ICT FOR MANUFACTURING

The ActionPlanT Vision for Manufacturing 2.0

SEVENTH FRAMEWORK PROGRAMME

ActionPlanT
Factories of the Future

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EXECUTIVE SUMMARY

To boost European competitiveness and speed the recovery from the 2008 financial crisis, Europe's manufacturing sector must fundamentally change its attitude and approach to business. Better use of information and communication technology (ICT) offers the key to meeting the challenges by enhancing end-to-end manufacturing processes from shop floor to customer engagement and all along the supply chain.

'ICT for manufacturing' is a specific research domain which merits public investment in the design and development of software facilitating shop-floor processes and connecting enterprises to each other and to customers. The objective is to use ICT to make manufacturing more efficient and user friendly, while enabling all European enterprises, irrespective of their location or size, to find opportunities beyond their borders through innovative business models.

The contribution of ICT to the manufacturing sector has become paramount over recent years and ICT is increasingly intertwined with future manufacturing processes and involved in developing efficient business processes. However, to ensure the sustainable competitiveness of Europe's manufacturing industry, a thorough analysis is required so that R&D resources are applied most efficiently. This analysis will consider technology and business trends as well as politics, environment, and societal needs.

The European Commission therefore encouraged the launch of the ActionPlanT project and is co-funding it under the private-public partnership 'Factories of the Future' within the Seventh Framework Programme (FP7). This initiative aims to establish a vision for the role of ICT in manufacturing of the future. The ActionPlanT *Vision for Manufacturing 2.0* identifies the global megatrends influencing the growth of European manufacturers and proposes new concepts for reviving the state of the European manufacturing sector. The overarching intention is to demonstrate that ICT has a major role to play in resolving some of the most crucial pinch points in European manufacturing.

The three key elements have been identified involving ICT:

1. European enterprises must bridge the gap between process- and commercially-oriented manufacturing operations by leveraging advances in the ICT world – notably in collaboration, connectivity, mobility and intelligence.

2. European manufacturers need to appreciate and use ICT to integrate the human element – workers and customers – to a greater degree in their day-to-day operations and businesses.

3. ICT innovation is a fundamental success factor for future manufacturing operations in Europe – enterprises have to be agile and swift when it comes to being innovative and applying innovation in practice.

The ActionPlanT *Vision for Manufacturing 2.0* will pave the way for a roadmap and strategy document which will identify, prioritise and schedule the most promising research topics in ICT for manufacturing for the next Framework Programme for Research and Innovation – 'Horizon 2020', covering the period 2014 to 2020.

THE CASE FOR ICT IN MANUFACTURING

Since the financial crisis of 2008, the recovery of European manufacturers has been painstakingly slow. European enterprises are lagging behind their counterparts in emerging markets, while their productivity has failed to catch up with Europe's pre-crisis rate[1]. Moreover, Europe's competitors in Brazil, Russia, India and China have grown significantly in the last five years. However, the global market for product and service consumption is constantly growing, driven primarily by demographics and economic prosperity. Yet, globalisation and cheaper labour will inevitably lead to even tougher competitive conditions.

To regain lost opportunities, European manufacturers must fundamentally change their attitude and approach to business. They must tackle the growing complexity of their processes and supply networks, handle cost pressures and meet customer requirements for quality, speed and customisation of products. Manufacturing enterprises increasingly specialise and outsource processes that are not their core competence.

Information and communication technology (ICT) can play a fundamental role in meeting these challenges by enhancing end-to-end manufacturing processes from shop-floor to customer-engagement levels.

Undeniably, ICT has become increasingly intertwined with *Factories of the Future* by delivering efficiency gains through automation and integration of diverse processes along the entire value chain. Several reports[2][3] demonstrate the positive effect of ICT capital on economic growth. Countries that lead in productivity have an equally high level of ICT *capital deepening* – i.e. investments in hardware, software and services. The positive correlation between ICT investment and ICT's contribution to productivity is also well established.

