Roadmap on Sustainable Manufacturing, Energy Efficient Manufacturing and Key Technologies

15 February 2010

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The views expressed in this publication are the sole responsibility of the author and do not necessarily reflect the views of the companies listed in this document.

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1. Introduction

The IMS2020 project developed three roadmaps:

- Roadmap on Sustainable Manufacturing, Energy Efficient Manufacturing and Key Technologies (this document);
- Roadmap on Standardization;
- Roadmap on Innovation, Competence Development and Education.

For any further information please and to find the other documents on the IMS2020 project website: www.ims2020.net

The roadmaps developed in the IMS2020 project focus upon the identification of relevant manufacturing research topics and supporting actions which need to be fostered through international cooperation between 2011 and 2013. These are critical research topics and actions which, when implemented, will allow the achievement of the defined IMS2020 Vision and thus the shaping of Manufacturing systems by the year 2020 and beyond.

The roadmaps depicted in this report depart from the implementation of the identified research topics and supporting actions between 2011 and 2013, and show the possible impacts or benefits that these could deliver in a timeline towards the IMS2020 Vision.

2. The IMS2020 Vision

The IMS2020 Vision shows a realistic and desirable future for manufacturing which can be achieved if the identified research topics and their supporting actions are put in place through international collaboration. The detailed vision can be found in the deliverable D2.2 of the IMS2020 project, and its main elements can be summarised as follows:

1. *Rapid and adaptive user-centred manufacturing which leads to customised and 'eternal' life cycle solutions.*
   Solutions (products + services + processes) are designed and managed across their life cycles based on the 'eternal' life cycle approach, which means that they generate no waste and that every material or resource is continuously transformed, and is geared by renewable and alternative energy sources. Solutions are co-created and customised to individuals who participate in the process from the identification of specific needs towards the design, production, delivery and disposal (reuse or recycle) of solutions and materials used. Business value becomes a balance of economic, social, environmental, spatial, cultural and political capital, which is enabled through stakeholder engagement (co-creation and open innovation).
2. *Highly flexible and self-organising value chains which enable for different ways of organising production systems, including related infrastructures, and reduces the time between engaging with end users and delivering a solution.*

Value chain networks created as partnerships and built according to specific needs, solutions and actors. Partnerships and a balance between cooperation and competition are the soft rules for all relationships, allowing value chain networks to self-organise and thus firms to effectively and transparently cooperate and to trust partners, while maintaining competitive advantages related to core competences. Value chains are driven by sustainability and new technologies which allow for information sharing and tractability, reuse/recycle through assembly and disassembly, and sustainable end of life (i.e. biodegradable or edible materials). Standards shifts towards sustainable solutions and processes of user engagement, which include technologies which speed the process of identifying a particular need and the rapid manufacturing of solutions.

3. *Sustainable manufacturing possible due to cultural change of individuals and corporations supported by the enforcement of rules and a proper regulatory framework co-designed between governments, industries and societies.*
   Shift in societies' values and behaviours from current individual consumers towards collective and sustainability values, with the single need being only met when in alignment with global values such as human rights. Sustainability policies and related regulations, which comprise an alignment between different policy realms, are globally aligned and enforced by supra-national institutions, which equally represent all world nations and support a shift towards participatory governance and decision making approaches. Multi-layer bottom-up and long term decision making processes are established across all layers of society. This is the backbone for greater inclusion, reduction of development gap between rich and poor nations, and sustainable manufacturing. Collaboration between governments, industries and societies, enabled by IT (Web 2.0) and accessible education to all, allows for citizens' awareness raising and engagement in decision making processes and co-design of global regulatory framework that is enforced by supra-national institutions.

3. Action Roadmaps

Within the current global manufacturing context the transformation process - that require technological innovation as core aspect - is influenced by other factors such as economic, social and environmental that refer to sustainability perspective.
The IMS2020 research actions, which cluster research topics, frame the future technology development within three important aspects of manufacturing:

- Economy with market and consumers’ implications
- Environment with environmental issues
- Society with political and ethical implications.

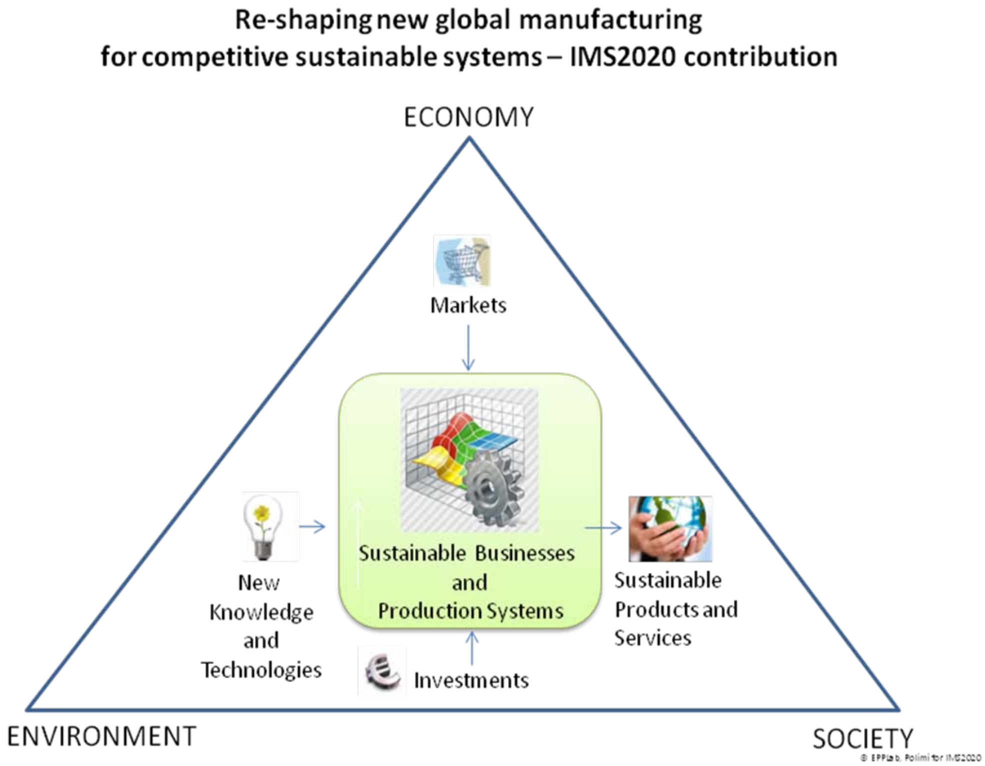


Figure 1: Sustainability and Research Model

Markets act as a control. Co-investments represent the constraints of the transformation process such as energy consumption from Environment perspective and jobs and social acceptance from the Society perspective. In this triangle model, IMS2020 Research Topics represent the new knowledge that may turn into new products and processes in the improvement of existing products and processes for new global industrial manufacturing.

In the IMS2020 roadmapping process, research topics have been elaborated and prioritised to focus fields to investigate or improve with technological development in the short term.

In the mid term, research topics are grouped into research actions that should make an expected impact on three aspects of sustainability (Economy, Environment and Society).

In the figure below is reported the evolution path that from research topics supports the achievement of specific visions and objectives to go towards the IMS2020 vision that represent the final aim of new global manufacturing system.

