ManVis Report No. 6

Manufacturing Visions
Policy Summary and Recommendations

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Executive Summary

The specific support action "Manufacturing Visions – Integrating Diverse Perspectives into Pan-European Foresight (ManVis)" (Contract No NMP2-CT-2003-507139) started early 2004. Its aim was to accompany the ongoing policy process of enhancing European competitiveness in manufacturing industries and to include views of more than 3000 European manufacturing experts collected through a Delphi-survey in 22 countries as well as views of stakeholders and overseas experts collected at workshops and in interviews.

The results and their impacts on industry and policy making were discussed on the ManVis Final Conference "European Manufacturing – Quo Vadis?" which took place October 24th/25th, 2005 in Bled/Slovenia.

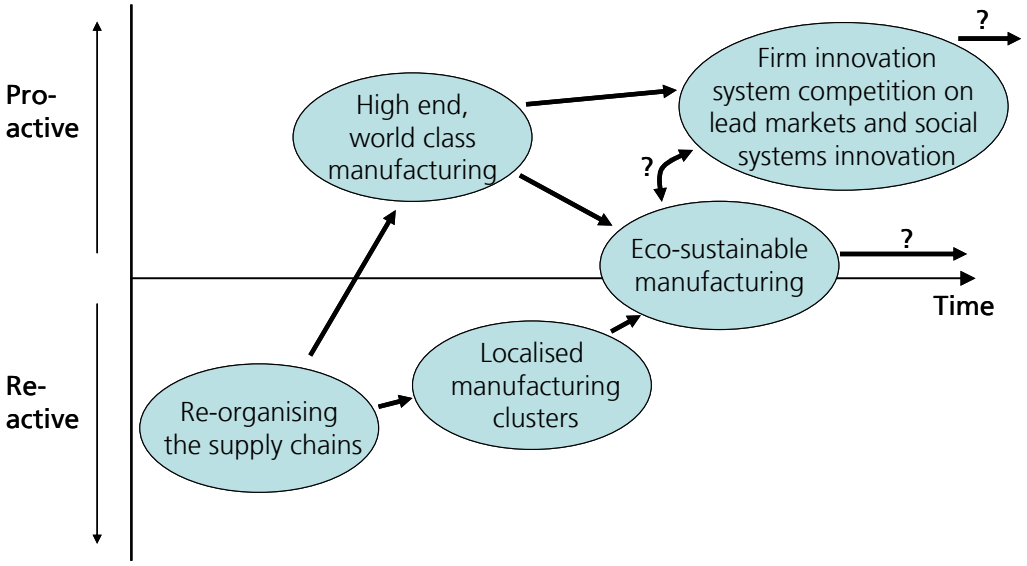

Figure: The ManVis trajectories for Manufacturing of Tomorrow

In particular, several possible trajectories for developments of the manufacturing of tomorrow came out of the ManVis findings:

- The struggle on labour cost competition will prevail in the next years. Basically there are two dimensions: the loss of operations to countries outside the European Union and the movement within the European Union. The strategies emerging from the ManVis expert consultation are mainly reactive i. e. cost reduction through automation and enhanced labour productivity. The New Mem-

ber States will exploit in the very near future an existing cost advantage but will loose it faster than competitors outside Europe. Without own innovation capacities for absorption and enhancement, this foreign direct investment will just pass through these Member States in a decade. In any way, outside Europe and intra Europe labour-cost competition are characterised by losses of employment in manufacturing.

- Local manufacturing operations and local R&D excellence – as general options – are reactive patterns as well. Very often based on concepts originating from the sustainable development debate this vision is characterized by local operations and development based upon very close interaction with local users – who still have to have purchasing power. The consulted manufacturing experts were quite sceptical on the prospects of this option because of their assessments on the weak ties of modern manufacturing into its environment, contrary to the consulted stakeholders who value this concept as feasible and competitive.
- Eco-sustainable manufacturing based on new products, new materials, energy efficiency, and last but not least on advanced product service systems could be developed into a competitive advantage for Europe – in the view of both experts and stakeholders. Regulations creating a demand pull, e. g. as outlined in the FutMan policy scenarios could be successfully mastered because of the excellent R&D position in this field.
- High end manufacturing will be based on the efficient use of sophisticated manufacturing technologies, which will enable world class highly automated operations for new products. This high ambition requires an exploitation of the expected potentials for micro electro-mechanical systems, related nanotechnologies, closing gaps in automation, and research on manufacturing with new materials. But this high efficiency approach will reduce or only maintain existing employment in European manufacturing.
- The most ambitious and far-reaching vision is the European best practice in competing all over the individual firm's innovation system. This comprises user interaction, product development, production, supply chain, and logistics. The successful mastering of this "system" is considered the most promising way to ensure long-term competitiveness. But innovative and adaptive lead markets have to give European companies the chance to be the first to learn if they have effective user/customer interaction mechanism in order to exploit this advantage. Nonetheless, high-end manufacturing with sophisticated technologies is a pre-requisite for any employment creating option.

In order to move along the different paths and create employment severe *challenges* have to be mastered:

- creating manufacturing based on sophisticated technology,
- developing knowledge based and learning companies and industries,
- competing through the firms individual innovation systems,
- re-defining and innovating demand through lead markets,
- keeping Europe economically united.

Because the science base is of growing importance in manufacturing, topics and issues have to be included into the funding mechanism of the planned European Science Council. Other existing mechanisms on transfer and mobility of researchers have to be maintained as well as international cooperation.

High-end manufacturing will not – in the view of the consulted experts – create new employment but safeguard existing jobs. Further, it is a necessary condition for the more advanced and employment creating overall trajectories. E.g. a successful and economically prevailing strategy on eco-sustainability requires high technology and professional organisation of product-service concepts.

Excellent research projects in manufacturing topics are needed (see box). It is important not to concentrate on technological developments alone but the whole system of innovation in the firms has to be considered. This implies tools, strategies, methods, procedures etc. for product development, logistics, innovation management, business concepts etc. had to be added to the technological research agenda. The main challenge towards more pro-active strategies lies in the implementation of successfully learning companies which can adapt their innovation system fast.

Enhanced funding mechanisms should focus on the integration of user-interaction mechanisms. Accompanying measures should ensure the transfer of the R&D results e.g. by feeding them into other policies (e. g. standards, regulation) as well as preparing diffusion.

A harmonized policy approach is absolutely necessary if societal requirements and existing competences should converge into a lead market. First mover advantages could be only obtained if quick and decisive moves in demand development and shaping as well as competence building are made. In order to be successful, a thorough analysis of long-term demand and interactive participation of stakeholders and users is decisive for policy makers and industry, both. Hence, while closing the loop, exercising these practices in the R&D projects and efforts in manufacturing becomes of crucial importance.

Imminent technological research needs

Paving the way for new technologies in manufacturing

- roadmapping and foresight on manufacturing relevance of nano- and (white) bio-technology
- measurement, workplace safety for nano-technology and bio-technology
- applied basic research for white bio technology and nano-manufacturing

Industrialising technologies

- processing and manipulation of new materials
- incorporating smart materials into components for process technologies
- combining new materials with micro electrical mechanical systems (adaptronic)
- exploring new modelling knowledge and high power computing for simulation of product development, of material behaviour, and of virtual experiments

Exploiting technology advantages

- micro-systems in machine tools and products
- intelligent mechatronic systems for automation and robotics (e.g. self adapting components)
- new automation technologies using advanced human-machine interaction by considering diverse workers capabilities
- ICT-tools for traditional sectors

Technologies for customising products/services

- Tagging and labeling technologies
- Approaches towards product customisation via software or electronic components that allow for maximum flexibility and user integration
- Technologies and concepts facilitating user integration into innovation processes
- Technologies and concepts facilitating personalisation and build to order concepts
- SME appropriate tools for networks and logistics

1 Introduction

The specific support action "Manufacturing Visions – Integrating Diverse Perspectives into Pan-European Foresight (ManVis)" (Contract No NMP2-CT-2003-507139) started early 2004. Its aim was to accompany the ongoing policy process of enhancing European competitiveness in manufacturing industries and to include views of European manufacturing experts collected through a Delphi-survey as well as views of stakeholders and overseas experts collected at workshops and in interviews. ManVis was an independently launched activity but has a supporting role in the policy process assembled under the catchword "Manufuture" as well.

In the meantime, ManVis has contributed to this process through presentations and inputs to Manufuture and other conferences. Several ManVis reports highlighted the preliminary and final results (see box).

ManVis Reports

ManVis Report No. 1:
The status of the project, questions and issues which may arise from ManVis for the Manufuture process, July 2004

ManVis Report No. 2:
Preliminary Results from the 1st Round of the ManVis Delphi Survey, April 2005

ManVis Report No. 3:
Delphi-Interpretation Report, October 2005

ManVis Report No. 4:
Overseas views: International perspectives on the future of manufacturing, December 2005

ManVis Report No. 5
Scenario-Report, October 2005

The results and their impacts on industry and policy making have been discussed on the ManVis Final Conference "European Manufacturing – Quo Vadis?" which took place October 24th/25th, 2005 in Bled/Slovenia.

This report condenses the information so far in order to prepare a public discourse on the Future of Manufacturing and on the necessary actions resulting from the ManVis findings.

The following chapter contains aims and tasks of the ManVis project. The report is structured along the leading questions of the ManVis project:

- Which technologies will be relevant for European manufacturing?
- Which role will European manufacturing play in a more competitive world?
- Is European manufacturing prepared to meet customer and societal needs?
- Is a diverse Europe prepared to meet the challenges of knowledge based manufacturing?
- Which visions and challenges emerge for European manufacturing?
- Which actions are recommended?

