PRODUCTION AUTOMATION & CONTROL NETWORKING INNOVATION IN EUROPE

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Abstract: In October 2004 the European Commission started a Network of Excellence to co-ordinate the Research and development for Production Technology on Europe. One of the four clusters of this Network is dedicated to Control & Automation Technology. This contribution presents the Network with emphasis to this Automation cluster. It describes the composition of the core consortium, the objectives and the activities of the network. The contribution also pictures the benefits of interaction with the network and how this can be achieved. *Copyright © 2005 IFAC.*

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1. INTRODUCTION

Manufacturing is critical to wealth generation, accounting for over 20% of the EU's Gross Domestic Product. To improve EU living standards, a thriving European manufacturing industry is required.

For the industry to prosper in a competitive global market, it must be underpinned by cutting-edge production research. Because of the breadth of the field and the multi-nationalism and multi-culturalism of the EU, production research activities within it have been naturally fragmented (http://prci-sophia.com/etfa2001/; http://smc02.ec-lille.fr/; http://iecon02.us.es/; http://www.icme.unina.it/ http://www.imsforum2004.org/; http://www.enel.ucalgary.ca/INDIN03/; http://www.indin.de/; http://www.mechrob.de/; http://www.ipa.fhg.de/Publikationen/aufsatz2004.php ; http://gerstner.felk.cvut.cz/HoloMAS/2003/; http://mecha.ee.boun.edu.tr/itm/). There is a need to re-organise this research to achieve excellence through greater co-ordination, coherence and synergy.
The Network of Excellence for Innovative Production Machines and Systems (I*PROMS) will address the area of production research in an integrated manner in order to reshape the area and overcome its current fragmentation

I*PROMS was launched under the Framework Program 6 of the European Union (Thematic Objective: New production equipment and technologies, and their incorporation into the factory of the future, http://www.iproms.org).

I*PROMS will develop concepts, tools and techniques enabling the creation and operation of flexible, re-configurable, fault-tolerant and eco- and user-friendly production systems. Using the research results of the network, developers and users of the kind of production systems addressed above will be able to react to changing customer needs, environmental requirements, design inputs, and material / process / labour availability to manufacture high quality, cost-effective products.

2. I*PROMS – MAIN FEATURES

*2.1 I*PROMS´s Vision.*

The knowledge-based "Autonomous Factory" is I*PROMS´s vision (see Fig. 1) for delivering increased competitiveness for manufacturing in 2020.

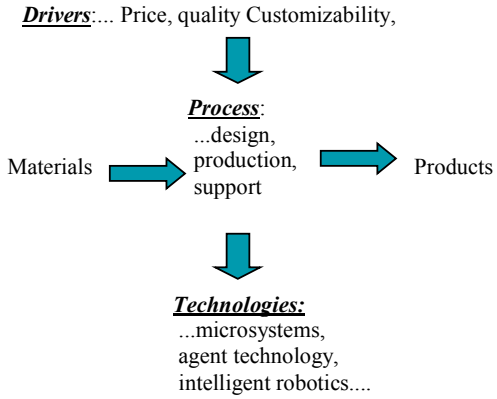

Fig.1. I*PROMS´s Vision

I*PROMS will focus on intelligent and adaptive production machines and systems that meet dynamic business and value drivers through advanced Information and Communication Technology (ICT).

*2.2 Ambition of I*PROMS.*

I*PROMS will be the European Union's authoritative research body for the whole area of Production Machines and Systems. The Network will integrate the activities of all key EU research institutions in the field of production research. These leading institutions possess wide-ranging and complementary human and material resources. This will enable I*PROMS to cover all future research priorities in the field without being prematurely restricted to particular, narrow topics that could lose their significance with time.

