Information Society

Perspectives on the Agile, Wireless Manufacturing Plant: Co-operating Objects for Information and Control

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Executive Summary

ICT is strategically important for European manufacturing enterprises and industrial automation vendors. For manufacturers these technologies offer the potential to improve productivity and competitiveness through the innovation that they will enable. For the industrial automation vendors, ICTs are important for maintaining their leading positions in various sectors of world markets, as well as developing their technological leadership given these technologies are fundamental to future-generation automation systems.

Wireless technologies are of particularly importance to both communities, since they offer significant potential to realise the vision of agile manufacturing plants and to achieve operational excellence. The philosophy behind applying wireless technologies in industrial plants, however, is not straightforward (driven by a simple notion of replacing cabling) because operating environment conditions are severe, applications demanding, and the consequences of failure potentially damaging. Predictability of wireless technologies also needs to be attained on a higher abstract level to achieve industrial adoption and significant applications.

Research and development is required at all levels within hierarchical management and control systems: operating environments; deployment issues; application capabilities; and middleware. A multi-sector, multi-vendor approach should be supported on a European scale to address significant precompetive research, technology development and standardisation activities. The Commission, within the next Framework Programme (FP7) should support research in this area. Coordination with the other national and European initiatives like the ARTEMIS ETP and the *Manufuture* ETP is essential to maintain leadership in the field. Increased awareness through promotion of the industrial significance of wireless technologies and their implications for reconfigurable, agile manufacturing plants is required. All this work needs to be considered in the context of embedded wireless communications at the machine and equipment level, the middleware layer level, the control systems level, and the production planning level.

Given that national activities in this particular area are very small-scale and unfocused, the recommendation for FP7 is that an Integrated Project, supported by some focused STREPS, is an appropriate way forward.

Investment in test and demonstration infrastructure, which could be of significant benefit to SMEs, is also desirable, linking with existing national initiatives.

Strategic Motivation

Manufacturing is an industry where Europe has strengths in many sectors, and ICT has been identified as an important enabler of both improved productivity and increased competitiveness in manufacturing (see ISTAG report on Shaping Europe's Future Through ICT, March 2006[1])

Industrial use of wireless technologies represents a topic that offers significant potential to realise the vision of agile manufacturing plants and to achieve operational excellence. It offers great potential to add value to manufacturing equipment and improve process excellence for boosting the competitiveness of both European manufacturing firms and European industrial automation vendors.

With respect to the latter, Europe is well-positioned in world markets in a number of key application domains. In the automation control market, primarily used by discrete-parts manufacturing industries, collectively, European vendors are the leaders in terms of global market share, positioned well ahead of the second place Japanese vendors, and significantly in front of third place US vendors. In the distributed control systems (DCS) market for continuous and batch processing industries, collectively, European vendors are positioned close behind US vendors, who are, collectively, the market leaders in terms of global market share. European vendors are significantly ahead of Japanese firms in this domain. In the area of robotics, Europe is positioned second behind the market leaders Japan, with the US vendors being only small players in this field.

However the strong position of European vendors in world markets cannot be taken for granted. To maintain leadership Europe must invest in new technologies for industrial automation, wireless technologies being one of several key areas requiring RTD investments. Already there is evidence of the importance that Europe's competitors attach to these technologies, with Rockwell Automation in the US having identified wireless technologies as an important element of future-generation industrial automation systems[2].

For European manufacturing enterprises, ICTs are a key enabler for improved manufacturing competitiveness. Over recent years there has been a movement to shift manufacturing operations to low wage economies in Asia. However, whilst off-shoring of production can bring benefits, it is often the case that some of these are only short-term. Cost related benefits in particular are often short-term, and potential savings can be easily off-set by increasing expenditure in other areas such as logistics, as well as by changing cost structures, such as the diminishing labour content of product-cost in relation to other cost items. In effect, off-shoring to Asia to achieve reduced labour costs is only cost-effective so long as the wages of Asian workers remain low, and labour costs represent a significant percentage of total costs. As neither of these elements is static, with the former tending to increase and the latter diminishing, and increasing oil prices driving up the cost of transportation, off-

[1] ISTAG Report on Shaping Europe's Future Through ICT, March 2006, http://www.cordis.lu/ist/istag-reports.htm

[2] http://www.iee.org/link.cfm?link=11511

shoring for tactical cost reasons often has limited utility in terms of long-term sustainable competitive advantage.