There is a marked disparity in ICT investment as share of GDP between European and other developed nations – Figure 1. The USA and Australia by far lead the share of ICT investment from 1990 to 2003. The share of ICT investment in major industrial European countries such as Germany and France is significantly lower. Also evident is a steep rise in investment share by Australia and the USA between these two periods.

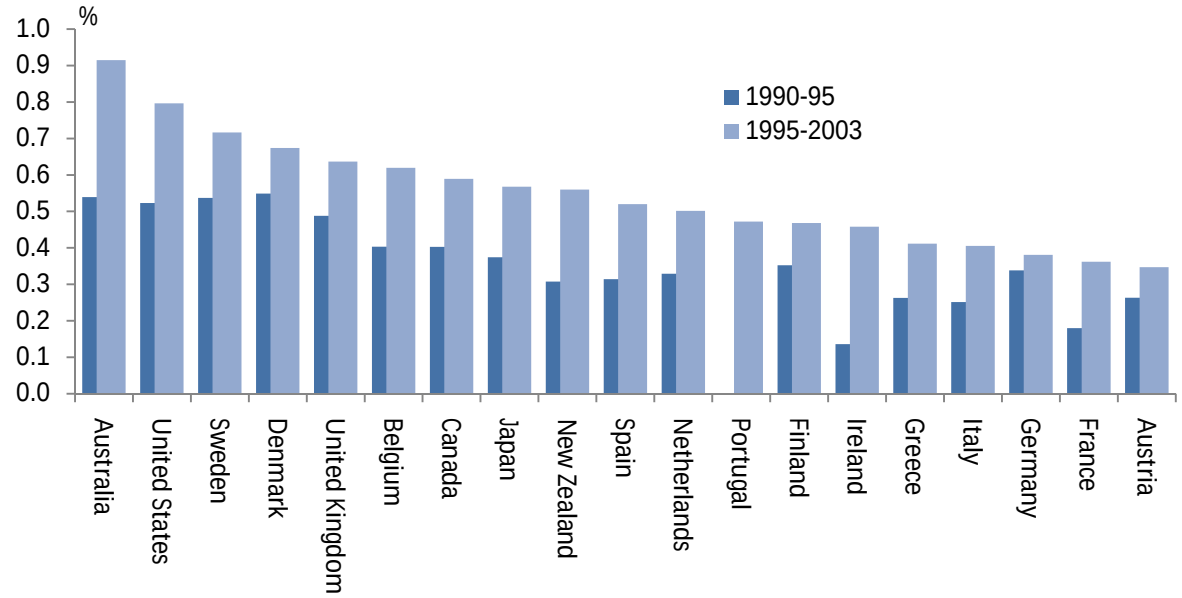

Figure 1: ICT investment as share of GDP (source: OECD[4])

Reasons for lower investment in Europe are manifold. Companies here, particularly SMEs, are less capable than their counterparts in the USA in turning their ICT potential into business results. The main explanations are: insufficient IT management skills; lack of technical skills – particularly in SMEs – and indifferent attitudes towards new IT or innovations in general. These deficiencies often hinder investments in ICT systems and delay organisational changes in business processes for production, supply chains and marketing.

The European Information Technology Observatory (EITO) lists further obstacles for Europe: scarcity of skilled human resources; limited investment in research and development (R&D) – Europe spends less than half of what its competitors invest in ICT research; a *not yet* favourable environment for new high-tech entrepreneurship; permanence of protected public markets; and very few pan-European leading-edge projects. Barriers preventing SMEs from adopting modern ICT technologies are technological, social and economic.