*2.3 Objectives of I*PROMS.*

- To create and publish a vision for, and roadmap to, the knowledge-based Autonomous Factory;
- To assemble a critical mass of world-class researchers focused upon jointly generating the innovative design and manufacturing concepts, tools and techniques needed to realise the vision;
- To establish a common research infrastructure to support researchers within the Network;
- To spread excellence to organisations outside the Network;
- To provide EU industry, through research training/ education, with a constant flow of qualified specialists adept at designing, managing and maintaining knowledge-based Autonomous Factories;
- To develop a strategy and mechanisms, including active leveraging of funds, provision of IPR and commercial services, sales and marketing, to sustain Network activities beyond the EC funding period;
- To contribute to social welfare improvement and sustainable growth of the economy in the EU through knowledge-based manufacturing.

I*PROMS will create a vibrant research community focusing on future manufacturing concepts, processes and systems. Initially, I*PROMS will address the six Manufacturing Challenges for 2020, as identified by the National Science Council (see: Visionary Research Challenges for 2020, Committee on Visionary Manufacturing Challenges, Board on Manufacturing and Engineering Design, Commission on Engineering and Technical Systems, National Research Council, National Academy of Sciences 1998), namely, Concurrent Manufacturing, Integration of Human and Technical Resources, Conversion of Information to Knowledge, Environmental Compatibility, Re-configurable Enterprises, and Innovative Manufacturing Processes and Products. Research on those themes will be prosecuted by four tightly orchestrated I*PROMS clusters.

The technologies covered by the clusters are key to attaining the EU´s goal set at the Lisbon Summit in March 2000 "of becoming the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion". (see: http://www.europa.eu.int/comm/lisbon_strategy/index_en.html). They include inter-alia-technologies for: micro-fabrication, rapid manufacturing, new (nano) material processing, re-configurable machines, multi-agent control, intelligent sensing, self-diagnosis, tuning and repair of machines and systems, total life-cycle design, automated innovation and advanced modeling and simulation.

I*PROMS technologies will be developed concurrently with research into new manufacturing management paradigms such as "Fit (Lean and Responsive) Manufacturing", "Holonic Manufacturing" and "Individualised Manufacturing.
Remark: Many of the technologies and paradigms addressed by I*PROMS have been identified as essential to future manufacturing industry in a major recent Foresight report commissioned by the EU on Manufacturing in Europe in 2015-2020 (see The Future of Manufacturing in Europe 2015-2020, Final

Report of the FuTMaN Project, European Commission, March 2003. and http://www.manufuture.org/).

2.4 Excellence and Appropriateness of the Partnership and Consortium Structure

The core partnership comprises 30 partners, which are all of proven excellence and international standing in production engineering and related disciplines.

Their expertise and resources cover all the key technologies and management paradigms to be addressed. They all have a track record of successful international collaboration and networking.

I*PROMS comprises also a large number of associate partners (SMEs, universities, associations, public bodies, publishers), to augment its research capacity and assist with the dissemination of results and spreading of excellence to the research and user communities beyond the Network.

The 30 core partners are grouped into a HUB of four clusters designed to cover the field of Production Research in a holistic, in-depth and integrated manner.

As depicted in Fig. 2, the four clusters are:

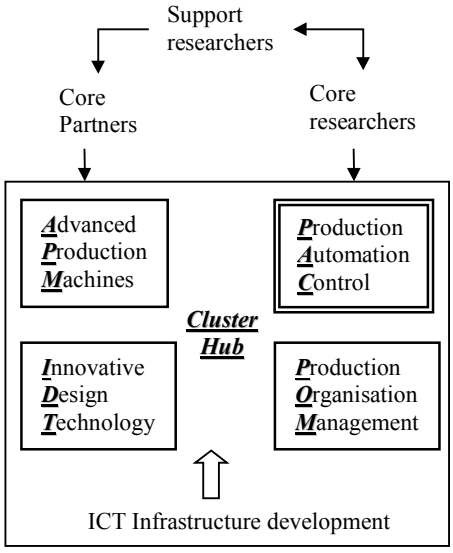

Fig. 2. Cluster HUB of the NoE I*PROMS

Advanced Production Machines (APM) Advanced Production Machines (APM) are the workmen of the factory of the future, whose capabilities are now rapidly expanding in terms of speed, cost, materials, accuracy, part size, and sustainability.