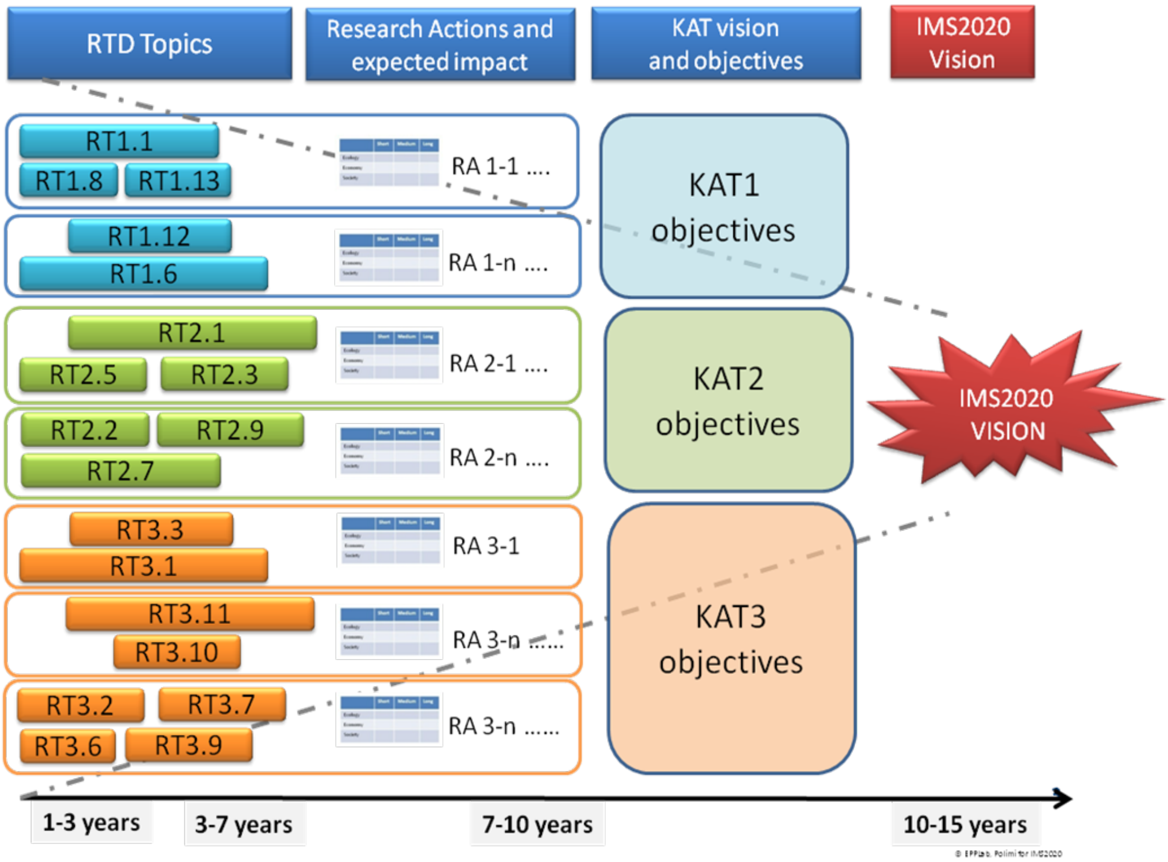


Figure 2: Research Topics and Research Actions toward the IMS2020 Vision

Following this point of view, the different structures have a specific role:

- The Research Topics are the *bricks*, "short" term (starting in 1-3 years, to be concluded in 3-7 years), focused actions to investigate or improve some research aspects;
- The Research Actions are middle term (7-10 years), wider, less focused. In a near future new RTs can be added to the research actions;
- The KATs contains specification of the vision objectives; long term, wide, strategic objectives to achieve the vision goals;
- The vision is the final aim, the wide, long term (10-15 years) and nice picture that provides in simple, strategic terms why all the efforts from the RTs on have to be done.

The Research Actions have been assessed through an Impact Matrix, which measures the impact and estimates the influence of the co-investment in technological development on multidimensional perspectives. The Impact Matrix, filled with expectations of all the stakeholders, sustains the validation process and facilitates the governance of the roadmap.
Finally, the Research Actions have been also distributed according to a time planning for implementation (paragraph 7 List and Timeline of the RTs. at page 44).

	Short	Medium	Long
Environment	++	++	++++
Economy	+	++	+++
Society	+	++	++++

Table 1 Impact of the Research Action.

4. Sustainable Manufacturing, Products and Services.

Sustainable manufacturing is ...
…The vision of a production system, in which production and consumption support the quality of individual and social life, in ways that are economically successful while respecting environmental limits. Knowledge and technology, capital, resources and needs are harnessed and governed so people can live better lives while consuming less material resources and energy [Geyer 2003].

And is framed into…
…Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs [UN 1987].

This vision of sustainable development and sustainable manufacturing is, nowadays, after years of pure speculations, growing into importance. Concrete application of sustainability issues are ongoing, while the market and the consumers are more and more asking and taking care of eco and sustainable issues. At the same time, the regulation work done in these years is being applied and is under continuous development to fit the growing requests and requirements for sustainable measure and rating, which is start being a competitive advantage.
Moreover, with the increase of price of resources and energy, it's a key aspect manage correctly their shortage.
All these issues are making sustainability a key aspect to be taken into consideration in business, business models and technological developments.

The sustainable manufacturing vision, is still far to be achieved, but has to be the basis of future researches and developments. Moreover, due to globalization, the sustainability issues have to be analyzed and developed not only at national or regional level, but guidelines and regulations have to be done at worldwide level.
For this reason, within the IMS2020 roadmap, sustainability has a great role, aiming at improving the sustainability of the technologies, the products and production systems as well as the businesses behind them.
According to this vision and this focus, the main areas of research and action identified are:

- Scarce Resources Management
- Technologies for Sustainability
- Sustainable Lifecycle of products and production systems
- Sustainable Product and Production

- Sustainable Businesses

The relevance of these areas, as well as the topics within them, defined through a worldwide industrial survey (paragraph 10.5 Second step of the survey 58), are shown in the following figures.

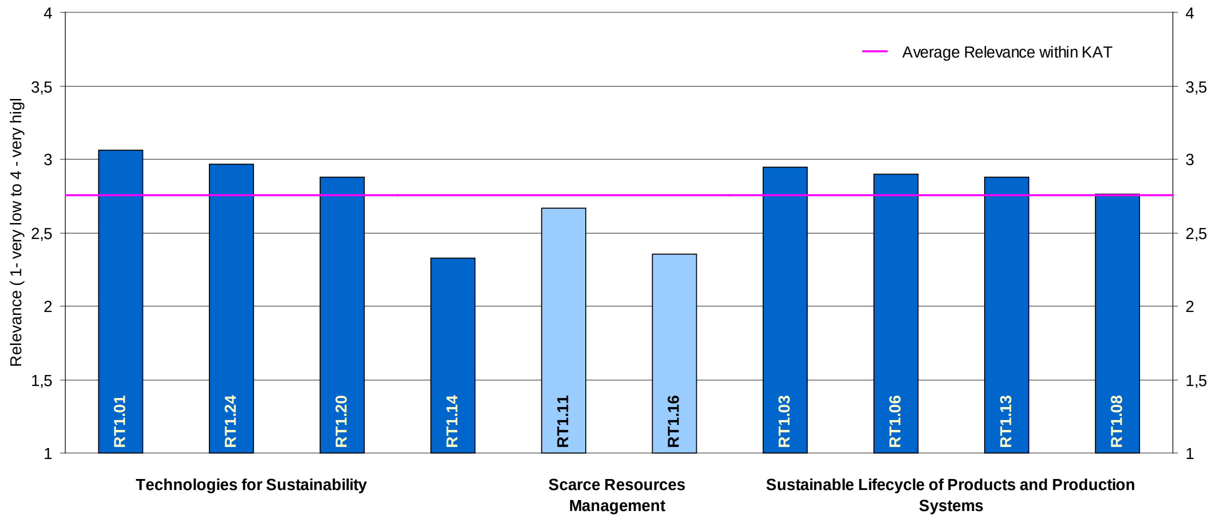


Figure 3: Overall relevance of the Research Topics

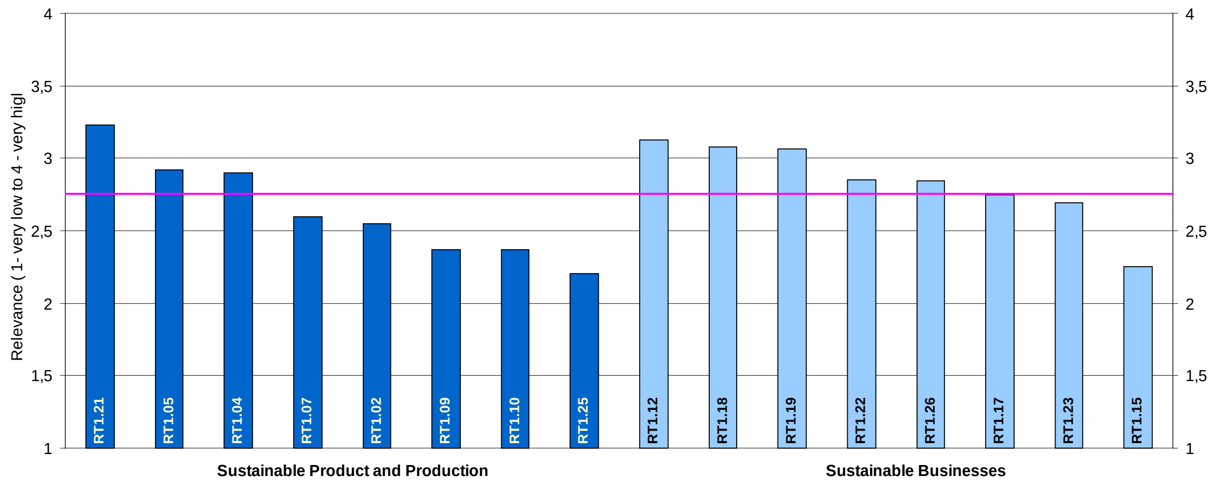


Figure 4: Overall relevance of the Research Topics (Continuation)

4.1 Technologies for Sustainability

The overall goal of sustainable manufacturing is to obtain a holistic view of product cycles in the manufacturing industry and optimise the life-cycle of manufacturing systems, products and services. Methodologies and tools to support the manufacturing of products and production need to be increasingly life-cycle and service oriented, in addition to the requirements for quality, cost-effectiveness, safety and cleanliness.

The picture below illustrates the technical, economic, ecological and social implications of a sustainable product/process/service system.