Through its Europe 2020 Flagship Initiative 'Digital Agenda for Europe'[5], the European Commission calls for more investment in ICT research. Underinvestment in such R&D in Europe continues. Compared with major trading partners such as the USA, the Commission observes that "R&D in ICT in Europe is not only a much smaller proportion of total R&D spend – 17% compared with 29% – but in absolute terms represents around 40% of US expenditure". Furthermore, as "ICT represents a significant share of total value-added in European industrial strengths such as automobile (25%), consumer appliances (41%) or health and medical (33%); the lack of investment in ICT R&D is a threat to the entire European manufacturing and service sectors."

MEGATRENDS INFLUENCING MANUFACTURING

A series of socio-economic and technological megatrends have a direct bearing on European manufacturing.

SOCIO-ECONOMIC MEGATRENDS

1. Demographics and consumption

Urbanisation with the development of megalopoles and a growing middle class in developing countries are fuelling demand for niche industrial products. Purchase decisions are being made based on brand perception of safety, quality and personalised/customisable products. Within Europe, the problem of an aging workforce is becoming critical and action must be taken to facilitate transfer of knowledge from the aged workforce to the younger workers, and to assist their daily work with user-friendly ICT tools.

2. Global competition and Innovation

Globalisation has led to the emergence of smaller dynamic enterprises able to put innovation into practice more rapidly than their bigger – and slow-moving – counterparts. The urge to be innovative is taking the global market by storm, putting pressure on large European enterprises once market leaders in their own domains but now losing out to smaller and more agile companies. To cope with growing competition, European enterprises must acknowledge the importance of innovation and put it to practice faster.

3. All-round sustainability

Sustainability has become a key topic on the agenda of politicians and corporate executives. It is necessary to transition from a wasteful to a frugal economy. This requires awareness and transformation of industrial processes towards low carbon footprints and energy efficiency. From a business point of view, the benefits of sustainability must be outlined to manufacturers without which enterprises would merely be sustainable on paper but not in practice.

TECHNOLOGICAL MEGATRENDS

1. Dynamic collaboration

Efficient collaboration between many different stakeholders will become crucial for day-to-day operations of European manufacturers. Large companies as well as SMEs stand to gain from collaborative manufacturing, service management and customer engagement via social media and other Web 2.0 tools. The trend of offering value-added services or even 'products as a service' will replace conventional business practices within Europe.

2. Enterprise mobility

The exponential proliferation of mobile devices presents an attractive proposition to 'on-the-go' and 'always-on' users. While mobile technologies have permeated the consumer market, enterprise applications are still relatively limited. To leverage the potential of next-generation smart phones and

handhelds, manufacturing enterprises should look beyond conventional desktop solutions and focus on new opportunities and businesses in the mobile world.

3. Real-world connectivity
   Sensors, automation controllers and embedded systems are already commonplace in personal life as well as in industrial applications. However, so far few companies have been deploying more than their own 'Intranet of Things' focused on local, isolated and closed-loop scenarios. The trend is to seamless and bi-directional interaction with real-world objects and systems on a global scale, across a variety of application domains and stakeholders thus realising the 'Internet of Things'.

4. Manufacturing intelligence
   Collaboration and connectivity will give rise to copious amounts of context and data which will have to be analysed on-the-fly and rendered on mobile devices of decision makers at both management and plant levels. Manufacturing enterprises will have a competitive advantage over their peers if they are able to perform real-time analysis over a large volume of data from processes, products and business systems.

MANUFACTURING 2.0: FOCUSING ON THE FUTURE

In the past few decades, manufacturing has gone through major changes driven primarily by globalisation, specialisation and customer demands. Major challenges facing manufacturers are the growing complexity of processes and supply networks, cost pressures and growing customer expectations for quality, speed and custom products. These enterprises increasingly specialise and outsource processes which are not core competences. The optimal orchestration of suppliers and other collaborators has become a key differentiator.