The APM cluster workpackage will integrate and carry out activities which will pave the way for the future joint research that will be necessary for developing and providing the next generation of advanced production machines. A roadmap of recommended research will be prepared and multidisciplinary joint research initiated in order to solve the identified needs and to provide enabling key technologies. This will help industry to produce machines and components for:

- High-speed and responsive manufacturing technology
- Rapid manufacturing technology
- Micro fabrication technology
- Reconfigurable manufacturing technology
- Sustainable manufacturing technology
- Next generation material processing technology

Production Automation and Control (PAC) The Production Automation and Control (PAC) cluster work package will integrate and carry out activities which will pave the way for the future joint research that will be necessary for developing and providing the next generation of production organization and automation and control tools. More information about this cluster can be found in Section 3.

Innovative Design Technology (IDT) The objective of this (IDT) cluster is to link product design with production process design and technology to produce innovative, customizable value-added products with speed and efficiency. The ultimate goal of this network is through collaboration to produce an integrated virtual design and production environment, which enables products to be developed and tested and product knowledge to be stored and transferred to new product development.

The IDT cluster workpackage will integrate and carry out activities which will pave the way for the future joint research that will be necessary for developing and providing the next generation of production organization and management tools. A roadmap of recommended research will be prepared and multidisciplinary joint research initiated in order to solve the identified needs and to provide enabling key technologies. This will help industry to produce tools for:

- Total design technology
- Advanced modeling and simulation technology
- Advanced computer aided manufacture
- Automated innovation and design complexity.
- Knowledge-based design and product knowledge management

Production Organisation and Management (POM). The POM cluster will address all relevant issues that are central to the definition: “The management of operations ranging from concept to disposal within the organization to incorporate the functions of innovation, planning, organizing, scheduling and controlling of production processes and the management of the interface with extended enterprise and other supporting functions is called production management”.

The POM cluster workpackage will integrate and carry out activities which will pave the way for the

future joint research that will be necessary for developing and providing the next generation of production organization and management tools. A roadmap of recommended research will be prepared and multidisciplinary joint research initiated in order to solve the identified needs and to provide enabling key technologies. This will help industry to produce tools for:

- "Fit Manufacturing" paradigm
- "Virtual Enterprise" paradigm
- "Holonic Enterprise" paradigm
- "Individualized Manufacturing" paradigm
- Integration of human and technical resources

Pervasive themes will include wide adoption of ICT, competitiveness, sustainability and the environment.

3. THE CLUSTER PRODUCTION AUTOMATION AND CONTROL (PAC)

*3.1 Cluster PAC – Core members from the I*PROMS Consortia.*

From the 30 core members of I*PROMS listed in Fig. 3, the 22 partners that are working within the cluster Production Automation and Control are dot marked.

The Consortium

I*PROMS comprises 30 core member institutions representing 14 European countries. These institutions are all of national or international standing in the field of Advanced Production Machines and Systems research. They possess extensive and complementary expertise and facilities and are actively involved in basic, strategic or applied research and technology transfer.