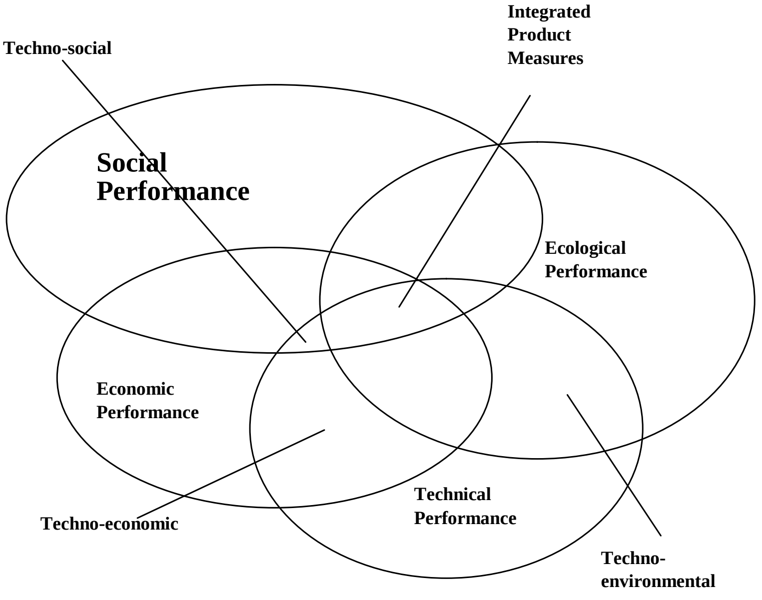


Figure 5: social implications of a sustainable product/process/service system.

With the sustainability vision in mind, technologies need to be developed that enable, support and improve the economic, ecological and social performance of product/process/service systems.

	Short	Medium	Long
Environment	++	+ +	++++
Economy	+	++	+++
Society	+	+ +	++++

Table 2 Impact of the Research Action.

Topics within the Research Action:

- **RT1.01 Quality Embedded Manufacturing**

In modern factories, smart products and machines (equipped with embedded smart devices) can be wirelessly networked and remotely monitored in a real-time way under intelligent control systems. As a result, we can do real-time data gathering; remote monitoring and analyzing of all manufacturing operations to control the quality of manufacturing, predict exceptional cases of manufacturing systems and taking appropriate actions through decision making. This provides a new environment for enhancing quality management in manufacturing.

- **RT1.14 Additive forming processes for manufacturing**
Traditional manufacturing processes are inefficient from the sustainability point of view. Additive Forming Technologies till now have been used mainly for rapid prototyping. Recently new developments start allowing metal additive forming, opening the doors to additive manufacturing of products components. The research will focus on advancing the state of the art of these technologies, understanding how can be used in manufacturing environments to improve both environmental impact and profitability.

- **RT1.20 Sustainable Data Management**
Nowadays enterprises fight the problem of inconsistent and redundant data. Although knowing about the negative impacts they are not able to avoid the appearance of these challenging effects. A sustainable management concept for data and specifying attributes is needed.

- **RT1.24 Integrative Logistics Tools for Supply Chain Improvement**
Local optimizations in the supply chain often lead to inefficiencies at other places. Therefore, tools to cooperate within a supply chain, to harmonize the logistics and improve the overall performance have to be found, implemented, and summarized in a tool box.

4.2 Scarce Resources Management

Manufacturing is strictly dependent on continuous flows of materials and energy. Global consumption of engineering materials (i.e. hydrocarbon fuels; metals and polymers) amounts actually to 10 billion tonnes per year. Hydrocarbon fuels (such as oil and coal) accounts for a colossal 9 billion tonnes per years. Today they are used as the principal source of energy; in fact non-renewable carbon based fuels oil, gas and coal account for 86% of the total world energy consumption. Nevertheless those materials are not infinite. Enterprises aims not only at surviving, but also at growing on the market; the population and its consumptions are growing as well as, but that means evidently a further growth of consumption of energy and materials. This situation requires a new way of thinking: see the end of the “first life” of products not as a problem but as a resource.
Today a lot of reusing technologies have been investigated but there is a strong need of a reference model for material reuse optimization.
Recycling is the second feasible options: waste materials should return in supply chain and can be used as raw materials, source of energy or to replace no renewable natural resources (minerals and fossil fuels).
The following table shows the impact of this research action.

	Short	Medium	Long
Environment	++	+ ++	++++

Economy	+	++	+++
Society			+

Table 3 Impact of the Research Action.

The following research topics address these issues and aim at providing solutions by research and development:

- **RT1.11 Material Re-use Optimization.**
  The aim of this research topic is to develop methodologies and tools to improve materials reuse after products' disposal. The research should include self disassembly technologies, de-manufacture methods, technologies for composite materials, IT tools, methods and best practices to be used by large companies as well as SMEs.

- **RT1.16 Resource Recovery from Alternative Fuels and Row Materials.**
  Due to increased utilization of waste materials to substitute either conventional fuels or raw materials in energy intensive industries, the recovery of trace elements contained in such material streams will become a crucial part of future manufacturing processes. Research should aim for technological solutions able to recover such trace elements in an ecological and economical way.

4.3 Sustainable Lifecycle of products and production systems

Sustainability of manufacturing is more and more affected by lifecycle considerations (Design, Production, Use, Retirement and EOL of products).
Sustainable manufacturing is not only "Green Machining" or "Environmental Benign Manufacturing". Manufacturing must be sustainable not only in terms of sustaining a certain level of environmental parameters, but it must be also sustainable in terms of Performance and Quality of both products (including services) and processes, and, Safety of people (workers and other people affected in one or another way by manufacturing process or facilities and their products) but also of the related facilities and infrastructure. Maintenance of manufacturing facilities is important to sustain (i) the quality of processes and (ii) safety.

	Short	Medium	Long
Environment	++	+ +	++++

Economy	+	++	+++
Society	+	+ +	++++

Table 4 Impact of the Research Action.

- **RT1.03 Real-time Life Cycle Assessment**

The aim is to develop a methodology and a set of tools to allow a precise esteem of the whole lifecycle impact (LCA) and costs of a product (LCC) to be used real-time by designers during the design process. This tool will use lifecycle data information from previous product and esteems to do a precise evaluation of the full lifecycle impact of a new product during its development as well as its full lifecycle cost.

- **RT1.06 Cost Based Product Lifecycle Management (PLM)**

Cost is the basic criteria for the product related decision making; manufacturers try to reduce the production cost, customers want to get a product in low cost, used products are differently handled depending on its estimated cost. But each participant in the product life cycle does not consider the cost from the global perspective but only from the local perspective. Hence an integrated cost management over the whole product life cycle would be beneficial for the products' ultimate value maximization.

- **RT1.13 Maintenance Concept for Sustainability**

Longer machine life cycles and higher equipment performance in respect to resource consumption, energy consumption and availability could be achieved through effective and efficient maintenance, making this topic an important issue for sustainability. New maintenance concepts should improve the level of sustainability in manufacturing through innovative and predictive measures. Therefore, new evaluation concepts integrating sustainability related aspects (e.g. Total Cost of Ownership (TCO) calculations, energy efficiency) into maintenance management need to be designed and implemented.

- **RT1.08 Predictive maintenance**

Traditionally, PLM has been based on integration of a number of centralised ICT tools (CAD, ERP, PDM, ...) predominately operated and used by manufacturers and suppliers, and hence impossible to have meaningful input by product users. With the development of distributed Closed-Loop PLM based on Embedded Information Devices that facilitates users to provide detailed and valuable information about the use stage of product, it is expected that distributed knowledge with an extended value chain demand including users/operators will be generated and used to support predictive maintenance applications for the optimal operation of an asset through its lifecycle.

4.4 Sustainable Product and Production

A sustainable product and production system will contribute towards the modernisation of industry by improving the quality of product information and ease of access to information at the design, production, utilization and end of life stages.
Such a system will make possible to achieve a less resource intensive society and a more competitive industry because:

- Material re-cycling can be significantly improved when products "know" themselves what material they contain, who manufactured them and other knowledge that facilitates material re-use.
- More knowledge-intensive products make it possible to optimise utilisation of resources (especially energy) during the product lifecycle.
- Improved product traceability, which is important for discovering manufacturing errors and other quality-related issues, which helps increasing competitivity.
- Traceability in logistics makes it possible to optimise stock utilisation, thus reducing material waste and transport costs.

	Short	Medium	Long
Environment	++	+ +	++++
Economy	+	++	+++
Society	+	+ +	++++

Table 5 Impact of the Research Action.

- **RT1.02 Green Controller for Machining**

Machine tools are considered as the "mothers" of all production systems in the sense that they are the fundamental production systems that substantially contribute to the competiveness and high employment levels of the European manufacturing industry. To maintain and further improve this position the European machining industry needs to be proactive and design and manufacture machine tools that respect higher levels of sustainability. The development of green controller for machining will be an important backbone of this proposed development. The development of such a controller will require a holistic understanding of the physics of the machining processes, the corresponding environmental impacts and their monitoring and control.

- **RT1.04 Sustainability Metrics**

The aim is to develop a scorecard for processes and a comparable "sustainability index" (Green/Sustainable Labelling) for products. The scorecard and the index have to take in account all sustainability pillars (environment, society, …) all the lifecycle phases, and information about the company and its supply chain. The scorecard will be used by decision makers to select best sustainable solutions for the companies, while the index will allow customers to understand the real impact of a product and, if they are willing, to choose competently the most sustainable product.