AMBITIONS FOR MANUFACTURING 2.0

The ActionPlanT vision for future manufacturing – 'Manufacturing 2.0' – aims to revive manufacturing within Europe in the short to mid term through *five* essential yet bold ambitions for ICT-enabled manufacturing:

1. On-demand: To sustain market share and create employment opportunities, Manufacturing 2.0 should accommodate changing demands from a new customer base and deliver customised products on-demand. With the increasing trend to last-minute purchases and online deals, it is important that European manufacturers are able to deliver products to customers quickly by collaborating with suppliers and subcontractors using agile supply chains which are interoperable, collaborative and manageable.

2. Optimal: European enterprises need to be able to produce products with superior quality, high security and durability and, at the same time, competitively priced compared to products from emerging markets. For this to happen, the next generation of product lifecycle management solutions should not only focus on designing the best products but consider the service life of products with special emphasis on value-added and after-sales services.

3. Innovative: Faster introduction of collective innovation is one of the three key growth factors together with human capital and infrastructures. Innovative thinking, design and manufacturing will lead the way to sovereignty, independence and growth of European manufacturing. As the French government observed in 2010[6], innovations still take considerable time to be put into practice – from laboratory prototype to full scale production – thereby giving competitors a chance to overtake European enterprises through *speed*.

4. Green: Manufacturing is responsible for significant energy use and consumption of natural resources. Manufacturing 2.0 needs focused initiatives to reduce energy footprints on shop floors and increase awareness of end-of-life (EoL) product use. Enterprises with high energy consumption, such as chemicals and steel producers, seem to have reached a limit in energy-reduction efforts and need an ICT-facilitated paradigm change to lower energy consumption further. As a side effect of being sustainable, new jobs within Europe would also be created such as in France where the National Research and Innovation Strategy states that around six million jobs could be created over the next ten years.

5. Human-centric: Manufacturing 2.0 will evolve from being perceived as production centred to human centred with greater emphasis on generating core value for human stakeholders. Future plants should be more accommodating towards the needs of the European workforce and consider them an integral stakeholder. In the same as 'assisted living' for aged citizens, 'assisted working' should aid an aging workforce to leverage skills and knowledge effectively for creation of innovative products. Furthermore, Manufacturing 2.0 will play a role in society by implementing all regulations linked with consumer safety, worker safety and other social obligations – such as REACH regulations for chemicals. The ability to guarantee compliance with regional and international regulations will also be key to setting new international standards, raising customer expectations and improving the market share of European products worldwide.

BEYOND THE SHOP FLOOR

To achieve these ambitions, enterprises must look beyond conventional shop-floor operations and consider the holistic *value chain*. Manufacturing 2.0 enterprises in Europe would therefore need to take collaboration and management of their supply chain stakeholders into account and also make provision for after-sales services in addition to improving engineering and production. Future enterprises would tightly integrate customers in their feedback loop for design and iterative improvements of products.

Figure 2 illustrates different operations within a future Manufacturing 2.0 enterprise. This encompasses the supply chain and customers in addition to manufacturing's traditional strength in engineering and production.