	Partner's Name	Country	Activity Type#
●	Profactor	Austria	REC
●	Department of Cybernatics Czech Technical University in Prague	Czech Republic	HES
●	VTT	Finland	REC
●	Centre Technique des Industries Mecaniques (CETIM)	France	REC
	National Engineering School of Tarbes	France	REC
●	INRIA	France	REC
●	Robosoft S.A.	France	IND
●	Schneider Electric GmbH	Germany	IND
●	Fraunhofer Institute of Manufacturing	Germany	REC
●	Fraunhofer Institute for Production Systems and Design Technology(IPK)	Germany	REC
●	Fraunhofer Institute ustrial Engineering (IAO)	Germany	REC
●	Institute of Mechanical Engineering Technical University of Clausthal	Germany	HES
●	Mechanical Engineering and Aeronautics Department Chemical Engineering Department University of Patras	Greece	HES
●	FIDIA S.P.A.	Italy	IND
●	Centro Ricerche Fiat	Italy	REC
●	Department of Materials and Production Engineering University of Naples Federico II	Italy	HES
●	PIAP	Poland	REC
	Centre for Proudction Systems Engineering University of Minho	Portugal	HES
	School of Mechanical and Manufacturing Engineering Dublin City University	Republic of Ireland	HES
●	Fundacion Fatronik	Spain	REC
●	Fundacion Tekniker	Spain	REC
●	TNO Industrial Technology	The Netherlands	REC
	Department of Industrial Engineering Sakarya University	Turkey	HES
●	Manufacturing Engineering Centre Cardiff University	United Kingdom	HES
●	Institute for Manufacturing University of Cambridge	United Kingdom	HES
	Department of Engineering Science University of Oxford	United Kingdom	HES
	International Manufacturing Centre University of Warwick	United Kingdom	HES
●	Department of Mechanical Aerospace and Manufacturing Engineering UMIST	United Kingdom	HES
	Industrial Statistics Research Unit University of Newcastle upon Tyne	United Kingdom	HES

Activity type: HES = Higher Education Institution; REC = Research Centre; IND = Industrial

Fig. 3. The Core Partners of the I*PROMS Cluster PAC

3.2 Cluster PAC – Main Features.

The major research issue identified for this cluster is collaborative agent-based (or holonic) manufacturing automation, and related to that, collaborative automation, self-adaptive control and human-machine interaction.

There is considerable interaction between this cluster and the Advanced Production Machines cluster in making these machines more "intelligent" and between this cluster and the Production Organisation and Management cluster in controlling these machines within the overall Autonomous Factory environment.

It is the combination of these cluster areas that will ultimately provide the overall flexible/reconfigurable Autonomous Factory.

Collaborative Agent-based Manufacturing Automation will provide the necessary collaboration of advanced production machines within the factory. "Agent-based" or "agent-wrapped" machines require two properties, namely, autonomy that is, independent knowledge-based action, and communication, between collaborating agents and between these agents and the general framework in which they act. This framework should, importantly, either be synonymous with the enterprise/manufacturing model or else tightly integrated to it.

Self-adaptive control is related to agent autonomy, but may be more closely distinguished as "autonomicity", that is, self-regulating/managing. It includes both self-adaptation of the machine control function as well as self-adaptation of machine supervision (e.g. self-service and self-tuning of machine components, fault tolerant robots and automatic machinery, autonomous and intelligent monitoring and diagnosis devices).

Human-machine interaction allows human "agents" effectively to integrate and interact with agent wrapped production machines, including advanced multimodal /multimedia and intelligent user-friendly interfaces for production machines.

3.3 Cluster PAC – Objectives.

PAC represents the foremen of the factory of the future, responsible for overseeing the machines (APM Cluster), and for communicating between machines and management (POM Cluster).

As one of the main tasks to be performed in the cluster, a roadmap of recommended research will be prepared and multidisciplinary joint research initiated in order to solve the identified needs and to provide enabling key technologies. This will help industry to

produce tools for each of the 5 technologies areas that the cluster will address:

- Multi-agent control technology
- Intelligent sensor technology
- Self-diagnostic, tuning and repair technology
- Human-machine interaction
- Reconfigurable manufacturing control

Activities in these research areas cover at least the following objectives:

