such as sustainability can be incorporated into public and private decision-making processes. As part of this, a growing need for strategic intelligence has been identified. Manufacturing industry will change systemically over the coming decades and in response to these changes the governance report suggests that recently developed concepts like “transition management” might provide a process for dealing with the combination of slower incremental developments and rapid disruptive dynamics, which typify such systemic changes over long time scales. This process would provide a framework for policy deliberation, the results of which could be evaluated against both the immediate impacts and the longer-term contribution to the transition process of Industry.

FuTMaN Partners
28/03/2003.

Appendix 1 : Partners in the FuTMaN Project.

IPC-Irish Productivity Centre (Ireland), Project Coordinator.

ARC Seibersdorf Research (Austria)

CM International (France)

European Commission Joint Research Centre, IPTS-Institute for Prospective Technological Studies (Spain)

Fondazione Rosselli (Italy)

Fraunhofer-Gesellschaft, ISI-Institut für Systemtechnik und Innovationsforschung (Germany)

Institute for Manufacturing, University of Cambridge (United Kingdom).

Jerome Casey and Company (Ireland)

PREST-Policy Research in Science, Engineering and Technology, University of Manchester (United Kingdom)