- **RT1.05 Sustainability workshops**

Deliver industrial driven workshops to exchange best practices and ideas on sustainability between industries and research. Some workshops have to be focused on SMEs.

- **RT1.09 Sustainable Packaging**

Packaging (primary, secondary and transit) forms an important part of wastes for both industrial and consumer goods. For this reason it is important to reduce its impact developing re-usable, biodegradable, environmental friendly or even edible packaging. The development of these issues has to take in account existing standards and regulations, finding optimizations for packaging sustainability (both ecological aspects and business aspects).

- **RT1.10 Optimization of Electronic Sustainability**

Electronic products (such as computers, IT infrastructures, TVs, etc.) could have a longer working life. Usually they are prematurely trashed because of obsolescence, not failures. Moreover these products' disposal has a high environmental impact because of the contained materials. Therefore, to reduce their impact, it is needed to develop a lifecycle comprehensive methodology to optimize the life usage of the products (re-use) as well as their disposal impact, using advanced identification (RFTags) and recycling techniques.

- **RT1.11 Materials re-use optimization**

The aim of this research topic is to develop methodologies and tools to improve materials reuse after products' disposal. The research should include self disassembly technologies, de-manufacture methods, technologies for composite materials, IT tools, methods and best practices to be used by large companies as well as SMEs.

- **RT1.21 Sustainable Supply Chain Design**

Nowadays more and more companies relocate production sites back to their original location. The reason for the failure of many outsourcing investments is the disregard of facts like skills of the workforce, transportation time and costs as well as ecological issues. Thus the development of a holistic model which is taking all relevant facts into account is necessary to enable sustainable location decisions.

- **RT 1.25 Management of hazardous substances in manufacturing**

Adequate management of hazardous substances is needed to reduce the impact of industry activity on the environment and human health and safety. Research focuses on the development of production methods, ICT solutions and recuperation technologies that reduce use and generation of hazardous substances as well as guarantee a safe management of them.

- **RT1.07 EOL management supporting technologies**

Remanufacturing is becoming more important as many countries are tightening environmental regulations or legislations in economic activities. The arrival qualities of used products are different and they even change during their remanufacturing processes. Hence, individual handling of used products depending on their dynamic quality can enhance the whole remanufacturing system performance. Optimisation of remanufacturing processes will lead to higher efficiency of remanufacturing systems that will allow for the cost effective re-use of remanufactured components while satisfying required quality specifications at the same time. This will contribute in a significant manner in the optimisation of resources usage which is one of the main objectives of sustainable manufacturing.

4.5 Sustainable Businesses

Nowadays sustainability is a challenging key business imperative, that calls for a new paradigm of thinking and acting.
Sustainability is a complex issue to manage due to the holistic nature of sustainability concept that embeds environmental, social and business aspects that are not independent of one other, but instead intertwine in tradeoffs. Enterprises need to manage all these conflicting aspects of sustainability in a integrate manner, focusing not only on environmental or social performances but also on sustainability of business: a shift to sustainability will only occur if it will not be costly and disadvantageous, but sound and attractive from economical point of view. There is a need to reach the so-called triple bottom line objectives: profitable growth, environmental friendliness, social responsibility. To achieve this aim enterprises, especially in SME sector, need to develop:

- business model that mediate between improving environmental performances and business competitiveness;
- methodologies and tools that support managers in decision making and in innovation process with the aim to exploit enterprise potential for sustainability;
- new approaches, workplaces, working methodologies or special training for disabled and aging people.

Moreover, two aspects are changing and focusing the future business arena:
First of all globalized market and networked supply chain require to act not only at enterprise level but also at value chain level in order to guarantee the sustainability of the business. A key feature of present production networks is the idea that supply chains compete, not single companies.
Moreover today customers ask not only for products but also for complementary services. Consequently producers have to advance to solutions provider by integrating products and services into a high value offering.
These two points, at value chain level, require to optimize information flows and facilitate communication and interaction among all actors not only of the whole chain, but also including service providers and customers. To achieve this vision, globalized supply chains will need new methodologies and tools for support synchronized decisions across and beyond the supply chain, aiming at improve their sustainable (both economical and environmental) performances.
The expected impact of this Research Action is shown in the following table.

	Short	Medium	Long
Environment	++	+ +	++++
Economy	+	++	+++
Society	+	+ +	++++

Table 6 Impact of the Research Action.

The following research topics address in-depth these issues and aim for providing solutions by research and development:

- **RT1.12 Sustainable SMEs.**
  SMEs impact is around 70% of the whole manufacturing. The aim of this research is to develop proper methodologies and business models to increase SMEs sustainability, minimizing their inefficiencies and finding a way to make sustainability a value, not a cost. The research will take in account many possibilities as, for example, the use of process modelling languages, standardization, data and procedures integration, new business and evaluation methods development.

- **RT1.17 Exploiting Disruptive Innovation for sustainability**
  Manufacturing companies need to change their approach to innovation if they want to face the current turbulent market. When developing new solutions companies need to take into account sustainability issues. The aim of this research is to develop methodologies and tools to manage and run simultaneously incremental and disruptive innovation, to exploit their potential for sustainability.

- **RT1.18 Integrated Service Supplier Development**
  Today suppliers have to provide both physical products as well as complementary services in order to meet the customer demands. Therefore, it is reasonable to build up networks in which producers and service suppliers work together on the configuration of product-service-systems. In order to realize these networks companies need standardized methods and tools for the definition of the relevant interfaces as a common basis for an integrative development process of products and services.

- **RT1.19 Product-Service Engineering**
  Due to differentiation needs, companies face tremendous challenges to develop customer solutions as a combination of products and services. The successful application of integrated product and service engineering as a general framework is needed. A set of methodologies, tools, business models and standards for products and services, their interfaces and the underlying processes need to be developed.

- **RT1.22 Alignment of IT and business strategies**

This research topic addresses the lack of knowledge regarding the ability to measure the benefits of IT as an indirect department. How to set up controlling and measurement standards to align IT activities to strategic company goals is the core question to be answered.

- **RT1.23 Multi-dimensional inventory management**
  Companies constantly reduce their depth of value creation leading to inherent but inefficient and ineffective increase of stock echelons in the supply chain.To overcome this, it is necessary to expand the perspective of current supply chain management to a multi-tier view by utilizing higher information flows in future. New multi-stage models for supply chain configuration defining stock keeping echelons and order penetration points to optimize supply chain inventory levels are undisputed required.

- **RT 1.26 Lean Management for Service Industries**
  Whereas the business world is constantly changing from a manufacturing into a service dominated world, service management still suffers from significant drawbacks in approaches for an efficient and effective service production. Lean management has considerable changed manufacturing industries and seems to be a promising approach for service industries too. Therefore implementation approaches as well as service-oriented lean management methodologies and tools have to be developed**.**

- **RT1.15 New workplaces for Aging and Disabled Workers**
  In the aging society also workers in manufacturing companies are affected. Moreover disabled people' integration is starting to be an important issue. Considering these social aspects companies have to renew the work processes. For this reason new approaches have to be developed using new tools (design for all), workplaces, working methodologies or special training.

5. Energy Efficient Manufacturing

Manufacturing is playing a core role when it comes to green house gases (GHG) and final energy consumption. With 33% of final energy consumption and 38% of direct and indirect CO2 emissions (IEA 2008), manufacturing industry has the biggest share in both.
From the companies' point of view the importance of energy efficient manufacturing has various reasons, for example customers changing their purchasing behaviour with regard to "green" products and services, rising energy prices, or emerging of new environmental regulations. Using the available energy more efficiently is a way to meet ever-rising energy needs and secure energy supplies.
The IMS2020 Key Area "Energy Efficient Manufacturing" aims for reducing the scarce resource depletion as well as the carbon footprint by considering innovative methods and technologies. Products and processes are no longer just subject to cost and quality. According to this vision there are four major areas for research and action.