The Appendix includes a list of project team members and displays the programme of the Final Conference. The project team is hoping for a lively debate of its recommendations and fruitful discussions in Bled.

2 What were the aims and tasks of ManVis?

In order to become the world's most competitive economy by 2010, the manufacturing and service engineering sectors will have to play a vital role in an enlarged Europe. Industry, government and other stakeholders need a strong vision of the future of the European economy based on an assessment of possible alternatives in order to develop their strategies. Manufacturing Visions (ManVis) aims to contribute to new and powerful visions of manufacturing for Europe in the decades to come. Such visions of manufacturing may support the development of policy and strategy focused on the proactive support of manufacturing.

Powerful visions do neither appear all of a sudden nor can they be declared by state authorities. They cannot be based on single perspectives or specialised approaches. For this reason, a new integrated knowledge community concerned with the future of manufacturing had to be created, including as many actors and stakeholders as possible from Europe and beyond. As a tool for initiating future-oriented thinking and to promote the linking of such diverse perspectives, a pan-European Delphi survey dealing with manufacturing issues was launched. In several workshops, manufacturing experts from all over Europe and overseas contributed to the shaping of the survey.

In order to avoid an isolated view of Europe's manufacturing issues experts from overseas were involved in the development of the statements of the Delphi questionnaire and commented on the results of the survey (cf. ManVis Report No. 4).

Emphasising and elaborating the demand side perspective on manufacturing was an important aim of this project. Because of this, the views of users, consumers and other societal groups concerned with manufacturing discussed the findings of the Delphi survey. In parallel to the Delphi activities, scenarios on the development of the demand side of manufacturing were elaborated (cf. ManVis Report No. 5).

The results are

- fed into the long-term planning of the European research funding for manufacturing,
- integrated in the debate on the Manufuture Technology Platform which is currently being developed (www.manufuture.org),
- published and disseminated to potential users in government, industry and the general public, and
- presented and discussed at the ManVis Final Conference in Bled, October 24th/25th, 2005.

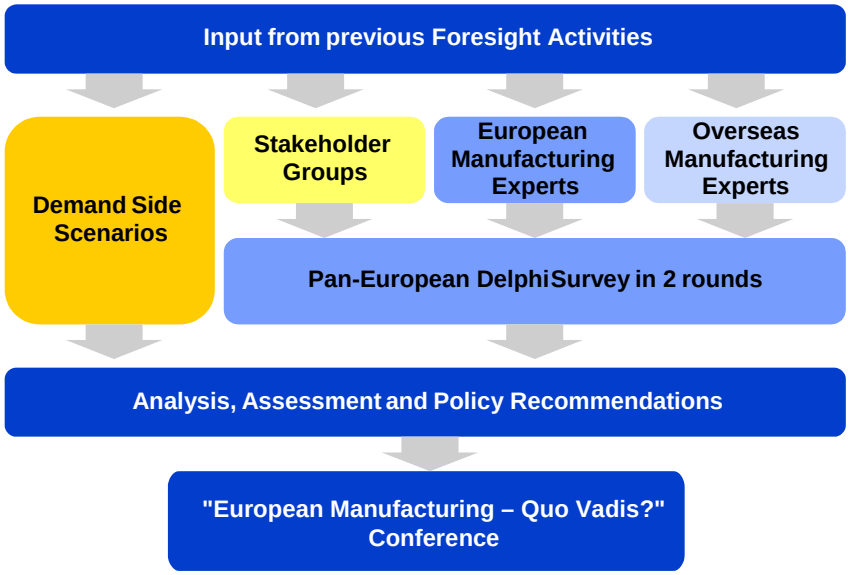

Figure 1: The ManVis approach

The core activity of the project was a pan-European Delphi survey dealing with manufacturing issues.

The Delphi methodology is a long-established tool for forecasting future technological (and other) developments. Foresight activities are a systematic effort of supporting policy by setting priorities in science and technology policy thereby stimulating communi-

cation between actors in innovation systems. Delphi studies have often been used as a tool to collect a wide range of opinions as a base for further panel debates (e.g. in the U.K. Foresight programme or the German Delphi Survey 1998). The advantage of the approach is its ability to collect a large amount of information in a structured form. However, there are certain aspects that do not allow Delphi to be used as the sole mean of a Foresight exercise. A Delphi does not describe steps and milestones towards visions, does not substitute other technology and innovation indicators nor does it include societal values or political targets.

The ManVis-Delphi survey was launched in 22 European countries. A core team of researchers from eight European institutes has conceptualised and conducted the Delphi survey. All these institutes have a solid background in research on manufacturing foresight issues, each of them focussing on particular aspects needed for a holistic view on manufacturing. National partners from 22 European nations supported the survey in their countries (cf. ManVis Report No. 1). Through several workshops approximately 280 manufacturing experts, from Europe and overseas and from both the research community and industry, contributed to the shaping of the survey. Furthermore a number of policy actors took part in the discussions (cf. ManVis-Report No. 1).

The Delphi survey coverd developments in all relevant aspects of manufacturing from technologies via organisational concerns to questions of the working environment. Further, enabling technologies for developments in all these areas were examined. New demands on skills and competencies can be derived from the results, while sustainability issues were a special focus throughout the whole project. Some statements in the Delphi questionnaire dealt with sector specific developments such as transport, machinery, or traditional products (the questionnaire is available in ManVis-report No. 1).

Because of the complex structure of the questionnaire, covering various areas of expertise, not all of the 3112 experts completed it entirely but chose to answer only those sections with which they felt most comfortable. Each statement has been answered by more than 1200 experts, allowing a solid statistical analysis for all the statements. The median number of answers per statement is 1332. Since no systematic differences have been discovered after the first round (for instance with respect to expert origin, country etc.), it was considered risk-free to include all answers, regardless of the number of statements each expert answered.

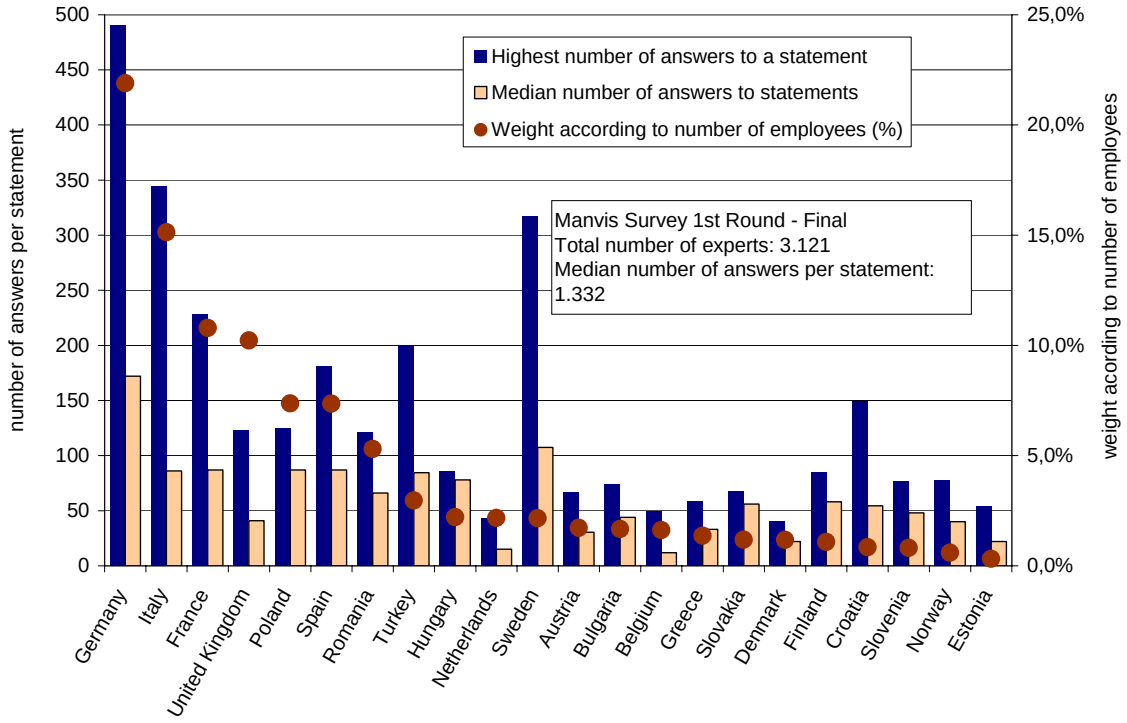

Figure 2: Expert participation of ManVis for participating countries and relative weight according to employment in manufacturing (n=3121)

For the second round (cf. ManVis Report No. 3) the team decided on a modification in the methodology. Instead of repeating the questionnaire of the first round, conflicting statements were regrouped and present jointly for re-consideration (see Annex in ManVis Report No. 3). In the second round, 1.359 experts participated. Generally, the results of the second round only partly changed the results of the first round.

It is important to highlight the role of foresight exercises based on surveys and expectations like Delphi-Studies, workshops, and expert interviews as a *starting point* or *one of several inputs* to public debates on future developments. It does not replace other research or strategic planning activities as for instance scenario building, patent data analysis or other technology assessment methods nor interpretation of innovation indicators.