- To define a comprehensive taxonomy for each PAC research area.
- To compile a comprehensive review of the state-of-the-art in each research area including research activities as well as industrial applications and best practices.
- To identify the key enabling features for each research area:
  - Control needs and methods and tools for autonomy and communication for Multi-agent control technology
  - Needs and applications, and the enabling components, tools, and technologies for Intelligent sensor technology
  - Needs and applications, and the enabling components, tools, methods, and technologies for Self-diagnostic, tuning and repair technology
  - Needs and benefits, and the enabling components, tools, methods, and technologies for effective Human-machine interaction
  - Requirements, and the enabling components, tools, methods, and technologies for Reconfigurable manufacturing control
- To create a roadmap for research into the five technology areas.
- To make recommendations for research in these areas, to bring together researchers and industry, and to produce high-quality proposals for IPs, addressing key areas of the roadmap.
- To provide measures for a technology-oriented benchmarking of new and innovative collaborative manufacturing systems to enable researchers as well as end-users to determine the innovative potential, estimation of benefit and economical impact of new technologies.
- To initiate joint research into:
  - Development of a common set of methodologies and tools which will give benefit to all partners in the cluster (e.g. for modelling of taxonomies, road-mapping and benchmarking)
  - Control needs and methods and tools for autonomy and communication for Multi-agent control technology
  - Needs and applications, and the enabling components, tools, and technologies for Intelligent sensor technology
  - Needs and applications, and the enabling components, tools, methods, and technologies for Self-diagnostic, tuning and repair technology
  - Needs and benefits, and the enabling components, tools, methods, and technologies for effective Human-machine interaction
  - Requirements, and the enabling components, tools, methods, and technologies for Reconfigurable manufacturing control

In addition to these research activities, the PAC cluster will identify best practice experience, which is not only valuable for the PAC cluster itself, but also for researchers involved in other clusters and beyond the I*PROMS network.

The PAC cluster will spread the experience and knowledge gained, e.g. by contribution to the cross-thematic integrating and spreading of excellence activities of the whole network. Furthermore, methods, techniques, and results from other clusters will be discussed, evaluated, and integrated into the research process of the PAC cluster so far as they will be applicable to APM and will add value to the cluster.

3.4 Cluster PAC – Research Areas. Description of planned tasks

The work of the PAC cluster will focus on the following set of tasks within each of the research/technology areas:

Multi-agent control technology Multi-agent technology is inherently simple but robust and capable of handling high degrees of complexity. Its adoption will make possible the sustainable control of the complex distributed systems forming an Autonomous Factory.

The task will identify the needs for agent technology for control and collaboration of production machines and the enabling methods and tools for autonomy and communication required bringing this about.
The task will identify the needs and applications for intelligent sensors, and the enabling components, tools, and technologies required for their incorporation within knowledge-based production machines.

Self-diagnostic, tuning and repair technology This will contribute to the ability of the Autonomous Factory to operate safely and reliably for sustained periods without human operators. It includes both self-adaptation of the machine control function as well as self-adaptation of machine supervision (e.g. self-service and self-tuning of machine components, fault tolerant robots and automatic machinery, autonomous and intelligent monitoring and diagnosis

devices).

The task will identify the needs and applications for self-diagnosis, self-tuning and self-repair, and the enabling components, tools, methods, and technologies required for their effective use with knowledge-based production machines.

Human-machine interaction This allows human "agents" effectively to integrate and interact with agent-wrapped production machines, including advanced multimodal/multimedia and intelligent user-friendly interfaces for production machines.

The task will identify the needs and benefits for effective human-machine interaction, and the enabling components, tools, methods, and technologies required for their implementation within knowledge-based production machines.

Reconfigurable manufacturing control This refers to the automated reconfiguration and control of the layout and interconnection of production machines to meet, and optimise their capability for, a particular product production requirement.

The task will identify the needs for reconfigurable manufacturing control, and the enabling components, tools, methods, and technologies required for its incorporation within the Autonomous Factory of the future.

Intelligent sensor technology Intelligent sensors, which will have embedded processing abilities and will make use of micro-systems technology, will be the quintessential components of the knowledge-based machines populating an Autonomous Factory. They will enable those machines to gain information about their own states and the state of their environment and optimally adapt their parameters to achieve sustainable, quality, knowledge-based operation.

Remark: A detailed roadmap showing the program of research required to realise these research areas and generate high-quality R&D project proposals for large-scale Integrated Projects in key areas of the roadmap will be produced. The research areas will also start joint research addressing the first steps on the roadmap.

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