Off-shoring of production also tends to go through phases, and is usually related to the emergence of opportunities that arise from newly industrialising countries seeking to attract external investments. The off-shoring of production can however be countered; it is not an inevitability. One way to achieve a resurgence of manufacturing within the established industrial economies is through the notion of manufacturing capabilities as a competitive weapon. The strategic logic behind this is that, in a world where manufacturing is no longer the exclusive domain of a few nations, advanced manufacturing skills, know-how, methods, and technologies can be used to add value through the manufacturing function.

This is one key area where the potential value of ICT in manufacturing lies, not just in enhanced products, but also through enhancements of the manufacturing function by quickly adopting rapid advances in ICT science and technology; advances that can contribute to realising a highly-flexible and highly reconfigurable production environment. ICTs are therefore a tool, along with other new technologies, to create advanced capabilities that can be strategically exploited for sustainable competitive advantage.

Wireless technologies are a prime example, since they potentially not only allow for classical cost reduction, but also open up numerous new opportunities for novel approaches and innovation, wireless as an enabler for agile manufacturing being a case in point. Therefore progress in the development of wireless communication technologies will not only have a deep impact on communication itself, but even more on system planning and operation. Wireless communication will allow a degree of fast reconfiguration and mobility for devices, as well as for humans, which has never been possible before.

However, today’s wireless technologies and protocol standards do not provide the quality of service (QoS) requirements needed and they are still too power-intensive for future applications. As 100 percent guaranteed performance cannot be provided, predictability of wireless communications therefore needs to be addressed at the low level for wireless networks, and at the high level for providing appropriate abstraction models.

Research is also needed to achieve a uniform, easy design of system architectures, that can integrate existing *islands of IT* into a coherent framework, whilst also adding other functions and flexibility that are presently missing. There are also still significant opportunities to improve productivity, in the range of 10 to 30 percent, in European manufacturing plants by using ICT; opportunities which are not being fully addressed nor exploited at the present time.

Flexibility, in its many forms, has been an important issue in manufacturing since the early 1980s, but the scope of this interest has now expanded to the factory design itself. Changes in the structure of the business environment now require more than just flexibility, but also adaptive or agile capabilities. The ability to quickly, and at low lost, and with high quality results, to redesign and reconfigure factories can be strategically important. At the present time this type of capability has mostly been relevant to manufacturing enterprises that regularly need to modify their plants to meet changing product mixes, such as contract manufacturers. However, interest in this type of agility is beginning to widen. Faster changing technologies, increasing product innovation and ever shorter design cycles, and the resulting need to upgrade existing facilities more often, to add new advanced processes, and to respond to other changes of a structural nature, are becoming mainstream issues. This will mean that agile capabilities will become of paramount importance to a wider range of manufacturing firms.

However, there are some major bottlenecks and cost items in any factory upgrading or reconfiguration, and one of these is the modification of cabling used by ICT systems. Hence, if the need for cabling can be significantly and cost-effectively reduced or eliminated, then a major barrier to achieving agility will have been overcome. This is one of the promises of wireless technologies in manufacturing.

Background Information

Wireless technologies are increasing used in many ICT systems, but primarily in consumer and commercial end user markets, mostly in office and mobile applications. In both segments wireless technologies are proving to be a growth area, being an important enabler for both mobility and flexibility. The potential of wireless technologies in industrial surroundings such as factories and processing plants has also been recognised, however application in these environments is still in its infancy, with many crucial technological and standardisation challenges remaining to be addressed before significant applications can be implemented.

Wireless technologies for manufacturing and process plants were discussed at a workshop held in Brussels in February 2005[3], reflecting the emerging awareness among researchers, industrial users and industrial automation vendor communities of the importance of this topic. The workshop not only considered the value of the technologies for industrial communications, monitoring, and control, but also as enablers of new capabilities such as factory agility. In addition, the workshop identified the development of wireless technologies as complementary to the development of embedded systems for products and processes, being an important component of systems of cooperating objects[4].

Cooperating objects are an emerging domain in embedded systems, and can be defined as platforms that can *glue* together diverse (physical) objects to enable seamless environments for computing, communication and service delivery. An object could be as small as a networked sensor or as complex as a robot. Wireless sensor networks are seen as a subset of systems of cooperating objects, consisting of a vast number of distributed embedded devices that autonomously coordinate to perform higher-level tasks and to provide a service with very limited resources.