3 Which technologies will be relevant for European manufacturing?

The analysis of individual technologies and their dynamics in manufacturing in ManVis can be concluded into the following messages:

- Micro electromechanical devices, smart materials, products using nano-coatings – in this timing order – are representing long-term developments in a *new type of products* with a disruptive character for markets. These product challenges offer an opportunity for strengthening competitiveness, which can only be exploited if appropriate manufacturing equipment is available and allowing the use of the technologies in new products. Hence, generic technology development needs complementary manufacturing technology research involvement.
- Such new *manufacturing technology principles* as bottom-up manufacturing technologies are only expected in the long-run. Manufacturing technologies using biotechnologies for creating and manipulating inorganic material and products such as nano-manufacturing should also be on the long-term "radar" of RTD-policy.
- Micro electromechanical systems (here a European advantage in R&D is seen by the experts) as well as flexible organisation and automation strategies combined e.g. in reconfigurable manufacturing systems supporting flexible business strategies are important for the *short-term research agenda*. However, the manless factory still receives a sceptical assessment by the experts. The humans working with flexible automation solutions in the near future will still play an important role in creating the flexibility. However, the experts expect people working with flexible automation technologies instead of a manless factory.
- Strong and important *long-term automation visions* comprise new ways of interactions between machines and humans such as human-machine interfaces, man-machine speech recognition, self-learning systems, and co-bots.

These issues underline the need for research on industrial adoption and innovation management practices in manufacturing industries and intensive communication and further debate of the ManVis results.

The development of new generic technologies and *knowledge challenges manufacturing research in two ways*. First, it creates a need for techno-organisational manufacturing processes in order to produce the new products and provide the new services. Secondly, these new technologies and knowledge have to be integrated into the production processes themselves. *Basic manufacturing research* has to foresee and prepare for the new challenges, and *applied manufacturing research* has to adapt and transform existing technologies and organisational processes. Furthermore, manufacturing research plays a decisive role in combining the long-term horizon in technology trajectories with the short-term need of firms to innovate successfully. This requires a good "timing" of research activities to have solutions and tools ready for industrial adoption.

Considering these functions of manufacturing research, the ManVis messages on technology can be discussed using the presented concept of the combined science-technology cycle on innovation presented in ManVis Report No. 3. Basically, four *groups of technologies* were discussed in several ManVis-statements:

- bottom-up manufacturing technologies (bio- or nano-processes)
- advanced materials
- micro systems technologies
- information and communication technologies.

For these technologies, the experts expressed different time horizons for realisation. Activities for basic and applied research have to be performed in advance (approx. 10 - 15 years basic research, 5 - 10 years applied research).

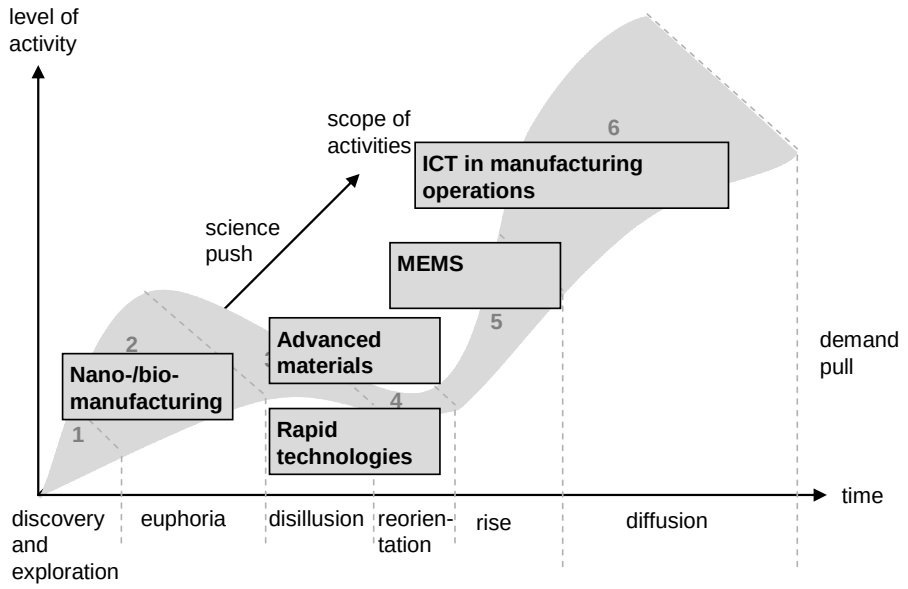

Figure 3: Manufacturing technologies on the Science-Technology Cycle for macro-innovations

ICT will still play the decisive role in the short-term perspective in *manufacturing operations*, but only if the man–machine interaction is considered properly because the manless factory is not realistically foreseen in the future. Using the assessment and referring to existing diffusion studies, ICT use in manufacturing operations is basically in phases 5 and 6, where application oriented industrial research is predominant. Therefore, attacking dominant designs with new solutions, e. g. in simulation of processes and the product life cycle, could be very costly and may have a lower success

rate than developing solutions in more open fields. Hence, some mapping information on simulation solutions seems necessary for better informed decisions.

As outlined by stakeholder assessments and the evaluation of the experts, ICT plays a *crucial role for customisation*. Software and ICT-components incorporated into products for customisation are important for product innovation. As said before, accompanying research on social and business impacts and standards (development and enforcement) should be important supporting elements in a public research strategy.

Micro systems (together with intelligent controls) are *key enablers* for plug-and-produce systems aiming at more flexible manufacturing systems as well as for process integration into multi-functional machinery. For this second technology, the necessary link from developing new machinery to creating new business models (although not emphasised by the experts) could be crucial as well as research bringing together equipment suppliers and users. This represents phase 4/5 as the most important stage of defining and setting dominant designs. The ManVis experts see Europe in an advantageous position (i.e. in some lead user industries as automotive and medical equipment) and at the forefront. Industrial research is the main driver now. To be very precise: Micro Electronic Mechanical Systems (MEMS) are not a basic research topic (and maybe because of that a little bit out of focus of the public attention) but are on the verge of a take-off in industrial use. It is important to maintain the existing advantage by applied R&D projects with strong industry participation and to exploit the commercialisation for the benefit of European manufacturing (cf. Bierhals et al. 2000[1]).

For advanced materials, the problem of making the *processing and manipulation of new materials* feasible and (more importantly) competitive has already been identified as an important research topic by the FutMan study. I.e. smart materials and rapid technologies are in phases 3 to 4 representing a selection process and the search for break-through applications. These phases are characterised by search processes to assess and exclude unviable options. It is a sobering phase of applied research in the concerned sciences and in engineering. Here, collective research efforts combining the related sciences, engineering and lead industries are helpful in bridging this period. The ManVis experts give a time horizon which may leave enough space for catching up in the R&D position which is considered lagging for the moment.

The new catchwords representing bottom-up manufacturing are in the middle of the first boom in the science cycle, close to euphoria (phase 2). The ManVis experts see

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1 Bierhals, R., Cuhls, C., et al. (2000): Mikrosystemtechnik – Wann kommt der Marktdurchbruch ? – Miniaturisierungsstrategien im Technologiewettbewerb zwischen USA, Japan und Deutschland, Heidelberg

the development as important for manufacturing but only on a very long-term horizon. Hence, basic research on nano- or bio-technology has to be carefully monitored for emerging manufacturing research fields. In addition, cross cutting manufacturing research issues like measurement, workplace safety of nano- or bio-based processes etc. may facilitate the basic research activities in other fields of nano- and bio-technology. A screening or roadmapping activity on manufacturing connected to product roadmaps using nano-technology is useful in order to prevent an overlooking of possibilities. An additional action is the analysis of linking micro systems technologies with nano-based technology using existing advantages in micro systems to facilitate faster diffusion of nano-technologies.

The analysis in different sectors basically confirmed these views of the experts on the technologies, but is varying in the time horizon (cf. ManVis Report No. 3).

The ManVis experts see that e. g. ICT use in manufacturing and product development operations will be a driving factor in traditional industries whereas in other sectors it will not play such an imminent role in operations and production technologies. More important is the role of ICT in customisation of products and product-service combinations. New materials may play a more prominent role in the sector of fabricated metal products. In machinery, MEMS are predominantly seen for the next steps; i.e. in self adopting systems as part of advanced machine tools. The car industry (often seen as a lead user for many technologies) is facing the challenge to master two more engine concepts (hybrid and fuel cells) parallel to the optimisation of the combustion engines. The ManVis experts do not prioritise one single option but the impacts on other industries could be dramatic.

The cross-check of ManVis results with the Dynamo database of TNO (comparing existing information on foresights and trends) confirms the analysis in the main points. Important remarks on the following three aspects are made:

- Micro electro-mechanical systems should not be seen limited to single components in machines and equipment, rather broaden the scope to new intelligent mechatronic systems, including robotics.
- High power computing, ubiquitous networks and theoretical/conceptual knowledge on modelling opens up the possibility for new ways and structures of product and process development, i.e. material behaviour assessment and virtual experiments replacing coincidental discoveries and developments. Simulation techniques in these fields and in logistics will have significant importance i.e. for product innovation and by e.g. simulation of product life cycles whereas for shop floor and product design, not so many advantages are expected in the near future.

- ManVis had a focus on discrete part production and no emphasis on process technologies in flow production such as food, chemicals etc.

This analysis is based on the ManVis experts' views and on secondary material. It could be useful to validate certain areas by using specialised innovation indicators (publications, patents, diffusion data) in targeted foresight and forecast studies.

4 Which role will European manufacturing play in a more competitive world?

Probably the currently most debated international aspect of industry policy and a question on everybody's mind is the relocation of industry and jobs to other regions. During the last decades, upswings in the economy have not – as previously was the rule – been followed by expansions of employment in industry. Improved productivity seems to give the ability to respond to market expansion without any increase of staff. In the US, the economy is growing due to the profits made on low price import from China, new developments in the retail business sector, and due to a labour intensive upswing in the construction industry. The increases in productivity combined with the accessibility to very cheap labour in the expanding economies in Asia put the industrial jobs in Europe under pressure. In most people's minds, outsourcing is making Europe loose lots of industrial jobs.