- Energy Sources for Factories
- Efficient Production Processes
- Energy Utilization in Collaborative Frameworks
- Management and Control of Energy Consumption

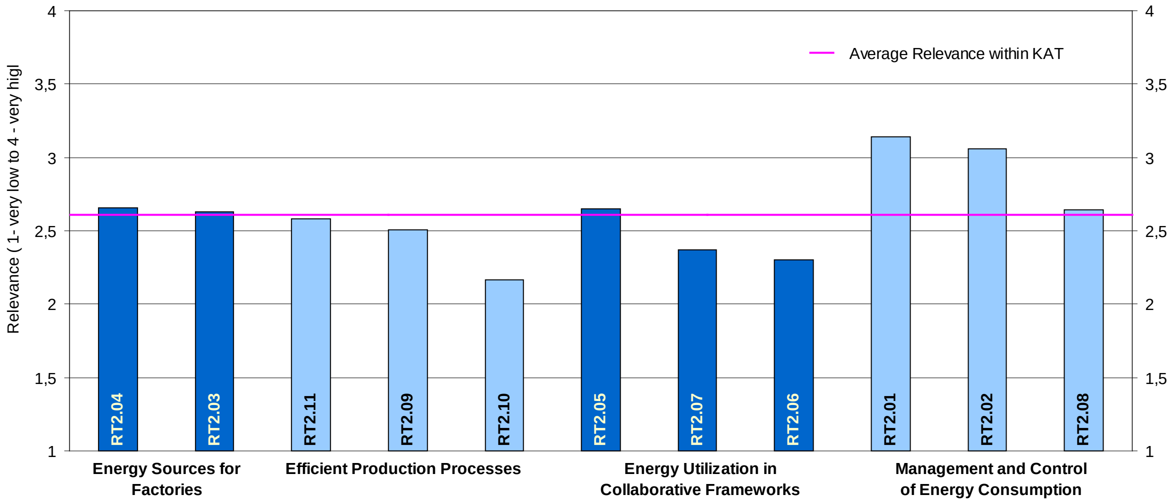


Figure 6: Overall relevance of the Research Topics (2)

5.1 Energy Sources for Factories

Rising energy prices, risk of unavailability, but also the environmental awareness of customers make companies to re-evaluate their energy sourcing strategy. New strategies may include becoming independent from external power supplies on the bigger scale, but also using smaller scale energy potentials to power devices as sensors and controllers.
Today, companies receive their electricity from external and centralized energy suppliers, who produce electrical energy in power plants to distribute the energy to their customers. This bears two problems regarding energy efficiency. On the one hand there are energy losses due to the distance between the plant and the companies. On the other hand the centralized energy supply has to produce more energy than needed in order to cover peaks in demand, decreasing the efficiency of the system. Although centralized power supply generally has the advantage of economies of scale, there are specific situations, e.g. factories with limited, unsecure or long-distance access to energy, where on a smaller scale level, energy demand and supply can be controlled to increase energy efficiency. With increased knowledge and data basis about internal manufacturing processes it is possible to control more effectively and thus increase the energy efficiency of the processes. By using energy potentials available in the environment, a “wireless” energy supply can be realized and sensors and controllers powered remotely, which contributes to the secondary energy savings.

	Short	Medium	Long
Environment	+	++	+++
Economy		+	++
Society		++	++

Table 7 Impact of the Research Action

The following two research topics deal with these issues and aim for providing solutions by research and development:

- **RT 2.04: Energy Autonomous Factory**
  In order to reduce energy consumption and to guarantee a reliable energy supply, technologies and frameworks have to be developed for production-sites, which enable self-dependent energy generation according to the actual on-site demand and facilitate the use of renewable energy sources.
- **RT 2.03: Using Energy Harvesting for Powering Electrical Sensors and Devices in Manufacturing Processes**
  Energy harvesting is a concept to transform surrounding energy (e.g. thermal, kinetic, waves) to electrical energy. By finding potentials and developing solutions for manufacturing, e.g. sensors’ and controllers’ energy storage devices can become smaller or even dispensable.

5.2 Efficient Production Processes

Reducing energy consumption in the manufacturing processes is a key lever when aiming for CO2 reduction and increase of energy efficiency. Due to the losses in energy generation, transformation and transportation from the power plant to the end-consumer, each kW saved in consumption results in a much larger amount saved in energy "generation". It has to be a strategic aim to reduce energy consumption on the long term whilst increasing the output of the manufacturing processes.

From an energy efficiency point of view, manufacturing processes can be improved in three different layers. The first layer is the technology of the existing manufacturing processes themselves. During technology development energy efficiency has to be taken into account as a priority objective besides of costs and quality. With this, the consumption itself can be further decreased. The second layer is the design of the process chains and the manufacturing systems, respectively. The planning and design of these systems includes a high potential for energy savings due to an improved configuration of process chains and manufacturing systems. The third layer considers the output streams from the manufacturing processes. There, technologies are required to decrease emissions and to filter pollution substances. Here, additional energy is required imposing indirect energy consumption on the manufacturing processes – decreasing the overall energy efficiency.

	Short	Medium	Long
Environment	+	++	+++
Economy		++	++
Society	+	++	+++

Table 8 Impact of the Research Action

In the following three research topics cover the issues mentioned, each of them covering one layer of decreasing the energy consumption in manufacturing processes:

- **RT 2.10: Energy Efficient Particle Size Reduction**
  Current grinding processes have very poor energy efficiency, as only few percents of power are used for breaking chemical bonds of materials. New grinding concepts and technologies have to be defined (e.g. pretreatments, flexible grinding systems) and demonstrated.

- **RT 2.11: Green Manufacturing for Future Vehicles**
  Taking into account the interdependencies of product design and the manufacturing process, new possibilities of car-manufacturing due to new product architecture of "green cars" (e.g. hybrid, electrical cars) should be analyzed and new energy efficient production concepts developed.

- **RT 2.09: Emission Reduction Technologies**

Resource and energy intensive industries emit substantial amounts of green house gases and other polluting substances. Secondary emission reduction technologies have to be developed in a coordinated approach across sectors. With this, benefits from implementing similar reduction and capture technologies in different industries can be expected.

5.3 Energy Utilization in Collaborative Frameworks

Today, energy is used in single factories for the own manufacturing processes. Dissipating energy in form of heat or by products is in many cases taken as waste output without potential of reusing it. However, this "waste" often includes a beneficial use or reuse in another production process or industrial sector. In future, companies and industries need to be able to collaborate on a cross-sector basis in order to use energy and waste streams in a symbiotic way.

Such waste streams cannot always be used directly in another process, factory or industry. Often, a pretreatment is required in order to make the "waste" reusable. Here, technology advancements have to be fostered in order to make the pretreatment and the reuse both environmentally as well as economically viable. As almost all manufacturing processes emit heat in some way (representing the inefficiencies of the processes), the recovery and usage of waste-heat has to be focused on. Here, especially low temperature waste heat, which has a low temperature level but at the same time is available to a big amount in many forms throughout different sectors, needs to be considered. Further, the transparency of available "waste streams" at cross-sector and cross-industry level has to be increased.

	Short	Medium	Long
Environment	+	++	+++
Economy		++	+++
Society	+	++	+++

Table 9 Impact of the Research Action

The following three research topics deal with the challenges in the fields of waste stream reuse:

- **RT 2.07: Technological Access to Wastes for Enhanced Utilization**
  Enhanced utilization of alternative fuels and raw materials, derived from waste, replaces natural resources and as such reduces the environmental impact of resource intensive industries. Technological advances in pre-treatment and upgrade options are required. Adaptation of the main existing processes needs to be demonstrated in a cross-industry approach.

- **RT 2.05: Intelligent Utilization of Waste Heat**

Factories in process industries are point sources of low and medium temperature waste heat, which remain widely unused representing environmental and economic opportunities. Expected outcomes are a methodology for cross-plant analysis of waste heat recovery potentials, recovery technologies and demonstrated co-operations between industries/plants for optimized utilization of heat at various temperature levels including low temperature waste heat.

- **RT 2.06: Framework for Collaboration in the Alternative Fuel and Raw Material Market**
  Resource intensive industries significantly contribute to green house gas emissions making it an important sector for mitigation actions. Here, waste/by-products can be used to replace raw material and fossil fuels in industrial processes. Methodologies and strategies for cross-industry and cross-sector collaboration have to be developed in order to enable increased utilization of waste.

5.4 Management and Control of Energy Consumption

The design of former manufacturing systems has been driven by the market, focusing on quality, fast delivery and low costs. Today, triggered through rising energy prices or environmental awareness of customers, energy efficiency is becoming increasingly important and the manufacturing systems have to be adapted, complemented and enhanced accordingly. In order to be aware of the energy consumption in the manufacturing processes, the measurement and control systems need to be integrated and become an integral part of the manufacturing system (“you cannot control what you cannot measure”). New Energy Management Systems will be the basis for deciding about and implementing energy efficiency improvement measures.
In order to develop new Energy Management Systems, the sensors and control devices require attention as well as the key performance indicators, the techno-human interfaces and new concepts of setting up a manufacturing system. With this, energy efficiency can become an integral part of the manufacturing systems and also be represented in the Information and Communication Technology Systems. The transparency of the energy consumed should be the final objective. With the aim to significantly increase energy efficiency, improvements have to be made with respect to the holistic picture, and not only locally. Based on standards, process changes at some tier of the supply chain need to be illustrated and communicated with all supply chain partners. Not only energy savings can be reached for the supply chain: due to the enhanced collaboration a positive effect on the productivity will result.

	Short	Medium	Long
Environment	+	++	+++
Economy	+	++	+++
Society	++	++	+++

Table 10 Impact of the Research Action

The following three topics deal with the challenges to manage manufacturing process in energy efficient way:

- **RT 2.01: Energy-Aware Manufacturing Processes - Measurement & Control**
  An effective energy control system has to be developed, using the information of sensors and in-process measurement and a suitable energy efficiency performance measuring system. This control system focuses on concepts, which facilitate the evaluation, control and improvement of energy efficiency in manufacturing processes.

- **RT 2.02: Integrating Energy Efficiency in Production Information Systems**
  A novel framework that manages and optimizes energy efficiency with respect to production planning and control needs to be developed and implemented in enterprise control and information systems, such as Enterprise Resource Planning (ERP), Manufacturing Execution Systems (MES), and Distributed Control Systems (DCS).