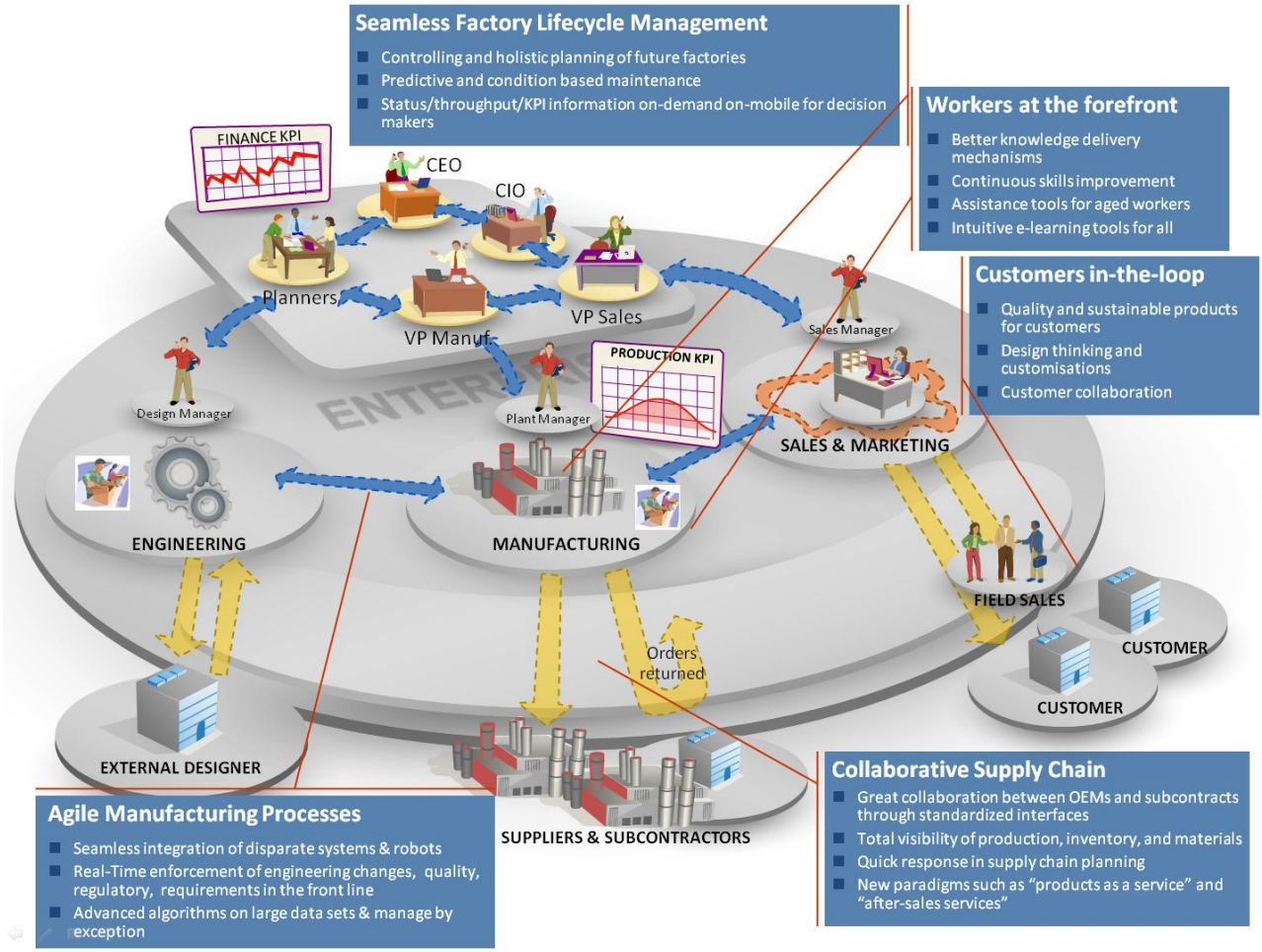

Figure 2: A Manufacturing 2.0 enterprise

Our vision involves a series of innovative concepts that could be carried out in Manufacturing 2.0 Enterprises:

- Agile manufacturing processes: The issues of systems interoperability would no longer be a deterrent to integrating disparate systems for design, manufacturing process control and operation, and business processes in Manufacturing 2.0 enterprises. These systems would integrate seamlessly and exchange data through standardised interfaces. Real-world resources such as connected objects, devices and advanced robots would leverage advances in the Internet of Things domain to communicate, collaborate and organise themselves autonomously. Furthermore, manufacturing processes would react in real-time to changes within an enterprise ecosystem – such as availability of equipment, assembly lines and dynamic configuration of process parameters. To achieve this, Manufacturing 2.0 enterprises would be capable of applying advanced computing operations to process large volumes of real-time manufacturing data, perform analyses and forecasting on productivity, throughput and downtime. Lastly, these real-time changes and decisions would be executed by plant managers on their smart phones which will process enterprise and manufacturing data to facilitate efficient management-by-exception.