Relocation of industry, usually discussed as outsourcing, is in reality several structural changes coinciding in time, both inside and across the borders of EU. In order to make the discussion meaningful, it is necessary to make distinctions between the different types of relocation. "Offshoring" means the movement of industry (production) to "low wage regions" in order to reduce the pure labour cost per unit produced, i.e. for commodities. "Outsourcing" is understood as buying parts or services from suppliers, mainly to improve the economies of scale for the intellectual part of a product. Outsourcing is common within a country or a region, and is basically a normal way to achieve industrial improvement. When Europe starts to outsource to other regions, the movement is a bigger threat than offshoring, because the creation of the intellectual capital is moved, and by that the more advanced jobs are lost.

Concerning relocation itself, there is on the one hand the relocation of production to locations near the consumers. With a rapid expansion of the product variants, it is more and more efficient to locate production closer to the market to avoid long delivery times and a growing stock of finished goods in the market chain. On the other hand, there is relocation of innovative production and development close to lead-markets. This is a way to get the signals from the most demanding customers. This change of industry

structure ought to be favourable for Europe, since the high living standard is creating demanding customers. Some of the Asian car manufacturers have recently announced openings of new production plants in Europe.

From the definitions above, we can see that offshoring is driven by pure cost reductions, while the other forms of relocation are driven by a need to improve the speed of innovation (cf. figure 4).

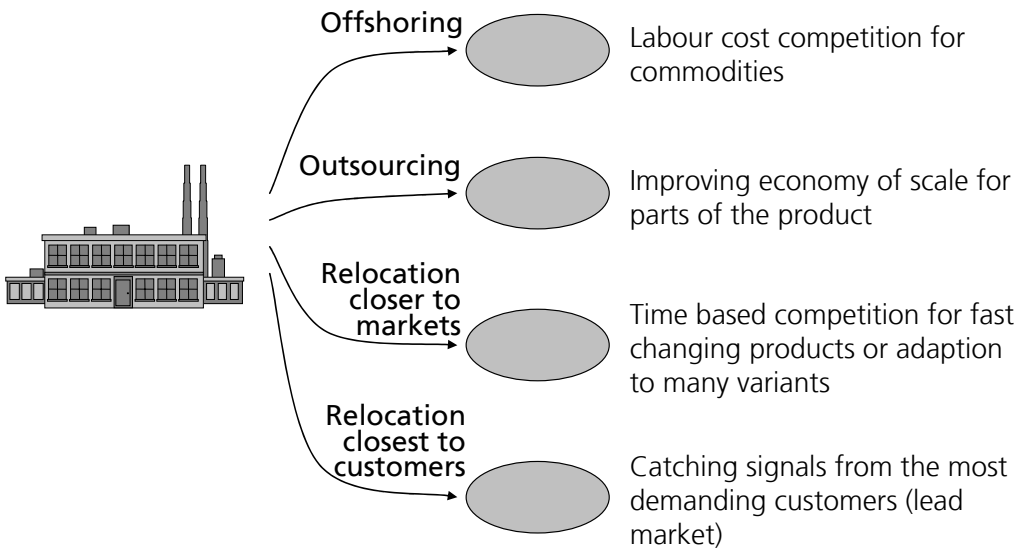

Figure 4: Patterns of relocation of operations and tasks in manufacturing

The current competition for Europe in the field of cost are China and India and in the field of innovation the US and Japan, which is also verified by the ManVis Experts when studying the appreciation of relative research positions. With the ambitions shown by China and India to expand the research and education, the situation can change and in a foreseeable time competition for innovation might be seen also from those countries. The answers from the ManVis experts are not altogether conclusive on the timeframe for the effects of relocations and we can also trace some contradictions in the answers on related statements:

- The ManVis experts are convinced that the traditional sectors will be subject to high levels of offshoring
- Despite a strong belief in a successful coming automation in the traditional sectors, 80% of the industry is still expected to be relocated outside Europe in a foreseeable time.

- The ManVis experts are not consistent in their opinions, but the general impression is that more jobs in manufacturing will be relocated to other regions, as long as the relative differences in cost levels remain.

Given their fast rate of growth, it cannot be taken for granted, that India and China will remain low wage regions for qualified work, since both show aggressive ambitions to grow into heavily industrialised regions on a much more sophisticated level than today competing on innovation as well.

On balance, can low cost labour competition be expected to remain on the current level? The ManVis experts were asked for a number of possible reasons which could alter the balance between low cost, far away producers and high cost producer near market. Most experts believe in the statements pointing to a reduced difference. The possible conclusion is that in a foreseeable future all these factors in combination will ease off the worst levels of competition. Production will be more automated due to a gradual development of more cost effective automation equipment. Wages will go up in China and India and since they are the most populous regions in the world, indeed Morgan Stanley estimates that they will have a per capita income in par with the global average within two decades, so any new low cost regions on the arena will not have a comparable impact. Product development will shrink the direct labour content in products even further. Maybe offshoring for cost reasons is a temporary phase after all? Maybe this development will continue in such a speed that the low wage profile for qualified personnel will come to an end in these parts of the world sooner than expected.

In looking outside of the European Union, it was decided to provide comments from three countries by additional expert interviews – the United States, Japan and China as obvious competitors and as key countries in the development of manufacturing (cf. ManVis Report No. 4). The common theme in each of the countries appears to be uncertainty. In the United States this is an uncertainty on whether manufacturing will remain a vibrant part of the economy, in Japan it is whether they can revitalise the manufacturing sector, and in China whether the rapid growth of manufacturing can be managed effectively. There are issues which are more individual, and these may turn out to be the most important, but the divergence of how manufacturing is perceived is crucial to understanding the probable future trajectories in each country. Uncertainty over China’s global role is obviously a core issue across all three countries as China continues to expand its trade and moves into higher value activities.

Within each country there are distinct top level issues in the debates:

- China's main concerns are managing growth and ensuring power and infrastructure in place to support that growth. Another issue is rebalancing the econ-

omy with services. China is actively encouraging the establishment of R&D activities, both Chinese public funding of R&D and international private R&D, and this is challenging developed economies perceptions of what activities they will remain competitive in and retain.

- Japan's main concerns are revitalising manufacturing and combating high wage rates and changing demographics with increased emphasis on production technology and automation. At the same time, Japan is strengthening its position in key manufacturing technologies – particularly emerging industries – creating further tension between the Japanese movement of production to China and their desire to lead in these new areas.
- In the USA, rising costs of doing business (especially healthcare) and concerns about outsourcing are dominating, but with widely divergent views within the country about whether it matters. The continued pressure on US manufacturers to outsource and offshore their manufacturing activities is leading to an emerging sense of protectionism. It is possible that barriers to such movements will emerge, depending on how threatening the developments are perceived to be by the American public and the political establishment.

ManVis results confirm the anxiety about the migration of European manufacturing. This anxiety is more often indicated by the experts from old Member States which is not surprising if we consider the present structure and directions of intra-EU foreign direct investment flows (towards new Member States and Candidate Countries migrate mainly low- and medium-tech industries and related sectors) and the nature of comparative advantages, which are possessed by new and prospective members of the EU.

The favourable position for Europe in design and trademark development is not covered in the ManVis study specifically but is probably a very strong factor for establishing and strengthening Europe as a true lead market for many product segments; a development thus attracting jobs from other regions and acting as an opposite movement to offshoring. A requirement for being a lead market is large segments of consumers with purchasing power and therefore a possible slowdown of future growth due to an aging population becomes a threat to our aspirations of acquiring a lead market recognition.

Considering these additional views, offshoring and outsourcing are structural changes which are both high on the importance ranking by the ManVis experts. Due to the far gone development of well defined and documented internal procedures, in the views of the experts it will become easier to relocate industries and manufacturing plants in particular. Companies which are late in reducing the dependence of local knowledge on

the production locations are instead more likely to outsource major parts of the operation.

The productivity has been enhanced more in production than in product development due to increased efficiency and automation which play an even more important role in the view of the ManVis experts. A majority of the ManVis experts believe in heavy automation as a way to counteract offshoring. But at the same time the experts identify Japan as the research leader in almost all issues concerning production and automation technologies. As an effect of this, the investment into automation leads to a declining relative importance of variable costs and the economies of scale are increased. Accordingly, many industries are trying to break the vertical ownership, moving into horizontal ownerships instead. When the value of knowledge is increasing and becoming the most important factor for industrial success, the companies try restructuring to maximise the utilisation of the knowledge created. The creation of tools and systems for knowledge administration and distribution and for control of the logistics will be a crucial success factor for survival as seen by the ManVis experts.

When analysing the answers the ManVis experts have given on regional leadership in different research and development areas, a clear pattern surfaces. The fields that Europe is seen as the leader in are all issues concerning environmental protection and sustainability. Japan leads in most issues on production and US in most issues on new technology. Although the estimated position in research, expressed by a relatively small selection of experts, should not be exaggerated in value, the question arises if Europe could do more in order to attract the global industry to locate the core functions for the future to our region.

Production itself is becoming less and less of a focal part of the industrial operation, while the interface to the customer and the interoperation with the customer to constitute an agile value chain, able to move closer to mass customisation, is growing in importance. The agile company must embrace many and frequent product changes as well as numerous models and options, thus leading to a need for very efficient change over procedures. As representing evidence the ManVis experts expect the development time for cars to be reduced to six months within ten years, e.g. Ford has recently reduced the development time to 18 months, and is aiming for 10 months. The whole innovation system of a firm understood as product development, production, services and logistics will be the core of a firm’s global competitiveness – if managed properly in a holistic way.