[3] The Agile Wireless Manufacturing Plant, February 2005, http://www.ims-noe.org/FP7.asp
[4] http://www.cordis.lu/ist/embedded/objects.htm

Wireless capabilities have also been identified elsewhere[5] as an important component of embedded miniaturised smart sensor systems. Such systems are seen as a new potentially disruptive technology.

Within FP6 there are a number of funded projects that are addressing the area of embedded systems[6] for advanced control. Topics being addressed include architectures for virtual automation networks (the VAN Integrated Project) and software architectures for linking smart physical objects through wireless communications (the SOCRADES Integrated Project). Proposals for the IST programme in FP7 include embedded systems, computing and control as one of the proposed ICT pillars.

Expenditure on embedded systems research by industry is predicted to increase significantly, in all major geographical regions, over the period up to 2009, representing growing industrial appreciation of the importance and value of embedding intelligence into products and processes. In particular, it is predicted that by 2009, embedded systems will represent around 22 percent of the value of industrial automation products.

Also proposed for the IST programme in FP7 is research in the area of *ICT for manufacturing* as part of the application pole, *ICT supporting business and industry*. Manufacturing is an industry where Europe has strengths in many sectors, and ICT has been identified as an important enabler of improved productivity and competitiveness in manufacturing. Several important ICTs have been identified in this respect, among them wireless communications for manufacturing plants. As considered in the February 2005 workshop, this recognition of the importance of wireless technologies not only encompasses embedded wireless communications at the machine and equipment level, but also the middleware layer, the control systems level, and production planning; all four being identified as key areas requiring RTD activities.

Planned for the period covered by FP7 are Joint Technology Initiatives (JTIs), with a proposal to turn the *Advanced Research and Technology in Embedded Intelligence and Systems* (ARTEMIS) European Technology Platform into a JTI. ARTEMIS seeks to align fragmented R&D efforts through a Strategic Research Agenda (SRA)[7], which may be implemented through the JTI with industry funding, plus a European Community contribution, but organised externally through national contracts.

The ARTEMIS SRA has identified manufacturing and processes industries as one of four strategically significant application contexts, the aim being to achieve efficient flexible manufacturing, in the form of 100 percent available, agile and safe factories. Areas to be addressed include reduced commissioning and ramp-up times, precise in-line process quality control, and safe operation with zero operator error.

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[5] Report on Industry Views Towards Categories of Innovative and Potentially Disruptive Advanced Manufacturing Technologies, April 2005, http://nacfam.org
[6] http://www.cordis.lu/ist/embedded/
[7] http://www.cordis.lu/ist/artemis/background.htm

Agility is also addressed in the *Manufuture* European Technology Platform's draft SRA[8], where the topic of agile manufacturing is seen as key for the future success of European manufacturing industries. Proposed as part of the SRA pillar, *advanced industrial engineering*, is a strategic target of global leadership in delivery of adaptable factories. One of the important enablers for these proposed agile manufacturing plants is the shift from analogue to digital technologies, with wireless components and systems playing a significant role in providing factory reconfiguration capabilities that will enable rapid adaptation to changing conditions in the business environment.

In this context, a further workshop was held in Brussels on 2-3 March 2006[9], to consult with relevant stakeholders concerning the RTD agenda for wireless technologies in manufacturing and to consider policies relating to standardisation and interoperability. This workshop considered both discrete-parts manufacturing and the process industries.

Important Questions Addressed by the Workshop

Workshop participants were asked to address three important questions relevant to the aim of defining future actions in the area of RTD, standardisation and interoperability.

The first of these was to consider and respond to a statement in the draft version of the *Manufuture* SRA:

> "The backbone of knowledge based manufacturing is the information (digital) system. Therefore it is important to develop a kind of a "Windows Platform" for manufacturing in networks and scalable from networks to function elements."

The second question related to standardisation and interoperability policies, in particular, in which areas should Europe promote standards and interoperability objectives? This is a crucial question as the answers could have important implications for such things as avoiding duplication of work, achieving re-use of results across industries, ensuring that multi-vendor solutions are interoperable, and achieving economies of scale through common system components.

The third and final question concerned technological challenges; what are the particular R&D issues to be tackled? This question was driven by the understanding that, wireless technologies, used in harsh industrial environments, will have to satisfy more demanding requirements when compared to the office and home domains. In addition, the large range of applications, including measurement and control, raise a whole set of new issues and problems, as yet unexplored and unresolved.