- Seamless factory lifecycle management: Product lifecycle management is well understood but, manufacturers struggle to put factory lifecycle management into practice. Enhanced information management will be applied for control and holistic planning in future factories. In Manufacturing 2.0 enterprises, assets and inventories together with assembly lines and machinery would be dynamically monitored, configured and maintained. As a prerequisite for advanced factory lifecycle management, visibility, real-time tracking and predictive maintenance information would be made available to plant managers and operators. Furthermore, managers would be able to drill down into any production area and observe throughput, use and consumption through intuitive key performance indicators (KPIs) even when on the move.

- Workers at the forefront: Human-centric ambition will become a reality in Manufacturing 2.0 enterprises with workers given more opportunity for continuous development of skills and competences through novel knowledge-delivery mechanisms. Future enterprises will not only be better equipped for transferring skills to a new generation of workers but also proficient in assisting older workers with better user interfaces, intuitive user-experience-driven workflows and other aids, such as mobile and service robots. Furthermore, Manufacturing 2.0 enterprises would be equipped with interactive e-learning tools to facilitate students, apprentices and new workers gaining understanding of advanced manufacturing operations involving new ICT paradigms.

- Collaborative supply chain: Manufacturing 2.0 enterprises will define a new collaboration paradigm between stakeholders in the manufacturing supply chain, including but not limited to original equipment manufacturers (OEM), suppliers and subcontractors. Manufacturing processes will run across organisational boundaries of OEMs and subcontractors with complete visibility of production, inventory and materials available while guaranteeing security and privacy for all stakeholders. As part of the extended collaboration paradigm, OEMs will be able to sell 'products as a service' and certified suppliers or subcontractors will be able to offer value-added services – such as maintenance or upgrades – to customers. So-called 'capability-based' contracts will offer use-based billing instead of requiring upfront investments in machinery by subcontractors. Remote service management will help improve equipment uptime, reduce costs such as travel for servicing, increase service efficiency – like first-visit-fix-rates – and accelerate innovation processes, for example by remote updating of device software.

- Bringing customers into the loop: Another level where Manufacturing 2.0 enterprises would excel is in customer engagement. Carmakers already mine customer feedback data on motoring blogs to improve design and performance. Taking this as an inspiration, Manufacturing 2.0 enterprises would extract customer feedback from social media and incorporate it into engineering and manufacturing processes. Product sustainability will take precedence in the future with customers preferring to buy greener products out of environmental consideration, to obtain tax breaks or both. However, sustainable products would not be acceptable at the cost of quality and performance. Manufacturing 2.0 enterprises would be able to attain the quality-price-sustainability trade-off by intelligent product design through customer collaboration as well as through state-of-the-art approaches such as design thinking. Furthermore, Manufacturing 2.0 enterprises would be able to mitigate barriers in 'make-to-order' production and deliver individualised products with increased complexity and variability to customers.

MANUFACTURING BUSINESS WEB: REALISING THE VISION

To realise the Manufacturing 2.0 enterprise vision, ICT innovations in the Internet of Things, Internet of Services, mobile computing, social computing and cloud/on-demand as well as fundamental improvements in security, trust and programming paradigms have to be consolidated and put into practice. Simultaneously, ICT innovations must be pursued for core functional aspects of manufacturing such as new algorithms for high-performance manufacturing processes, mobile and service robots, and advanced product design with the help of simulation, 3D modelling and virtual reality. For competitive advantage of future Manufacturing 2.0 enterprises, ICT should assist in opening up new avenues of revenue generation by providing secure pay-per-use models, product-centred services and after-sales service strategies.

To bring all ICT-enabled technological advances together, ActionPlanT proposes the concept of a 'manufacturing business web' (MBW) – essentially a melting pot where disparate solutions for process- and commercially-oriented technologies converge. MBW will encourage core technology developers as well as manufacturing service providers to build individual solutions with minimal time-to-market. With MBW-compliant solutions, customers will not need to invest significant resources in configuring and consuming services.