Based on this discussion of the ManVis results, the *main policy recommendations* on long-term global competitiveness can be summarised as follows:

- The experts express a strong belief in automation as a way to keep industrial operations in Europe but the opinions on Europe's position in research do not match. Europe ought to consider how to gain a more advanced position in R&D on automation. But the considerations given by the experts and stakeholders on user-friendliness and worker's participation as well as on SME orientation are necessary to obey in any future R&D activities.
- The experts also send a clear message that the industry position in the global competition will be based on the performance of the total value chain, the industrial system, and its speed of renewal and integration which therefore should also be considered a focussed development area. The emphasised issue, as expressed by the experts, is the speed of change. Europe must try to act strategically in order to ease flexibility on such a change capacity that lies in our favoured path of development.
- The expectations for more jobs on the factory floor are more or less nonexistent, Europe will either have to automate or offshore and in any of the cases the less advanced jobs will disappear. The focus should therefore be on attracting the core operations of the global companies, which often means staying or becoming a lead market.
- The ManVis experts are convinced of the importance of SMEs and of networked SMEs but they show very limited interest or expectations for an economy based on local production. The observation is that SMEs must go global and platforms are required which support SMEs' entrance to the global markets. New tools for that strategy have to be developed and existing ones have to be enhanced.

5 How to meet customer and societal needs?

The ManVis analysis comprises the Delphi survey and – in addition – workshops with stakeholders and the advancement of the FutMan-scenarios. The underlying rationale of these analyses is the role manufacturing plays for competitiveness and society. Manufacturing competitiveness increases if customer and societal needs are fulfilled and satisfied successfully. Manufacturing may even flourish if these needs are new, innovative and become a role model for other markets. These innovative markets are lead markets which allow for valuable learning in innovative demand.

The analysis of the ManVis survey and stakeholder workshops revealed a number of challenges to European manufacturing arising from developments of demand from users and consumers. It was emphasised that addressing these challenges will not only

serve particular interests of users and consumers but significantly strengthen the competitiveness of European manufacturing industry. It was further argued – in line with findings from the Manufuture group and literature – that the close interaction with users and customers on a local level is offering an opportunity to keep high value adding parts of the manufacturing value chain within Europe while at the same time ensuring the supply of highly customised products suited to the needs of European customers and users.

The following key challenges for European manufacturing industry were outlined:

- Facilitating transparent provision of information on products and processes
- Ensuring product usability for groups with special needs
- Preparing for social innovation
- Enabling systemic innovation
- Developing technological and organisational visions for localised manufacturing approaches
- Facilitating user centred innovation.

Regarding user centred and localised manufacturing the ManVis survey had taken up a number of aspects. However, the Delphi results revealed that there is only a limited recognition of the challenges arising from changing demand patterns within the community of manufacturing experts that was addressed by the ManVis survey. This scepticism again is pointing to the deep transformation European manufacturing needs to undergo on the road towards the "user driven innovation system" (Manufuture 2004, 8[2]). Policy and more specifically R&D policy could support this transformation on several levels.

The analysis of the results of the stakeholder workshop together with an assessment of the relevant Delphi results and literature from the field identified a number of *key challenges* arising from emerging new patterns of working, learning and living:

- Balancing individual and organisational learning
- Implementing new ways of acquiring skills within manufacturing
- Taking a new approach to workplace innovation enabling contribution to innovation from all workplaces
- Widening the concept of research to include a broader range of knowledge generating activities (open innovation)

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2 Manufuture High Level Group (2004): Manufuture – A Vision for 2020, Brussels

- Securing a competent workforce
    - Attracting competent people to manufacturing especially women
    - Improving accessibility of manufacturing workplaces for groups with special needs
- Foster sustainable structuring of work and facilitate a better reconciliation of working and non-working life.
- Avoiding exclusion from learning processes

These issues were all in some way or other addressed by the ManVis Delphi survey. The results revealed that the experts who answered the Delphi survey stressed the tremendous importance of incorporating continuous learning processes into manufacturing companies in much the same way as the stakeholder representatives in the demand perspective workshop. Both groups are expecting that companies will have to make huge efforts to become truly learning organisations.

However, when it comes to the nature of these efforts assessments differ between Delphi experts and stakeholders from the demand side. While the ManVis Delphi experts placed a rather low emphasis on working and living conditions, the participants of the demand perspective workshop strongly emphasised the close interrelation between the learning capacity of companies and the quality of workplaces. Workplace innovation was seen as a crucial prerequisite for ensuring innovation capacity and thereby competitiveness of European manufacturing companies. It was pointed out, that emerging types of knowledge generation call for contribution to innovation and learning processes from every workplace which is only possible if the workplace is enabling such contributions. Adaptation of the working environment to emerging new patterns of living and working was thought to be part of these enabling conditions. Although the participants in the demand perspective workshop recognised the economic difficulties companies are facing in realising workplace innovation, it was thought that without these efforts companies will not be able to meet future challenges and fail to attract a competent workforce in the future.

In addition, *ecological sustainability is a major European policy goal*. Based on the analysis of the results of the Delphi study the most important visions can be seen when it comes to environmentally sustainable development are:

- Environmentally sustainable development is an important issue and will continue to be so. The majority of the experts who were consulted assess the statements that were selected on the subject as important/very important. Most important are statements on renewable resources/remanufacturing/recycling. The main barriers for these are technical feasibility and economic viability. So-

cial acceptability is not an issue here, but when it comes to decision making based on the principles of sustainability there are strong differences of opinion. The time of realisation will not be in the present but will be approximately between 2010 and 2020.

- For New Member States the possibility of making steps forward on sustainability is clear. Political pressure concerning the reduction of environmental impact on these countries is higher than in the other Member States. Also the fact that many new (energy) infrastructures and technologies will be built in these countries makes it possible to use 'state of the art technology' and also creates an atmosphere of innovation as companies could use experiences from these countries to improve for example their production processes, use of renewable resources, and transport systems. This can also lead to an economic impulse for the New Member States, since a majority of the experts thinks that competitiveness will benefit from the developments in alternative energy resources concerning transport.
- The most important barriers that are named by the experts for reaching ecological sustainability are economic viability and technological feasibility. Although legislation is often referred to as a barrier by external sources this is not an important issue according to the majority of the experts. Economic viability and technological feasibility are strongly related to the demand side of the market. If the market is willing to pay a price than almost everything is possible. To deal with the barriers, it is important to look at the whole system of a certain sector system but also to the interactions between sectors. For example the changes in design, production and the logistics of collecting and processing used and discarded products will have a substantial impact on the manufacturing industry, transportation companies, and design studios.

One important step in the discussion of the ManVis results is the *linkage to general policy options* achieving overall sustainability. In the FutMan project four scenarios were developed (cf. Figure 5). They were based on the four possible combinations resulting of (1) the development in public values and consumer behaviour and (2) on the integration of sustainable development policies (Gothenburg objectives).

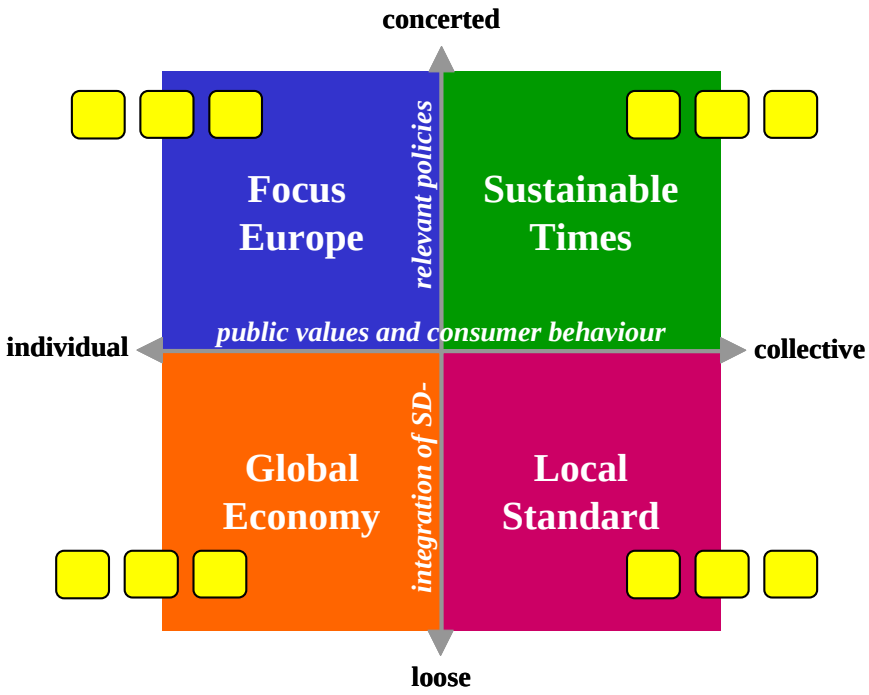


Figure 5: FutMan scenarios on sustainable manufacturing

Therefore, the Global Economy scenario is characterised by a loose degree of policy integration and individualistic values whereas in the Local Standard scenario collective values prevail but policy is only loosely integrated. On the contrary, the Focus Europe scenario is characterised by a strong integration of European policies and prevailing individualistic values. The Sustainable Times scenario features highly collective values along with strong concerted policy actions towards sustainability. The IPTS discussed the results of the ManVis demand strand in the view of these scenarios in ManVis Report No. 5 based on an expert workshop and secondary material.