The workshop split into three parallel working groups to address these questions. The working groups were organised around the following three topics:

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8 http://www.manufuture.org/strategic.html
9 http://www.ims-noe.org/COfIC.asp

- Industrial wireless communication;
- Embedded middleware – implementing a service-oriented architecture;
- Embedded intelligence in collaborative automation systems.

Key Workshop Messages

Key workshop messages emerging from the three working groups were discussed in plenary session. These messages can be grouped under four headings:

- General Objectives;
- Standard Platforms vs. Reference Architectures;
- Standardisation; and
- Research and Development.

General Objectives

The goal of developing and applying wireless communications in industry should not be singly focused on replacing cabling. Wired and wireless system will coexist for the foreseeable future. However, in some circumstances, it may be economically feasible to use wireless technologies to eliminate large capital expenditures on cabling installations, and the associated revenue expenditures on maintenance and repairs, provided that the cost of wireless technologies can be significantly reduced. Also, in certain circumstances, such as clean room environments, wireless communications could provide significant benefits, since there are severe restrictions on introducing more process monitoring and metrology equipment into such surroundings. Moreover, in the process industries the use of wireless technologies may eliminate the tradeoffs that now often occur between the number of sensors used to collect data and the cost and complexity of the associated cabling. Furthermore, collecting more data through wireless sensors could help to improve the quality of empirical models used in process control.

In addition to the above, the main value of wireless technologies is expected to come from two sources. The first is applications where there are significant existing problems, such as measurements where it is difficult to insert measuring devices or to collect the measurement data from sensors, the measurement of rotation being one example.

The second is the use of wireless technologies to enable completely new approaches. There are numerous possibilities. Mobility aspects are one of these and need to be exploited, not just for mobile communications between employees, but also for other tasks. For example, mobility in terms of controlling and monitoring, regardless of distance and place, so as to enable roaming operators to collect data and make adjustments locally. This implies that it should be possible to collect data and transform it into useful information, near to the sensors, using mobile wireless devices. Other examples are:

- Wireless as an enabler for agile factories;

- Wireless connections to enable products to communicate data about their status to the production planning system;
- Wireless used within networks of embedded micro-sensors.

Standard Platforms vs. Reference Architectures

With respect to the question posed concerning the statement extracted from the draft *Manufuture* SRA, the participants considered that platforms were of use to industry. The primary benefit of platforms is that they can enable the adoption of standard components such as middleware, thus avoiding duplication of research and development effort, helping to focus vendors' attention on competing at the application level. However, the development of any platform must take into account differences between sector needs and characteristics, for example, process versus discrete-parts manufacturing. Platform development should also address the issue of scalability, that is to say, capability to handle applications where there are only tens of wireless devices, up to circumstances involving thousands of wireless devices.

Another important dimension of platforms is openness to ensure the interoperability of multi-vendor solutions and tools. Avoiding the domination of a platform by one powerful vendor or user group is also crucial, as is the *de-facto* adoption of a single proprietary approach. A platform needs to be suitable for SME vendors to incorporate their offerings in an easy and cost-effective way. The components of a platform must also be highly integrated; data generated by one component must be useable elsewhere within the platform.

Another important requirement for platforms is that they should facilitate rapid reconfiguration, thus this aspect has to be considered during the development of a platform. It may also be useful to develop ontologies that represent models of product, process and production equipment. Decomposition of processes into elemental constituent parts and the introduction of an abstract layer within the platform, to manage complexly, also need to be considered.

The process by which such a platform should be developed is still an open question but the process must address the needs of all stakeholders. Before establishing a dominating standard platform for the manufacturing market (taking into consideration all the pros and cons of standard platform like the Windows platform for the office market), the design of reference architectures should be taken as an intermediate step to move forward. This reference architecture could be developed bottom-up and should support all major stakeholders. To achieve an agreed reference architecture, the process must seek support of leading industrial players and in addition, must be open and accessible to all stakeholders, including SMEs (see also the section later on National Activities and Infrastructure).

Standardisation

Standardisation is a key issue, as it will contribute towards reducing the cost of equipment and will help to make implementation simpler. The former point is important to enable wide adoption, and the latter point, while of concern to all industrial users, is of particular relevance to SMEs who have limited resources in terms of expertise and time.