- **RT 2.08: Product Tags for Holistic Value Chain improvements**
  Product related information about the in and outputs of manufacturing processes make the value chain transparent for its stakeholders. The transparency allows process improvements to be coordinated in order to increase the overall value chain performance (in terms of e.g. efficiency, costs, delivery time).

6. Key Technologies

In the manufacturing sector the main technological driver has been the productivity growth while reducing costs. In the next decade, in a view of global markets and networking manufacturing communities, state-of-the-art technologies will continue playing that key role because this time manufactures will demand value-adding, competitive and sustainable manufacturing systems and processes along their entire lifecycle, so that appropriate enabling technologies will be required for that ambitious goal. Indeed, technologies such as e.g. intelligent cognitive elements, adaptive systems, diagnostic features and multi-disciplinary simulations will establish the basis for allowing system builders to deliver to customers customised configurable systems at reduced costs and minimised lead-times, and in turn, will allow the users of said systems to embed value into their manufactured final products along highly efficient production processes.

Within this vision, the IMS2020 Key Area “Key Technologies for Manufacturing” aims at developing the technologies for allowing system builders to produce value-adding systems at minimised costs and environmental impacts and for allowing the users of said systems to produce value-adding customised products with increasingly shorter delivery times and of high technological content. In particular, four areas are proposed for that research:

- Flexible Manufacturing Systems

- Cost-Saving Manufacturing Systems
- Energy-Saving Manufacturing Systems
- Key Technologies embedded in manufactured products

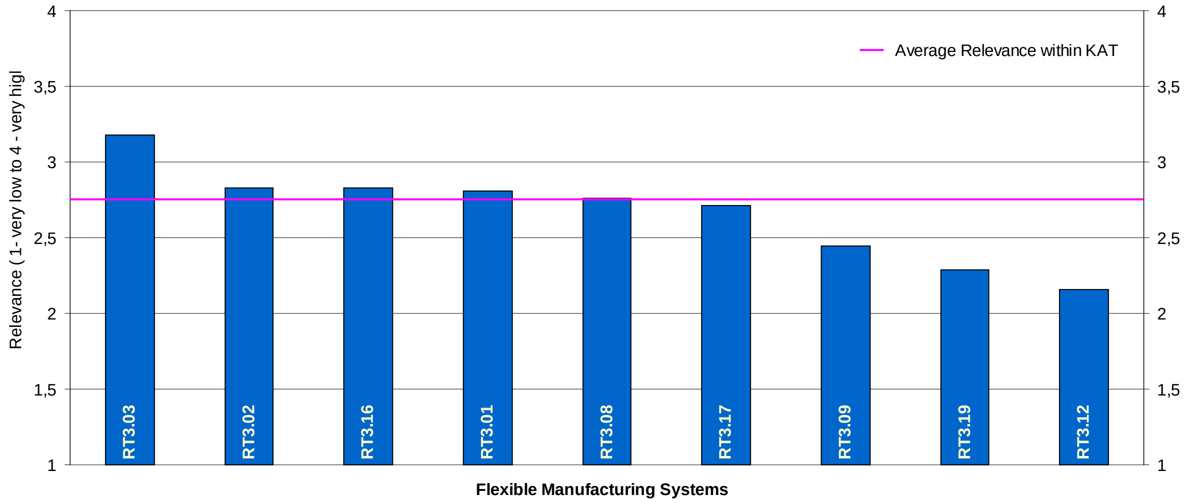


Figure 7: Overall relevance of the Research Topics (3)

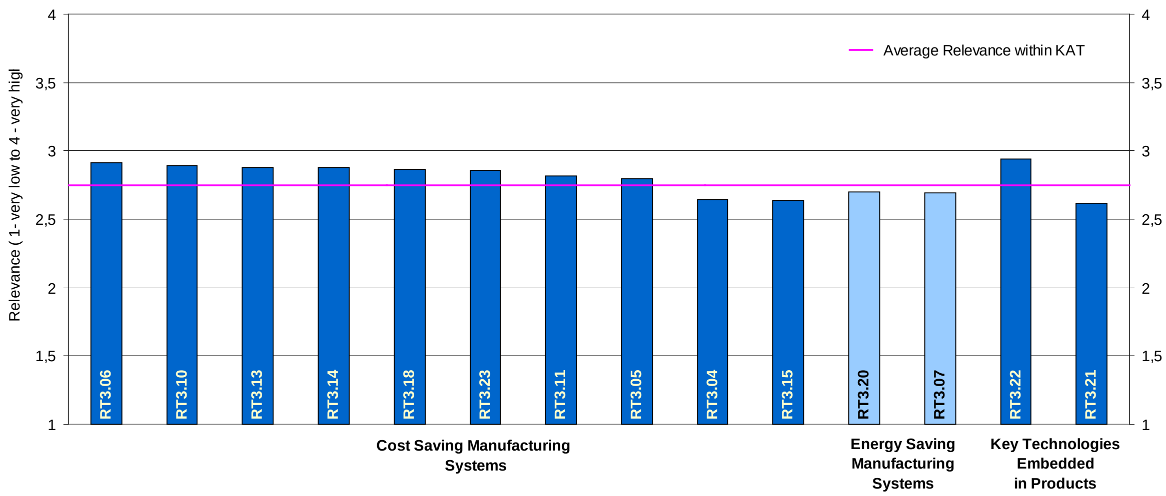


Figure 8: Overall relevance of the Research Topics (3) (Continuation)

6.1 Flexible Manufacturing Systems

	Short	Medium	Long
Environment		+	+++
Economy	+	++	+++
Society		+	++

Table 11 Impact of the Research Action

Macro Vision:
In the sustainability perspective, manufacturing industries need to be able to adapt quickly to market challenges and to take advantage from market changes. Flexible production systems may mitigate the effect of demand uncertainties. Compared to dedicated systems, flexible systems require new investment costs. Companies need new knowledge for the creation of new products and processes and the improvement of existing products and processes of new global manufacturing systems.

The end users in the manufacturing value chain are demanding to their providers customised products with increasingly shorter delivery times, in line with the so-called "mass customization" and "build-to-order" manufacturing paradigms, so that for facing this technological challenge, the manufacturing companies need machines and manufacturing systems that are productive and reliable and that at the same time are highly flexible and adaptive both in terms of volume and variants of the manufactured products.

To achieve this vision, the manufacturing sector needs a multi-disciplinary approach for conceiving and manufacturing flexible and adaptive manufacturing systems by covering the different stages of their life-cycle, from design and assembly to use and end-of-life. More precisely, these technologies are required for integrating new knowledge for new or improved products and processes needed for industrial innovation. The following technologies refer to new architectures and components

- New architecture include:
    - Comprehensive models integrating products+services, processes and business models for allowing engineering of customised manufacturing systems
    - New concepts for interfacing, assembling and disassembling mechatronic components with ease for adapting manufacturing systems to varying demands in volume and product type
    - New concepts for flexible manufacturing plants based on dynamic communities of mobile robots, machines and human workers, capable of reacting to demand fluctuations in an agile manner

    - New business models aimed at improving the efficiency of operating production plants in terms of re-use of machine components and re-programming of control systems in easily adaptable plants
- New components include:
    - Miniaturised, compact and modular mechatronic devices integrating simulated models and process control systems for building flexible systems that fulfil varying product and process requirements
    - Innovative technologies for developing miniaturised machine components with embedded sensors and actuators
    - Innovative manufacturing processes based on additive forming technologies as a means for enabling short lead to markets of customised machines

This new generation of technologies for manufacturing systems will impact in a decisive manner in their production lead time that will be reduced above 30%, in their reconfiguration time that will be reduced above 50% and in their productivity that will be adjusted 100% to the specific needs of the different customers.

This research action focuses the following specific domains oriented to provide solutions for economy, environment and society, in short, medium and long term :

- To develop semantic knowledge models that integrate machine products and services and associated business models along the life cycle of manufacturing system products, as well as tools and methodologies for analysing and modelling the value added in the manufacturing value chain and along the entire lifecycle of the production system(economy, short term)
- To develop advanced tools for modelling adaptive system configurations that are based on adaptronic modules with embedded intelligence and with standardised plug-and-play interfaces (economy and society, mid-term)
- To develop additive manufacturing processes and integrate them into agile and responsive manufacturing environments for machine and component builders (economy and environment, mid term)
- To develop knowledge-based and self-learning control systems that are based on multi-layer controls capable of managing dynamic and easily adaptive networks of machines, robotic members and human workers (economy, Environment and society, mid-long term)
- To develop methodologies and tools for managing the re-use of the modular and adaptronic components within easily reconfigurable machines and easily adaptive production plants (economy, environment and society, mid-long term)

The following research topics deal with the challenges in the fields of Flexible Manufacturing Systems :

- **RT3.01 : Modular Assembly /Disassembly Production Systems**
  In manufacturing systems, assembly and disassembly of machines and systems are labour-intensive processes that are traditionally linked to customization aspects and variations of the produced products. To respond to the needs of complex products and to change the operations in-situ between automation and human work, depending on the changing volume, the new generation of adaptive production systems, looking to the entire product and process life cycles.