All four scenarios embrace *new forms of knowledge generation*. In all scenarios knowledge has become the most critical factor for manufacturing industries. However, the way the "knowledge economy" is realised and embedded into society is differing. Within the Global Economy scenario the emphasis is on highly formalised knowledge that is transmitted worldwide through advanced ICT tools. Knowledge generation for the manufacturing industry is largely performed by specialised experts within each field.

Tacit knowledge and experience is less emphasized. The picture is quite similar in the Focus Europe Scenario. However, in this scenario concerted policy action has introduced some elements such as strong orientation on interdisciplinarity that have helped to foster knowledge generation in Europe. Also the exclusive effect is less prevalent as

targeted government initiatives have enabled a wide range of societal groups to be part of the knowledge generation process. Within the Local Standard scenario knowledge generation is more localized. As the access to local knowledge sources is important for the manufacturing industry, there is less emphasis on formalisation and worldwide exchange of knowledge but more on integration of different types of knowledge. More societal groups are participating in the knowledge generation process. However modes of knowledge generation within Europe differ widely from region to region. Finally within the Sustainable Times scenario the open innovation mode outlined by the stakeholders in the ManVis scenario report has been adopted by the manufacturing industry. The focus of knowledge learning is on real life learning integration of knowledge types and the inclusion of a wide diversity of knowledge sources.

In all four scenarios *new patterns of work* have emerged as the classical linear model (education, work, and retirement) has dissolved into a continuous model with fluctuating pieces. However the integration of these pieces is on a different level. While in the Global Economy scenario the employers struggle to integrate learning phases often on the cost of spare time (similar to Focus Europe but here limited by legislation), in the Sustainable Times scenario the integration is helped by companies themselves supported by strong legislation. In the Local Standard scenario, a number of local initiatives on new models of working and living have been initiated by local groups.

There are three major challenges to manufacturing arising from the demand side:

- Adoption of a user driven innovation approach
- Adoption of open forms of knowledge generation
- Adoption of all three dimensions of sustainability (economic, social, ecological) in manufacturing decisions.

To cope with these challenges, the manufacturing industry needs to undergo a major transformation. This transformation embraces a number of technological and organisational innovations. The main challenge of the transformation is the integration of technical and organisational innovations into new socio-technical patterns of production and consumption. Central elements of these new patterns are joint learning processes between different actors of the value chain as well as workplace innovation enabling contributions to innovation from all workplaces. *This supports very much the same views emerging from the discussion of the global competitiveness aspects.*

Research policy can support the necessary transition of the manufacturing industry by targeted funding of the technological elements and even more by adjusting the way it designs its funding activities. Research activities within manufacturing will have to open up their focus and embrace knowledge sources from users and customers. R&D fund-

ing could foster workplace innovation and thereby the ability of European manufacturing to incorporate learning and embrace new modes of innovation by systematically integrating this aspect into the funding strategies.

6 Is a diverse Europe prepared to meet the challenges of knowledge based manufacturing?

Considering the technology drivers, the outlook on Europe’s role in global manufacturing and the customers and societal stakeholder demands, managing the knowledge base in European manufacturing is pivotal for manufacturing survival in Europe.

Hence, internal as well as external knowledge management activities are supposed to be very important for the future of the European manufacturing industry. The majority of ManVis experts believe that acquiring knowledge by cooperating with industrial partners and research organisations or by employing people with completely different educational, professional, and cultural backgrounds is an important issue for the future of manufacturing companies. Similarly, internal knowledge management activities such as the development of knowledge by acquiring new competencies, by increasing qualification certificates, or by reducing the amount of unskilled labour as well as knowledge sharing within manufacturing companies through self-managing teams, communication friendly organisational culture or through the location of R&D departments close to production are also considered very important for the future of manufacturing.

However, analyses of the ManVis data also reveal contradictions, problems and inconsistencies concerning knowledge-based activities of the manufacturing industry. Regarding the acquisition of external knowledge bases, experts indeed have a high awareness that clustering, networking, and other types of joint innovation activities have a positive impact on Europe's competitiveness. On the other hand, experts' opinions contradict to this positive impact on competitiveness as they estimate that economic viability might be one severe barrier for an effective realisation of external cooperative activities. Moreover, experts' estimations on the expected effects on employment and regional differences are also unclear. Thus, although there are a variety of policy measures at the European level supporting inter-organisational clusters and networks in order to strengthen company's innovation capacity, there is a need for more transparency regarding the positive and negative impacts of external cooperation for the manufacturing companies and for the entire European economy.

Concerning the demand for an increased workforce diversity as a further activity for acquiring external knowledge, experts also show a highly developed sensibility for this topic all over Europe. However, experts' assessments demonstrate that employees'

education and qualification is one barrier that might hinder the implementation of increased workforce diversity. Thus, experts think that most employees are not sufficiently competent to successfully work together with colleagues who have diverse professional, educational, and cultural backgrounds. One first conclusion might imply that the educational system of Europe does not provide enough employees to generate a diverse workforce within companies. The second and even more important conclusion is to generate an awareness among European manufacturing experts that not only the educational system but also the manufacturing companies themselves have to take responsibility for promotion and development of employees' and organisational competences which are necessary for working in a diverse environment.

Estimations on the involvement of stakeholders into product development processes as another example of incorporating external knowledge bases into companies show a much lower relevance for this issue compared to all other activities of external knowledge acquisition. Moreover, except for a clear assessment on the positive effects on the competitiveness, experts' assessments are rather unclear and even contradictory on this issue. Further qualitative and more detailed analyses are needed to investigate reasons for the low relevance of stakeholder involvement in the views of the manufacturing experts.

As with external knowledge management activities, internal knowledge management activities such as knowledge sharing supported by a communication friendly organisational culture, acquiring new competences during working time or the reduction of unskilled labour through trainings are also considered very important for the future of Europe's manufacturing industry. Experts believe that these activities will mostly be realised within the next 5 years. They foresee positive effects on living and working conditions as well as on Europe's competitiveness. Obviously, experts expect internal knowledge management activities to gain competitive advantages for manufacturing enterprises. However, one main barrier for internal knowledge management activities is supposed to be employees' level of education and qualification. Thus, again the employees' level of education and qualification is seen as a barrier for knowledge management activities. Obviously, there is strong scepticism among the experts towards the educational system as well as towards employees' capacity to implement and "live" knowledge sharing and knowledge development within manufacturing companies. Additionally, probably even more severe is the fact that many experts think that knowledge sharing and knowledge development are economically not effective.

It is quite surprising that the assessments of the experts from Candidate Countries are much closer to the estimates of the experts from old Member States than those from New Member States. The times of realisation of particular developments given by the latter are more often more distant (than those given by the experts from old Member

States and Candidate Countries). This may suggest either a more preserved attitude of the experts from New Member States or – which is more likely – bigger scepticism about the speed of introduction of desirable changes in management of economy, and consequently about the speed of realisation of the idea of learning organisation.

Working conditions are clearly considered less important not only in comparison to a company's knowledge management activities but also compared to the importance of the entire statements. Obviously, there is almost no sensitivity for the relevance of employees' working conditions. This is surprising since working conditions are prerequisites for sustainable knowledge development and sharing in companies. Experts think that the main barrier for the implementation of these working conditions is their social acceptability. Thus, not only the fact that working conditions do not have high priority in Europe's manufacturing companies, but also that social values and norms as well as traditional role models hinder the implementation of such working conditions is a serious problem for the future of the manufacturing industry. Only with motivating and fair working conditions for the employees, manufacturing companies are able to keep their valuable workforce and be competitive on the market. To provide and support these working conditions is the future challenge of European society and policymakers.

The ManVis Delphi results further confirm that a substantial technological gap maintains between old Member States, on the one hand, and New Member States and Candidate Countries, on the other hand. It can be seen in each of the areas discussed above: emerging product technologies, new manufacturing technologies and flexible automation. It is still reality although huge advancements could be observed since the beginning of the 1990s. All ways are used by which technology can be transferred: foreign direct investment, licensing, learning by exporting and imitation.

The technology gap can be deepened by existing barriers, among which top ranked are: education and qualification and lack of R&D funding, which are much more strongly indicated by the experts from outside old Member States. It is expected that the transition from resource-based to knowledge-based manufacturing will result in an increase in regional differences and deterioration of the situation on the labour market. These fears are indicated particularly by the experts from New Member States and Candidate Countries and they are strongly correlated with an assessment of future effects of joint R&D in technology clusters, R&D near production and networks of specialised SMEs.

The concentration of New Member States and Candidate Countries on the development of system competition based on knowledge-intensive advantages is inasmuch justified as for the time being these countries possess substantial cost advantages. However, the source of these advantages is mainly a relatively low cost of labour; unit

labour costs are currently significantly lower than in the old Member States. This advantage is, however, temporary due to the process of convergence with the rest of the EU (although the rates of convergence will vary). In addition, the cost advantage of the New Member States is reduced by the fact that their labour productivity is lower than in the old Member States. An underestimation of strategies based on cost advantages can weaken substantially in the end (even in a relatively short term) the chances to face the competition from other low-wage economies.

From this viewpoint, the differences in opinions about a positive impact of innovation in big multinational companies are interesting. It is exclusively achieved by corporate venture with spin-off or by acquisition of innovative SMEs; old Member States have a substantially higher proportion of experts who assess that impact as positive. That suggests different experiences and the resulting differences in opinions about the role of big, international firms, and more generally foreign direct investments. The scepticism manifested in this regard by the experts from New Member States can result from the previous practice in the framework of which foreign investors remained isolated from the wider local and regional economic context in which they were situated.