MBW will provide a framework for customers to compose and configure manufacturing services in-situ for their customers, opening up a new prospect of revenue generation for third-party service providers. Hooks to context providers will enable service offers – logistics, weather forecasts, financial transactions and foreign exchange – to OEMs for consumption based on a pay-per-use business model. MBW will also accommodate infrastructure providers so SMEs could use hosted solutions on-demand through pay-per-use. Finally, all services provided in the MBW will be consumable at all levels of the enterprise stack by both heavyweight solutions deployed on-premises as well as lightweight ones deployed on mobile devices of managers and workers.

Figure 3 illustrates a Manufacturing 2.0 scenario involving different stakeholders in the supply chain of a future enterprise.

Figure 3: A manufacturing business web scenario

Here, the MBW acts as a facilitator for collaboration and a consumption platform for different Manufacturing 2.0 services. It enables the OEM to look for subcontractors fulfilling specialised production services such as SMEs offering after-sales services for the product manufactured by the OEM like firmware upgrades, maintenance or collection after a product has reached its end-of-life. Apart from specialised production services, the MBW is here providing customs clearance and logistics services for the OEM. Furthermore, the MBW enables the OEM to find an affordable logistics provider as well as connecting to retailers and field representatives.

The MBW as enabler of the Manufacturing 2.0 vision is more than a one-off service-oriented platform for manufacturing. In fact, the MBW can be considered as a *benchmark* for consolidating future R&D activities in ICT for manufacturing. Enterprises can no longer afford to develop silo solutions with limited use behind closed doors; instead, rich software needs to be built for manufacturing that holistically enhances all operations within Manufacturing 2.0 enterprises.

CONCLUSION

It is imperative that Europe's manufacturing sector makes improvements at both the technological and awareness level for ICT-enabled manufacturing processes to retain global leadership and excellence in manufacturing. This requires a thorough analysis to understand the fundamental driving factors of the future manufacturing landscape in terms of the technology as well as of political, environmental and societal needs.

ActionPlanT is therefore addressing the short-, medium- and long-term role of ICT in the manufacturing industry. Its vision of the future role of ICT in manufacturing will feed into the European Commission's common strategic framework for Horizon 2020.

Following on from this vision document, the ActionPlanT project is now preparing a roadmap for its realisation. This continuing work includes organising a series of workshops and validation sessions, analysing the gaps in the research topics so far collected and working on the scheduling and prioritization of research topics for the new Framework Programme.

Make you mark

As an academic or an expert in the manufacturing or ICT industries, you too can participate in ActionPlanT roadmap validation workshops. Please contact us if you are interested in contributing to this exercise. More information and contact details can be found on the ActionPlanT project website at:
http://www.actionplant-project.eu/

[1] OECD, Index of Industrial Production statistics, http://stats.oecd.org (Accessed July 2011)
[2] Effects of ICT capital on economic growth, EC, Technology for innovation: ICT industries and E-business, 2006, http://ec.europa.eu/enterprise/sectors/ict/files/ict-cap-eff_en.pdf
[3] The 2010 Report on R&D in ICT in the European Union, JRC Scientific and Technical Reports, 2010, http://www.ictventuregate.eu/wp-content/uploads/2011/01/The-2010-report-on-R-D-in-ICT-in-the-EU.pdf
[4] OECD Productivity Database, 2005, http://www.oecd.org/statistics/productivity (Accessed July 2011)
[5] A Digital Agenda For Europe, EC, 2010, http://ec.europa.eu/information_society/digital-agenda/documents/digital-agenda-communication-en.pdf
[6] Priorités stratégiques d'investissement et emprunt national [in French], Alain Juppé & Michel Rocard Commission, 2009, http://www.emprunt-national-2010.fr/iso_album/rapport_191109.pdf (Accessed July 2011)