There are several areas where standardisation could be considered:

- Interfaces to exchange information;
- Wireless technology fundamentals, especially radio frequency spectrum allocation for industrial automation applications;
- Safety standards to establish safe use and working practices;
- Mobile terminals for industrial applications, especially standard functions and services;
- Performance standards to compare different wireless technologies;
- Automation objects, web services, and model driven architecture for control engineering;

Importantly, standardisation needs to be addressed at an international level given the global nature of modern manufacturing. There is a need to identify and provide a map of current relevant standardisation activities. The possibility of undertaking some standardisation activities within the framework of IMS projects should also be considered. An analysis should be undertaken of the benefit of adapting Standards for the Exchange of Product Data (STEP) (which already have broad acceptance) to the domain of factory communications. Standardisation should also aim to achieve, where feasible, commonality in equipment used in process and discrete-parts manufacturing.

There are also a number of open issues in the area of protocols and frequency bands that need to be resolved.

In relation to protocols, the industrial domain provides a wide range of wireless communication challenges, covering the vertical dimension of communications from the shop-floor up to the business level, as well the horizontal dimension of communications between devices and applications, as well as across firms and industrial sectors. It may therefore be unreasonable to expect one protocol to cover all these needs and requirements and several protocols may be required. The feasibility of adapting or using existing protocols from the office and consumer environments also needs to be investigated, perhaps with specialised protocols developed for specific applications. The use of elements from existing wireless standards might also help the development of industrial protocols by providing stable fundament components.

Whatever in the end is decided upon, it is however fundamentally important that there should be a capability to co-exist with established protocols such as Bluetooth and WLAN, and emerging protocols such as ZigBee, as well as proprietary standards that will enable customised migration and user acceptance in the mid-term.

With respect to frequency bands, there is a need to decide if licence-fee based or licence-free bands should be used. Furthermore, there are many open questions that need to be answered in relation to setting aside dedicated frequencies for industrial wireless applications. It is not clear if the scale of expected industrial use would warrant such an approach, or if wireless equipment manufacturers would find attractive, what could be a niche market. It may be better, in terms of achieving economics of scale for items such as transceivers, to use frequency bands that are presently used for non-industrial applications.

The use of UWB frequencies for industrial purposes could be an option, but for industrial users this may prove to be problematic. First, slow adoption of UWB in Europe may stall the take-up of industrial wireless technologies and hinder the development of innovative products and applications. Second, given the conservatism of industrial users, it is probably not realistic to expect them to adopt what are at the moment still unproven technologies.

Research and Development

Topics that need to be researched to advance the area of industrial wireless systems are wide ranging:

Operating Environment Issues

Safety is deemed to be a critical issue, to ensure that wireless systems do not lead to any unsafe operating conditions, under any circumstances, and to ensure that wireless systems, if they fail, do so in an manner appropriate to the safety requirements of applications. There is also a need to develop a better understanding of radio noise disturbances in industrial environments and the characteristics of noise sources. The sensitivity of plant equipment to wireless signals also needs to be investigated.

Long-life energy supplies (up to 10 years) for wireless devices need to be developed, including energy harvesting approaches, as these are a key enabler for industrial wireless systems, since the cost of replacing batteries every few months would be prohibitive. Related to energy supplies is the area of achieving energy efficiency in applications.

The ability to operate in harsh industrial environments is also an essential requirement and has to be ensured for a wide range of potential operating conditions: dust, gases, moisture, corrosive chemicals, temperature extremes, etc.

Security of wireless industrial systems has to be ensured, without compromising operating characteristics such as real-time capabilities. Issues such as jamming and interference, both intentional and unintentional, need to be resolved.

Until predictability at higher levels of abstraction is achieved, reliability and predictability may be achievable through building redundancy into the wireless networks and moving from a control paradigm based a node-centric architecture, to one based on data-centric routing algorithms.

Deployment Issues

Industrial deployment issues such as design, predictable behaviour and deployment, and maintenance issues, along with the development of a simple plug-and-play approach to the implementation of industrial wireless systems, needs to be addressed. This should consider innovation at component level to achieve fast and easy deployment, enabling the construction of built systems based on standard modules. Zero maintenance of industrial wireless systems is desirable.

Development of experience of using wireless technologies in industrial environments needs to be developed. This should address a wide range of applications, including in-process use, data gathering, resource utilisation monitoring, control, predictive maintenance, factory reconfiguration, and decentralised decision making, with the development of use cases complete with business justifications.

New ways of working enabled by novel mobile wireless devices for monitoring and control need to be investigated, and the associated organisational issues established. Human-machine interface (HMI) requirements for these wireless devices need to be researched and appropriate HMIs developed.

Low cost wireless sensors also need to be developed to enable low cost large-scale implementations.