That points to a strong fear for possible asymmetric development of European manufacturing. The fear is also indicated in many previous analyses that highlight the tendency to the concentration of economic activity and human capital primarily in EU's core regions. Also the specialist infrastructure, research and development, know-how and other high value-added activities concentrate on these areas, which imply that low value-added activities are localised on the peripheries of the Community.

7 Which visions, challenges, and needed policy actions emerge for European Manufacturing?

ManVis had to explore the ambitions and expectations of manufacturing experts throughout Europe and reflect them with societal stakeholders and overseas views. During this exercise, diverse – sometimes conflicting – views emerged showing the scope and complexity of today's and tomorrow's manufacturing. The main difficulty of this policy paper is to bridge between the generalistic views and the mass of details available in the various reports and databases. This chapter tries to summarise the findings and views. It condenses them into several visions and discusses their impacts as well as the main challenges lying ahead. This should lay ground for the recommended actions.

In particular, several trajectories for developments of the manufacturing of tomorrow came out of the ManVis findings:

- The struggle on labour cost competition will prevail in the next years. Basically there are two dimensions: the loss of operations to countries outside the European Union and the movement within the European Union. The strategies emerging from the ManVis expert consultation are mainly reactive i. e. cost reduction through automation and enhanced labour productivity. The New Member States will exploit in the very near future an existing cost advantage but will loose it faster then competitors outside Europe. Without own innovative capacity for absorption and enhancement this Foreign Direct Investment will just pass through these Member States in a decade. In any way, both developments are characterised by losses of employment in manufacturing and, of course, retreat from markets.
- Local manufacturing operations and local R+D excellence – as general options – are reactive patterns as well. Very often based on concepts originating from the sustainable development debate this vision is characterized by local operations and development based upon very close interaction with local users – who still have to have purchasing power. The consulted manufacturing experts were quite sceptical on the prospects of this option because of their assessments on the weak ties of modern manufacturing into its environment, contrary to the consulted stakeholders' representatives who value this concept as feasible and competitive.

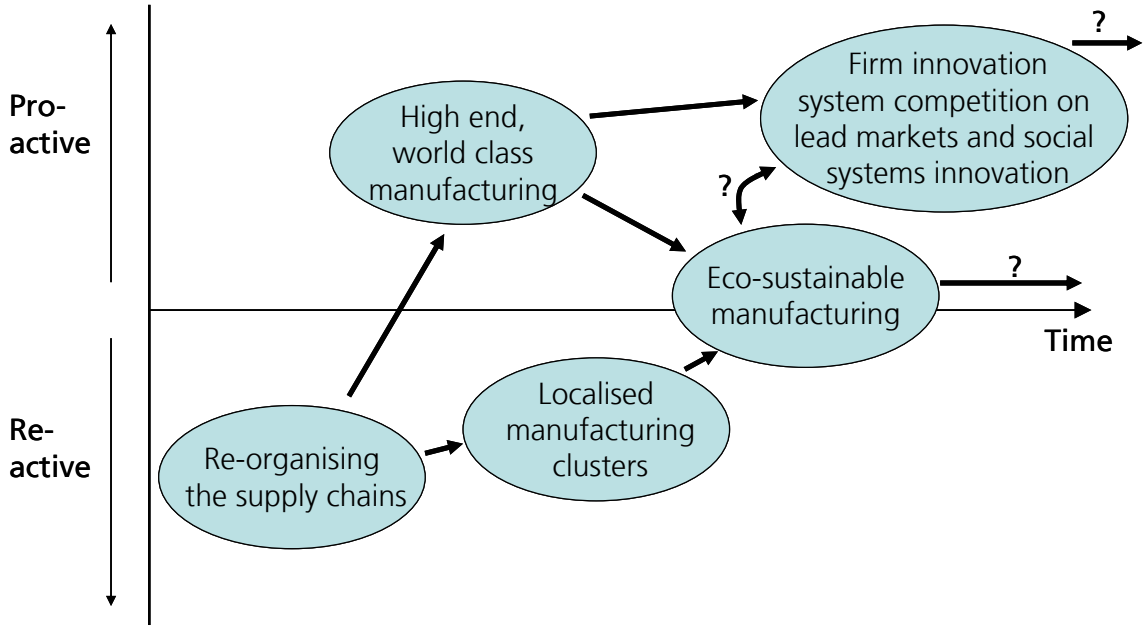


Figure 6: The ManVis trajectories for Manufacturing of Tomorrow

- Eco-sustainable manufacturing based on new products, new materials, energy efficiency, and last but not least on advanced product service systems could be developed into a competitive advantage for Europe – in the view of both experts and stakeholders. Regulations creating a technology pull, e. g. as outlined in the FutMan policy scenarios could be successfully mastered because of the excellent R&D position in this field.
- High end manufacturing will be based on the efficient use of sophisticated manufacturing technologies, which will enable world class highly automated operations for new products. This high ambition requires an exploitation of the expected potentials for micro electro-mechanical systems, related nano-technologies, closing gaps in automation, and research on manufacturing with new materials. But this high efficiency approach will reduce or only maintain existing employment in European manufacturing.
- The most ambitious and far-reaching vision is the European best practice in competing over all parts and tasks of the firms innovation system. This comprises user interaction, product development, production, supply chain, and logistics. The successful mastering of this "system" is considered the most promising way to ensure long-term competitiveness. In order to achieve that, two main crucial elements have to be realised:
    - Innovative and adaptive lead markets have to give European companies the chance to be the first to learn and
    - that they have effective user/customer interaction mechanism in order to exploit this advantage.

These different visions or perceptions of trajectories are not independent from each other nor do they emerge in the same time period. Today, the struggle for labour cost competition dominates the debate, although several European big and small firms are successfully performing the high end manufacturing on their markets. The restructuring of the supply chains enables i. e. in the New Member States the establishment of new operations but does not yet ensure a real long-term impact on their innovation system. If the New Member States are not developing their own innovative and absorptive capacities very soon, the labour cost advantage will disappear – and with that the newly erected plants.

The scenario analysis in ManVis Report No. 5 furthermore indicates that in many respects advanced solutions are likely to emerge from a local level. For policy making, this implies that it could be useful to support such local "model" approaches to then be able to systematically foster their transfer and adaptation to other conditions. But contrary to that, global competition in the view of the ManVis experts requires global pres-

ence. Hence, the European Unions cluster oriented innovation policy could develop such needed islands in the New Member States. But this strategy will remain reactive considering global competition as long as it is not connected to newly created market opportunities.

The drivers for approaching competition based on the firm's system of innovation are lead markets. Innovation and adaptation take place where a satisfying number of demanding customers are. New lead markets attracting new companies have to emerge in Europe. In order to achieve this, besides new technologies and excellent products and operations, changes and social innovations are necessary in order to create the new demands and to allow firms to operate successfully.

In order to move along the different paths and create employment severe *challenges* can be concluded which have to be mastered:

- creating manufacturing based on advanced technology,
- developing knowledge based and learning companies and industries,
- competing through the firms individual innovation systems,
- re-defining and innovating demand through lead markets,
- keeping Europe economically united.

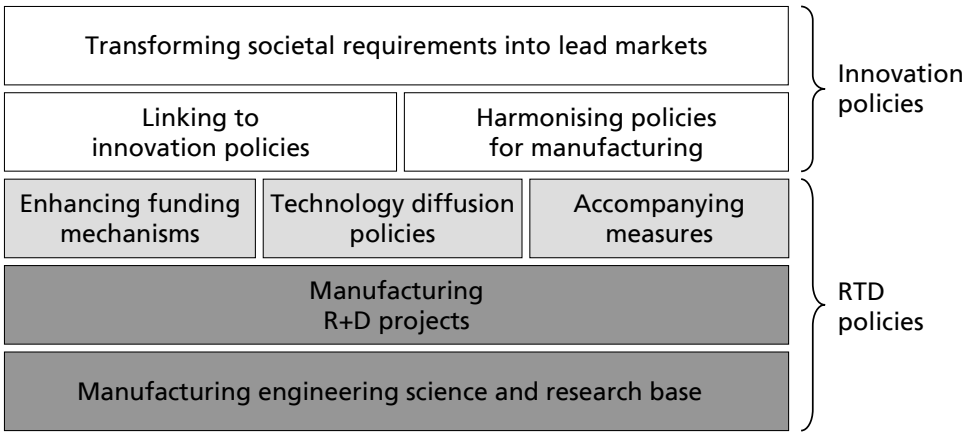


Figure 7: Elements of policies for knowledge based manufacturing

In order to master the challenges, *several types of actions* are recommended (cf. figure 7).

- An advanced science and research base for manufacturing and engineering as basic conditions,

- excellent R&D projects (collective or academic) on manufacturing issues as core activities which bring forward manufacturing excellences,
- accompanying measures on innovation management and research on social and business impacts facilitating change and innovation,
- enhanced funding mechanisms to foster joint learning in order to match the challenges in a more appropriate way,
- establishing diffusion policies for manufacturing technologies and best practices,
- linking manufacturing R&D policies to innovation policies,
- harmonize and re-directing various policies with impact on manufacturing towards innovation and competition of firm systems of innovation,
- transforming societal requirements into lead markets.

The Manufuture vision document (p. 14) has highlighted the complexity, the multidisciplinarity and urgency of holistic views of manufacturing engineering. They reflect the developments on the markets, maintaining or re-gaining for manufacturing industries' competitiveness today and to ensure it in the future. In addition, new technologies and new knowledge are provided which have to be exploited, adapted, and put into practical use. Hence, manufacturing engineering is the motor which brings new products and services on the market using technological, organisational, and human resources.