- **RT3.02 : Control for Adaptability**
  In manufacturing process it is essential to integrate process models in the control system that allows optimal performance under different conditions. New control systems could overcome the limits of traditional systems and be able to react in time to fluctuations during the process, to changes of process parameters and disturbance variables.

- **RT3.03 : Mutable Production Systems**
  Short delivery times and the increasing complexity and variety of manufactured products are demanding more than highly flexible production systems. Furthermore production systems need to be changeable enabling the reconfiguration to adapt to changed conditions in a fast an efficient way.

- **RT3.08 : Model Based Engineering and Sustainability**
  The engineering of customised manufacturing systems involves an integrated model-based approach that covers products+services, processes and business models in an integrated way.

- **RT3.09 : Cooperative & Mobile Manufacturing Systems**
  An innovative way for conceiving flexible production plants lies in reconceiving those production plants as dynamic communities of mobile robots capable of cooperating among them and with human workers.

- **RT3.12 : Mechanical MicroMachining Enhancement**
  The miniaturization of machine components is unanimously a key issue for the future technological development. However, numerous technological problems prevent the adoption of micro-manufacturing technologies at the industrial level. Cost effective and reliable mechanical micromachining processes must be developed through a deep comprehension of the material removal mechanisms and of the micro structural behaviour of materials and its effects on machining forces, deformations and quality on the work piece. New concepts are also needed for fixturing and handling systems, modular and multifunctional machine tools, process monitoring and control through accurate sensors and methods of data analysis.

- **RT3.19 : Forthcoming "Brown Fields" Re-Engineering**
  The scope of this research is the development of a new business model to increase the effectiveness of brown field production. Therefore it is essential to develop supporting tools and methodologies such as, for example, “plug and interoperate” devices, interfaces for interoperability, fast simulations and re-programming tools, methods to improve the plant control, assembly and disassembly aspects.

- **RT3.16 : Extracting Higher Potential from Regional Cluster Based on Professional Virtual Collaboration Platforms**

For the manufacturing industry it is imperative to continue to exploit innovative business strategies long time in advanced. One essential strategy of the future is to participate in dynamic business networks. Two major objectives of this strategy are to bring the core capabilities into a flexible network and to govern through stakeholders. The result should be dynamic and flexible representation of business processes and technology for virtual collaboration among regional clusters. Therefore, the research focus should be on extracting higher potential from regional cluster based on professional virtual collaboration platforms (collective governance and expert contribution).

- **RT3.17 : Ontology Based Engineering Asset Management**
  The main goal of Product Lifecycle Management (PLM) is the management of all the business processes distributed along the product's lifecycle phases. These phases are BOL (Beginning-Of-Life including design and production), MOL (Middle-Of-Life including logistics, usage, maintenance and service) and EOL (End-Of-Life including reverse logistics, recovery, disassemble, remanufacturing, reuse, recycle and disposal). A major requirement for efficient PLM is the traceability of the product which is the acquirement of information along the product's lifecycle about the product. Although the volume of information may be manageable at the beginning of product lifecycle, it will rapidly grow as product lifecycle becomes evolving. This generates a comprehensive genealogy of product lifecycle meta-data, which causes difficulty in managing and retrieving the data or information that we need. Information can be used to extract knowledge, to improve features of products and of future products. A big amount of this information-knowledge is being lost, due to lack of reasoning capabilities as well as lack of interoperability and integration of information of today's PLM systems and models.

6.2 Cost-Saving Manufacturing Systems

	Short	Medium	Long
Environment	++	+++	+++
Economy	+++	+++	+++
Society	+	++	+++

Table 12 Impact of the Research Action

Macro Vision:
Present manufacturing systems are characterised by sophisticated processes. To be competitive, minimisation of costs is a new approach that makes possible to reduce systems' downtime and maximising efficiency. In the current industrial environment,

anyway, companies need to reconsider their production systems and processes within a life-cycle view, aiming at conceiving, designing, producing and using cost-effective, value-adding and sustainable manufacturing systems as basis for minimising total life-cycle costs associated to manufacturing systems.

To achieve this vision, the manufacturing sector needs a multi-disciplinary approach for conceiving new concepts for manufacturing systems that fulfil users needs while reducing total life-cycle costs. More precisely, both physical and organizational processes must be able to achieve new performances to quickly respond to technical and cost constraints due to environmental, economic and societal issues.

The following technologies are required for enabling cost-reduction changes in manufacturing systems facing that overall need of efficiency. The following technologies refer to a sustainable production and innovative solutions for value chain management.

- Sustainable production includes:
    - Innovative methods and technologies for increasing the *efficiency of work force* that is actively involved in the manufacturing process, and also the effectiveness and safety of manufacturing processes and peoples' activities
    - Technologies for more *efficient and productive manufacturing systems* for maintaining highest standards in the event of changing operating conditions: "zero-defect" manufacturing
    - Semantic systems for supporting collaborative engineering for *value-adding and cost-effective manufacturing systems*
    - Production Planning and Control approaches based on high resolution models for allowing companies to plan *production processes in a cost-effective manner*
    - Advanced ICT Tools for allowing companies *predict the risk and opportunity potential* associated to developing new products, services and manufacturing processes
- The innovative ICT solutions for value chain management include:
    - Innovative tools for allowing planning, management and optimisation of production and logistic resources within companies and within manufacturing networks
    - control mechanisms of decentralised production for allowing companies of the manufacturing value chain to adapt their production and capacity management in a cost-efficient manner
    - New production planning and control approaches for coordinating the production activities and for assuring good process reliability, short delivery times and low production costs
    - Virtual manufacturing environments for integrating knowledge into the manufacturing value chain in an explicit manner
    - Tools, standards and innovative co-operation models for efficient inter-organizational workflows among companies along the manufacturing value chain

This new generation of technologies will impact in a decisive manner in their life-cycle production costs that will be reduced above 10% as well as in the costs associated to logistic costs that will be reduced above 20%. In addition, these technologies will lead to shorter lead times of material and information and improved service levels and added value for the end users in a customer-oriented way.

This research action, which will be oriented to providing solutions for economy, environment and society in short, medium and long term, will focus the following specific domains:

- To conceive and develop cognitive systems and ICT tools for condition monitoring, diagnostics and prognostics as means for building intelligent, self-optimising and cost-effective machines with “zero-defect” manufacturing (economy and society, mid-term)
- To develop methodologies and ICT tools for allowing high resolution planning and forecasting of Production, Planning and Control processes within complex networks of companies and multiple stakeholders (economy and society, mid-term)
- To develop organizational concepts, processes and methods for the collaborative planning, management and optimisation of production and logistic resources, (economy and society, mid-term)
- To develop digital factory models with real time animations for assuring concurrent and distributed engineering activities within networks of companies and research institutions (economy and society, mid-term)
- To develop ICT tools for creating value within globally networked operations including global supply chain management, product-service linkage and management of distributed manufacturing assets (virtual factories), securing of information and knowledge exchange and process synchronization. (economy and society, mid-long term)
- To develop ICT tools for enhancing the accessibility and sharing of the information generated in the virtual manufacturing environment as a means for integrate that information within design and life cycle analysis for holistic approaches. (economy and society, long-term)
- To develop methods and ICT Tools for assessing risks and improve the predictability associated to new products, services and manufacturing processes and thus avoid future expensive corrections and production re-orientations (economy and society, short-mid term).

The following research topics deal with the challenges in the fields of Cost-Saving Manufacturing Systems :

- **RT3.04 : Lower Labour and Energy Cost Performance**
  COST linked to SUSTAINABILITY is the main driver of this research topic. Cost issues are fundamental in the manufacturing industry and when addressing them, two main aspects come in front: the labour cost and the energy cost, which are linked to environmental sustainability and to aspects of human safety at work. This research topic addresses both issues in a combined way: the efficiency, effectiveness and safety of work force (people) involved in manufacturing activities, and the optimised utilisation of energy streams with a low energy consumption level.

- **RT3.05 : Interoperable Products and Production data exchange**

Companies can be part of several production networks at the same time thus making the planning, management and optimisation of these networks a very complex task. This requests collaborative planning, management and optimisation of production and logistic resources, including the production planning and capacity management in non-hierarchical company networks. These processes have to be standardised across industries in order to come up with the necessary speed and flexibility in the network integration.

- **RT3.13 : High Resolution Total Supply Chain**
  To keep production units in high-wage countries, companies have to concentrate on manufacturing complex and individualized products. Being able to adapt processes according to supply chain requirements is a key success factor. Decentralized self optimizing control mechanisms, based on a new level of information transparency and synchronized target systems are indispensible. Therefore a multistage control loop system of intelligent objects based on cybernetic models has to be developed.

- **RT3.06 : Build-to-Order - New Production Planning and Control Models for Complex Individualized Products**
  The production of complex products requires the involvement of different partners providing services, materials or manufacturing activities. The demand of individualized products asks these non-hierarchical organizations the ability to quickly respond to customers with high service levels and low overall costs. New production planning and control approaches must be developed to coordinate the production activities and to assure robust production performance against uncertain events and against the propagation of production plan disruptions within the network enterprise.