The development of an independent virtual European industrial laboratory environment to support research and development of industrial wireless systems, along the lines of the *living lab* concept, would be beneficial. The concept of so-called *living labs* was raised as a means of showcasing an advanced level of sophisticated manufacturing technologies and for bringing together different groups like users, customers, system integrators, service providers, equipment vendors, component suppliers and academic researchers. The concept might be particularly useful for involving users in research and development activities, and would also be beneficial for SME vendors to test their new wireless products and enable technology transfer to user SMEs. Such a virtual laboratory should build on national facilities that already exist or are planned, and also link with other facilities that may have relevant resources.

The development of national industrial wireless test and demonstration facilities is at an early stage of development. Therefore, there is an opportunity to co-ordinate the set-up of such national centres, to avoid duplication of efforts and to create a virtual laboratory environment that can provide compressive coverage of industrial sectors and manufacturing environments.

Such as virtual laboratory could also take a role in information dissemination and education.

Applications Capabilities

The development of wireless systems for real-time operation, such as real-time control, and cross layer designs needs to be researched. New communication approaches addressing network, control and communications issues, exploration and development of novel methods and design principles, and new layering approaches, also need to be investigated.

Wireless sensors should be capable of cooperating, that is to say they should talk to each other, provide information validation and enable aggregation by a group of sensors, and perform information routing, all in an energy efficient way.

More effective methods and tools for rapidly gathering data, possibly through the use of model-based approaches, into useful information need to be investigated, along with the methods that will facilitate this at a local level, close to the equipment fitted with wireless devices. Improvement of process models accuracy through the collection of more data, and the transformation of process data into business knowledge should also be addressed.

In the context of discrete-parts manufacturing, similar data collection activities provide a valuable tool for commissioning manufacturing plants, providing a means to help set-up equipment and processes.

Development of applications capabilities should keep humans in the loop, as people are an important feature of knowledge-based approaches to manufacturing.

The development of wireless industrial systems needs to address the integration with wireless technologies attached to or built into products, along with the innovative approaches that this could enable, such as new production planning methods and tools. Collecting product data across the whole lifecycle is also important, as is keeping the customer involved in this process.

Middleware Issues

Predictability of wireless technologies needs to be achieved at higher layers of abstraction. Until this is achieved, one way of providing reliability and predictability, may be to make the middleware capable of undertaking timing and synchronization, whilst at the same time handling resource conflicts and fading links.

Middleware technologies for wireless industrial use need to be developed to take account of collaboration requirements, within the enterprise from shop floor to business levels, across the value chain from suppliers to customers, and across the full lifecycle from design to support and disposal.

Security is also needed in the middleware layer for functions such as the self-discovery of resources, self-reconfiguration, and self-service oriented applications.

Development of ontologies and a generic abstract reference model that can be instantiated in specific applications and sectors also needs to be considered.

Coordination Issues

Given that there is a proposal to address manufacturing within the planned ARTEMIS JTI, there is a need to influence the manufacturing related work that may be undertaken, and to co-ordinate with this initiative.

National Activities and Infrastructure

The workshop identified that there are a number of national activities relevant to industrial wireless systems, including product development activities by small-specialised vendors, national government supported initiatives, and some first use applications by industry. However it seems that there are no national research activities specifically devoted to industrial wireless systems, the tendency being to address this topic on a small scale within the context of a broader range of industrial technologies.

In Germany the SmartFactory[10] technology initiative is one example. It promotes the development, application and dissemination of industrial automation technologies, and includes industrial wireless communications in the range of technologies considered.

In Sweden, the ProcessIT Innovations[11] initiative addresses the area of ICT in process industries, and within this programme wireless devices are being addressed for applications such as mobile communications, mobile working, and in-process non-contact measurement of material properties.

In the UK there is a government-industry funded research programme called Basic Technologies for Industrial Applications[12], that includes wireless technologies as a basic technology. Within this initiative there is one small project, SMARTTAG[13] (More Profitable Business using RFID, Wireless and Related Technologies) that addressed the formation of an industrial network for the oil, wastewater (including brewery), corrosion and construction sectors to investigate the basic applications of RFID, wireless sensor and related technologies.