By research on technologies for manufacturing and on organisation and management research, manufacturing research provides manufacturing engineering with the necessary knowledge, tools, and solutions. Basic manufacturing research has to foresee and prepare for the new challenges and applied manufacturing research has to adapt and transform existing technologies and organisational processes. Furthermore, manufacturing research plays a decisive role in combining the long-term horizon in technology trajectories with the short-term need of firms to innovate successfully.

Even for practical and industrial manufacturing research the science base is of growing importance. The inclusion of manufacturing topics and issues into the funding mechanism of the planned European Science Council is of crucial importance. Other existing mechanisms on transfer and mobility of researchers have to be maintained as well as international cooperation.

Excellent research projects in manufacturing are needed. The topics were elaborated from chapters 2, 6 and 8 of ManVis report No.3 i. e. the different foci and main tasks are displayed in the box below. It is important to notice not to concentrate on technological developments only but the whole system of innovation in the firms has to be

considered. This implies tools, strategies, methods, procedures etc. for product development, logistics, innovation management, business concepts etc. had to be added to the technological research agenda. The main challenge towards more pro-active strategies lies in the implementation of successfully learning companies which can adapt their innovation system fast.

Imminent technological research needs

Paving the way for new technologies in manufacturing

- roadmapping and foresight on manufacturing relevance of nano- and (white) bio-technology
- measurement, workplace safety for nano-technology and bio-technology
- applied basic research for white bio technology and nano-manufacturing

Industrialising technologies

- processing and manipulation of new materials
- incorporating smart materials into components for process technologies
- combining new materials with micro electrical mechanical systems (adaptronic)
- exploring new modelling knowledge and high power computing for simulation of product development, of material behaviour, and of virtual experiments

Exploiting technology advantages

- micro-systems in machine tools and products
- intelligent mechatronic systems for automation and robotics (e.g. self adapting components)
- new automation technologies using advanced human-machine interaction by considering diverse workers capabilities
- ICT-tools for traditional sectors

Technologies for customising products/services

- Tagging and labeling technologies
- Approaches towards product customisation via software or electronic components that allow for maximum flexibility and user integration
- Technologies and concepts facilitating user integration into innovation processes
- Technologies and concepts facilitating personalisation and build to order concepts
- SME appropriate tools for networks and logistics

Enhanced funding mechanisms should focus on the integration of user-interaction mechanisms. In order to exploit lead markets in Europe for their advantage, the following measures should be considered:

- Supporting joint learning between users and producers ranging from user centred innovation to social innovation initiatives by providing spaces and tools for joint innovation initiatives, e.g. demanding user integration and participative approaches in publicly funded R&D projects.
- Supporting the development of methodologies for participative design. This could e.g. be done by funding small pilot projects realising advanced participative design concepts.
- Funding also research projects starting from user initiatives instead from research institutions, or inclusion of representatives of consumer organisations into the development of future oriented R&D strategies.
- Promoting integration of socio-economic aspects into technological oriented research projects e.g. by requesting consortia to take on board partners with knowledge in this area.

Accompanying measures should ensure the transferability of the results e.g. by feeding them into other policies (e. g. standards, regulation) as well as preparing diffusion:

- Include knowledge on sustainability requirements into education on all levels.
- Support transparency, usability, and sustainability through legislation, standardisation, and public procurement.
- Supporting research projects in assessing the impact of new manufacturing technologies on workplace quality.
- Supporting innovation projects that involve other actors than classical R&D departments. (E.g. Integrate representatives of the workforce)

Technology diffusion policy measures seem necessary in order to avoid a leapfrogging of the New Member States by Far Eastern competitors. The New Member States have to change gear from labour cost based advantage to innovation system based advantage much earlier then China or India which both invest heavily into R&D. Hence, excellent research locations have to be established which deal with manufacturing and engineering research. Some sort of institutional support motivating existing excellent research institutions to help and enhance New Member States partners in their field will enable a quicker knowledge transfer towards a high-end manufacturing research.

Harmonizing policies for manufacturing is something which has started already (cf. COM (2005) 474). But as mentioned above the relationship between research issues and topics for manufacturing engineering and has to be in two directions; e.g. developing policy support for new ways of biotechnology based production ("white" biotech), or what should workplace safety for nano-technology workers look like or how to ensure product reliability through simulation tests. These cross cutting issues require parallel

and coordinated activities in order to adapt the sectoral innovation system in the concerned fields as quickly as possible. In addition, education and training policies have to consider the needs for learning firms, i. e. foster in-house activities much more than external institutions. It will be in the firms where the struggle for a competitive corporate innovation system is decided.

This harmonized policy approach is absolutely necessary if societal requirements and existing competences should converge into a lead market. First mover advantages could be only obtained if quick and decisive moves in demand shaping and competence building are made. In order to be successful, a thorough analysis of long-term demand and interactive participation of stakeholders and users is decisive for policy makers and industry, both. Hence, while closing the loop, exercising these practices in the R&D projects and efforts becomes of crucial importance.

In general, the radical transition process which is needed to keep manufacturing competitive within Europe embraces elements from completely different realms. Therefore, it cannot be achieved by research policy alone. It needs to be pushed by a strong concerted alignment of policies from different areas. Just as research itself has to adopt more open approaches, research policy will have to join efforts with other actors in the political arena. To coordinate these concerted measures guiding visions such as they were developed within the scenario exercise or by the Manufuture high level group can play a vital role. Further foresight activities can serve to orient the various stakeholders towards these visions.

Finally, from the scenario analysis it became clear that the issues at stake are not only relevant for the manufacturing industry but for society as a whole. On the one hand, many of the challenges the manufacturing industry is facing involve major societal transformation. On the other hand, failure to address challenges like inclusion of societal groups into learning processes, provision of customised products for groups with special needs or establishment of sustainable working patterns fitting societal needs may lead to major social tensions and affect the quality of life for European citizens.

Figures

The ManVis Consortium

Austria, ARC systems research GmbH

Belgium, Agoria, the multisector federation for the technology industry

Bulgaria, BAMDE, Bulgarian Association for Management Development and Entrepreneurship

Croatia, University of Zagreb, Faculty of Economics Department of Organisation and Management

Denmark, DTI, Danish Technological Institute

Estonia, EIETTU, Estonian Institute of Economics at Tallinn Technical University

Finland, VTT, Technical Research Centre of Finland

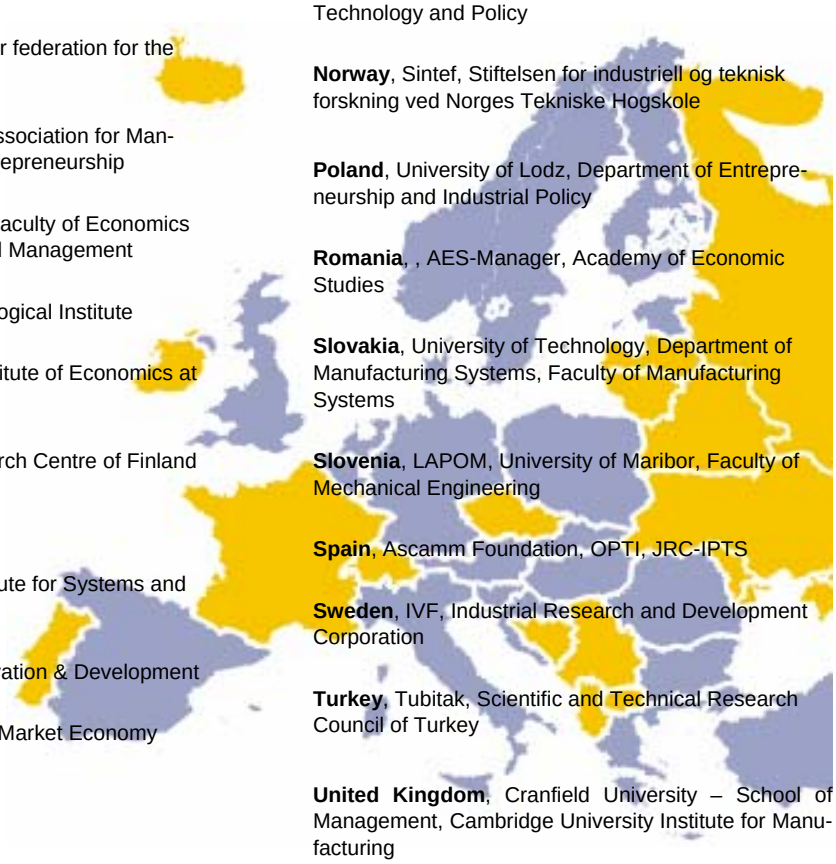
France, CMI

Germany, ISI, Fraunhofer Institute for Systems and Innovation Research

Greece, LOGOTECH SA, Innovation & Development

Hungary, FME, Foundation for Market Economy

Italy, FR, Fondazione Rosselli



Netherlands, TNO-STB, TNO-Institute for Strategy, Technology and Policy

Norway, Sintef, Stiftelsen for industriell og teknisk forskning ved Norges Tekniske Hogskole

Poland, University of Lodz, Department of Entrepreneurship and Industrial Policy

Romania, , AES-Manager, Academy of Economic Studies

Slovakia, University of Technology, Department of Manufacturing Systems, Faculty of Manufacturing Systems

Slovenia, LAPOM, University of Maribor, Faculty of Mechanical Engineering

Spain, Ascamm Foundation, OPTI, JRC-IPTS

Sweden, IVF, Industrial Research and Development Corporation

Turkey, Tubitak, Scientific and Technical Research Council of Turkey

United Kingdom, Cranfield University – School of Management, Cambridge University Institute for Manufacturing