Proposed Activities to Increase the Visibility of the Topic

Given that the research, development and application of industrial wireless technologies are at a very early stage, there is a need to undertake activities that will help to raise the visibility of the topic. Suggested activities are:

- Use of existing related projects to increase awareness, for example the IMS OOONEIDA[14] CCI, the German SmartFactory initiative, and relevant FP6 projects;
- Use of existing related national programmes to increase awareness, for example Swedish ProcessIT Innovation, UK Basic Technologies for Industrial Applications programme, etc.;
- Actions at IEEE level, including papers for IEEE transactions, input to their Technical Committees, contributions for IEEE conferences;
- Exploitation of company-based channels, for example SAP, ABB, Siemens, Schneider;
- Actions through national professional institutions, such as the IEE;

[10] http://www.smartfactory-kl.de
[11] http://www.processitinnovations.se
[12] http://www.basictechnologies.gov.uk/default.cfm
[13] http://www.basictechnologies.gov.uk/Site/Projects/default.cfm?subcat=SMARTTAG
[14] http://www.oooneida.org/

- Communications to the public and to politicians, for example through newspaper articles.

Conclusions and Recommendations

Significant economic growth potential in manufacturing is related to innovation at product level, but equally at the level of the production technologies that are needed to reach operational excellence and to maximise productivity. ICT is an enabling factor to facilitate process monitoring and control, maintenance and safety services, and scheduling tasks and activities.
The workshop demonstrated that there is increasing industrial interest in wireless industrial systems, both on the part of manufacturing companies and industrial automation system vendors. Whether planning new plants or retrofitting existing ones, highly flexible and highly reconfigurable operational environments are required to benefit from economic growth in emerging markets and to maintain leadership in an increasingly global competitive climate. Wireless control technologies, and the design of service-oriented architectures, were identified by both manufacturers and vendors as building blocks that will enable migration from conventional, hierarchical management and control strategies, to flexible and collaborative automation systems. However, the initial steps that have been taken so far are very small-scale and do not address the wide-ranging research, development and international standardisation work that need to be tackled.

The main conclusions of the workshop in terms of measures that need to be taken within FP7 are:

- A multi-vendor, multi-sector, European level approach to deal with numerous significant pre-competitive research, technology development and standardisation activities is required. Given the numerous areas that need to be tackled, the use of an Integrated Project, supported by some focused STREPS would be appropriate.

- Large-scale industry take-up and investment in infrastructure to demonstrate proof of concept and best practice has been identified as an important issue. Backed by a couple of national initiatives, support for investment in infrastructure trials seems to be gaining momentum. In this context, the idea of establishing a wide agreement on reference architectures should be pursued, and demonstrated and be open for test and exploitation, in one of the trial sites. Furthermore, a leverage effect might be achieved by linking existing and emerging national infrastructure projects, to help accelerate take up of research results, establish an agreement on potential manufacturing reference architectures, streamline standardisation effort, and (in the best case) achieve a *de-facto* standard for a manufacturing development platform. Appropriate instruments for public-funding support of this idea, should therefore be considered.

- In the near term there is a need to undertake preparatory work on standardisation, which will require vendor and industry agreement on standardisation platforms addressing issues such as ICT interfaces, wireless industrial protocols, interoperability at device-level, modular exchange at component level, domain-specific semantics (ontologies) and methodological design frameworks.

- In the area of research, critical issues such as middleware, energy supplies, safety, security, real-time capabilities, robustness, and the integration of wireless devices into factory communication networks and control systems need to be tackled. The capability to integrate factory and product based wireless devices should be ensured.

- In addition, applications and industrial deployment of the technologies also need to be addressed, to provide use cases as proof of concept and a scalable and open modular reference architecture, and also to develop application deployment know-how. In this context the notion of *living labs* could be one way forward to showcase new technologies, for the purpose of demonstrating interoperability and scalability and providing means of technology access, in particular for SMEs.

- All the above work needs to be considered in the context of embedded wireless communications at the machine and equipment level, the middleware layer level, the control systems level, and the production planning level.

- The proposed research challenges will improve production process control and manufacturing automation both in the discrete and the continuous process industries. Wireless technologies will enhance the flexibility, the agility and the networking capability of manufacturing plans, will accelerate production ramp-up, and reduce down times, and therefore lead to reductions in total manufacturing operating costs.

- Given the importance of wireless technologies as one of the enablers for agile manufacturing, in particular factory reconfiguration, this topic could be addressed specifically in the context of joint calls with the NMP programme. The justification for this is that achieving factory reconfiguration requires more than just ICT enablers; there are also process, organisation, design, and implementation issues that need to be considered.

LIST OF PARTICIPANTS

Participant's Last Name	Participant's Name	Organisation	Country
Babikian	Richard	Intel Ireland	IR
Colombo	Armando	SchneiderElectric	F
Delamer	Ivan M.	Tampere University	FIN
Drews	Paul	RWTH Aachen	DE
Eberst	Christof	PROFACTOR Produktionsforschungs GmbH	A
Ferrarini	Luca	Polimi	I
Filos	Erastos	European Commission	0
Fogliazza	Guiseppe	MACHINING CENTERS MANUFACTURING SPA	I
Glinos	Kostas	European Commission	0
Herian	Dietmar	Siemens	DE
Kiritsis	Dimitris	EPFL STI IPR-LICP	CH
Konstantellos	Alkis	European Commission	0
Krambrock	Nikolai	RWTH Aachen	DE
Leblanc	James	Lulea University	SE
Martinez-Lastra	Jose Luis	Tampere University	FI
Oliveira	Alvaro	Alfamicro Lisbon	Pt
Riemenschneider	Rolf	European Commission	0
Starke	Günther	APS	DE
Suominen	Jyrki	European Commission	0
Taisch	Marco	Polimi	I
Zühlke	Detlef	TU Kaiserslautern	DE
Johansson	Anders	Lulea University	S
Rönnbäck	Stefan	Optimation AB Eurocon-Optimation AB	S
Skoglund	Mikael	Royal Institute of Technology (KTH)	S
Hedlund	Bjoern	VDMA	B
Leverano	Alessandro	Centro Ricerche Fiat	I
Jammes	Francois	SchneiderElectric	F

Dirlenbach	Heiko	RWTH Aachen	DE
Leffler	Nils	ABB	CH
Maleysson	Laurent	Coronis Systems	F
Strand	Martin	ABB	S
Klostermeyer	Axel	Siemens Automation & Drives	DE
Valentini	Antonio	O3NEIDA	I
Tokamanis	Christos	European Commission	BE
Zobel	Rosalie	European Commission	BE
Zampollo	Marco	COMAU Robotics	I
Kidd	Paul T.	Cheshire Henbury	U.K.
Sacco	Marco	ITIA-CNR Milano	I

FP7 Workshop
Perspectives of the Agile, Wireless Manufacturing Plant:
Cooperating Objects for Information and Control

02-03 March 2006
Avenue de Beaulieu 33, Ground floor, Room 54
1160 Brussels-Auderghem (near Metro Station « Beaulieu »)

Agenda

Day 1: March, 02 2006

13.30 - 14:00 Registration

14.00 Welcome and FP7 Work Programme Objectives
Rosalie Zobel
Director, Components and Systems, DG INFSO, European Commission

14.20 Wireless Manufacturing: A Perspective from MANUFUTURE
Christos Tokamanis,
Head of Unit Products Processes and Organisation, DG RTD, European Commission

14.40 Perspectives for Embedded Systems in FP7
Kostas Glinos
Head of Unit, Embedded Systems, European Commission

15.00 Keynote: The Industrial Perspectives
Nils Leffler, ABB

15.20 The Agile, Wireless Manufacturing Plant – State of Play
Rolf Riemenschneideroderation
Embedded Systems, European Commission

15.40 Coffee Break

16.00 Splitting into 3 Groups
(Introduction by chairmen/contribution of participants/ incl. Q&A/ discussion)
Wireless Industrial Communications (BU33/054)
Chair: Martin Strand (ABB)
Embedded Middleware – Implementing a service-oriented architecture (BU33/055)
Chair: A. Colombo (Schneider Electric)
Embedded Intelligence in Collaborative (automation) systems (BU31/040)
Chair: Rolf Riemenschneider (European Commission)

17.30 End of Day

19.30 Dinner in the Center of Brussel

Day 2: March, 03 2006

09.00 Wireless Sensors for Manufacturing – A SME's View
Laurent Maleysson, Coronis Systems, F

09.20 A view of the process industry
Richard Babikian, Intel Ireland
ProcessIT – Initiative in Sweden
Anders OE Johansson, CEO ProcessIT Innovations, Lulea University of Technology

10.00 Key Messages of the 3 Workshop Reports
(05 slides/20 minutes each by representative of each workshop team
– incl. Q&A, coffee break)

11.15 Activities in the national context
Moderation: Paul Drews, APS Aachen

11.45 Discussion on future needs, follow-up actions
Moderation: N.N.

12.00 Wrap-up, preparation of Report
Rapporteur: Paul T. Kidd

12.30 Closing
Rolf Riemenschneider