- **RT3.10 : High Performance (High Precision, High Speed, Zero Defect)**
  To increase efficiency of manufacturing system, this topic covers productivity gains and cost saving to face market changes and eco- society sustainability issues. The aim of this topic is to increase the capability of manufacturing systems to maintain highest standards in the event of frequently changing operating and product-mix conditions. To provide more efficient and productive outputs, technologies for high volume, high speed and new capabilities of processes are needed.

- **RT3.11 : Model-based Manufacturing**
  Model-based manufacturing refers to the development of virtual manufacturing environments that will allow explicitly integrating knowledge in the manufacturing chain. Expected outcomes are tools for manufacturing environment simulation and information exchange with other production stages.

- **RT3.18 : Knowledge Generation Systems**
  Although a lot of data is being collected by various systems, there is no efficient and productive method to process the data. The development of Systems capable of generating knowledge is required. These systems will be concept-based and will combine concepts with data to generate new knowledge.

- **RT3.14 : High Accuracy Modelling**
  Companies face the problem that current planning approaches aren't able to incorporate all relevant influence factors leading to inefficient and ineffective production in worldwide networks. Integrated multiple optimization of economic and sustainable production based on high resolution modelling seem to be a reasonable solution. There is a need for development of methodologies and new ways of visualization based on ICT. This would improve planning and forecasting of processes within complex company networks involving multiple stakeholders.

- **RT3.15 : Semantic Business Processes**
  The intensive global competition motivates an increasing number of companies to cooperate throughout the entire value chain. Models, tools and standards for inter- and intra-organizational business workflows and process execution have to be developed in order to guarantee high-quality integration of processes within cooperation. Using semantic descriptions for this purpose ensures flexibility and a common understanding of involved processes.

- **RT3.23 : Dealing with unpredictability**
  Innovation processes are crucial in developing products and processes in manufacturing companies. Traditional methods are insufficient to cope with the risk embedded in such projects and radically new methods are needed taking both contextual and strategic risk into account. The impact of this topic will be better predictability of innovation projects. It will develop a new attitude towards delaying with risk in manufacturing projects.

6.3 Energy saving Manufacturing Systems

	Short	Medium	Long
Environment	++	+++	+++
Economy	++	+++	
Society	++		

Table 13 Impact of the Research Action

Macro Vision:
Taking into account the high environmental impact associated to current manufacturing systems and related processes along their whole life-cycle, both builders and users of manufacturing systems demand innovative solutions (manufacturing systems + services + processes) with reduced consumption of energy and material resources. This enables to

assure a competitive position and a sustainable development of the manufacturing sector, that needs solutions ensuring quality rates of manufacturing systems while reducing energy and material resources. This target means introducing new parameters for energy efficiency and raw-material efficiency. A paradigm shift will be necessary in the current design approaches of manufacturing processes towards new conceptual approaches that relate specific energy and materials savings to manufacturing..

To achieve this vision, the manufacturing sector will need a multi-disciplinary approach for managing the environmental impact associated to the life-cycle of manufacturing systems. The efficiency of energy and raw materials needs to be correlated to the involved processes and products that have to be highly improved. More precisely, the following technologies will be required for facing that overall need that will refer to both efficient manufacturing processes and manufacturing systems.

- Efficient manufacturing systems will include:
    - Innovative manufacturing equipment for increased raw material efficiency and “zero defect” parts through new manufacturing methods, use of detailed modelling and simulation tools and the integration of monitoring and control techniques in the design process
    - New intelligent automation and control systems for ensuring stability of manufacturing processes as a means for improving the energy efficiency of manufacturing systems
- Efficient manufacturing processes will include:
    - Innovative manufacturing processes including near-net or finishing techniques that will minimize material stocks and scrapes as a means for achieving “zero waste” manufacturing processes
    - The use of innovative materials with pertinent machinability and tribology characteristics for achieving efficient cutting processes. In addition, environmentally-friendly structural materials with the pertinent damping, stiffness and recyclability characteristics for reducing the material content of current material intensive machine structures

This new generation of technologies will impact in a decisive manner in the life-cycle environment associated to manufacturing systems, that will be reduced above 20%, especially because of the energy consumption reduction, as well as in the consumption of raw materials, that will be reduced above 10%. The increased process stability technologies will lead to working places with less acoustic contamination and safer working conditions. In addition, constant product quality and decreased energy cost will contribute to strengthening the competitive position of manufacturing companies.

This research action, which will be oriented to providing solutions for economy, environment and society in short, medium and long term, will focus the following specific domains:

- To conceive and develop innovative concepts for manufacturing systems where their associated functionalities of accuracy, productivity and reliability are achieved with the minimum possible of involved material resources (economy, environment and society, short term)

- To develop innovative control and monitoring algorithms and systems for enhancing on-line the stability of manufacturing processes in an autonomous and intelligent manner (economy, environment and society, short term)
- To conceive innovative manufacturing processes aimed at minimizing the consumption of raw materials as well as of consumables such as lubricants, refrigerants etc. (economy, environment and society, short-mid term)
- To research on simplified life-cycle assessments methods for enabling users and builders of manufacturing systems integrate environmental-friendly materials both in the cutting processes as well as in the structural components (economy, environment and society, short term)

The following research topics deal with the challenges in the fields of Energy-Saving Manufacturing Systems :

- **RT3.07 : Efficient Use of Raw Materials**
  In manufacturing, using raw materials efficiently directly saves costs and energy in transformation, transportation, and disposal and, with this, reduces Green House Gas Emissions. By focusing on “zero-waste” and “zero-defect” technology developments, the amount of energy and resources required in manufacturing can be reduced as it is linked to the amount of material processed in the whole supply chain.
- **RT3.20 : Advanced Automation for Demanding Process Conditions**
  Advanced automation and control systems for process industries with fluctuating input streams (such as raw materials, fuels, etc.) need to be developed. The aim is to increase process stability. Besides of a constant product quality, energy consumption and production costs can be reduced by achieving higher throughputs and increased energy efficiency of the process.

6.4 Key Technologies Embedded in the Products

	Short	Medium	Long
Environment	+	+	++
Economy	++	+++	+++
Society	++	++	+++

Table 14 Impact of the Research Action

Macro Vision:
In current global markets, the manufacturing industry needs to pass from providing technologically advanced products to providing total solutions, i.e. products + services + processes, as a means for increasing the value that customers perceive when using said technological products. Within this view, manufacturers will have to focus on solution

thinking and besides will have to integrate their potential customers in the development process of those innovative solutions as a means for generating new business opportunities and for creating more value for their customers.

To achieve this vision, the manufacturing sector will need innovative concepts of intelligent products and customised services for allowing customers obtain the maximum value. In this respect, innovative customer-oriented services and new knowledge will be required for having it embedded into this new generation of total solutions. More precisely, the following technologies will be required for facing this overall need, which will refer to value-adding products and solutions as well as to customer-oriented manufacturing processes.

- Value-adding products and solutions will include:
    - Smart materials, sensors and RFID technologies for developing products with embedded knowledge and innovative customer-oriented functionalities
    - Value-adding information, services and functionalities such as educating customers for obtaining the maximum added value from those intelligent products
- Customer-oriented manufacturing processes will include:
    - Innovative tools and standards for allowing companies to build up business communities that will integrate customers with their requirements
    - Innovative methods for assuring active participation of customers in such communities

This new generation of products and services will impact in a decisive manner in the added-value associated to products and services, especially because of the integration of customer requirements into the development process of those products and services. In addition, this concept will increase the added-value in the life-cycle of such products and services, will reduce manufacturing costs above 20% and will create new markets for new types of products and solutions.

(What will be done to fulfil those needs)
This research action, which will be oriented to providing solutions for economy, ecology and society in short, medium and long term, as shown in Figure 2, will focus the following specific domains:

- To develop mechatronic systems with embedded knowledge and customer-oriented information that in turn will be embedded into innovative services and business models (economy society and ecology, short-mid term)
- To embed intelligent functionalities such as self-learning capabilities and self-repairing capabilities within knowledge-embedded products (economy and society, mid-long term)
- To develop tools for supervising the efficient operation of communities that include customers and their requirements (economy and society, long term)
- To develop guidelines, methods and tools for meeting and transferring customers requirements to different business communities (economy society and ecology, long term)

The following research topics deal with the challenges in the fields of Key Technologies Embedded in the Products :

- **RT3.21 : Business concept B2C-communities**
  The increasing competitive pressure on global markets constrains companies to reduce their costs and to encourage customer retention. By integrating customers into the development process of new products and services, companies are able to save money and to meet end customers' requirements. Therefore methods, tools and standards are needed that help companies to build up their individual B2C-communities.

- **RT3.22 : Knowledge Embedded Products**
  More intelligent products with embedded knowledge, use of smart materials, sensors, RFID etc will generate new business opportunities and competitiveness for the manufacturing industry and more value for the customers. Through case studies of best practice and state-of-the art within knowledge embedded products, the manufacturing industry will obtain new innovative ideas on how to provide more value for their customers. For the manufacturing industry this will not only represent new markets but also more value and sales to existing customers.

7. List and Timeline of the RTs.

Follows a possible timeline of the Research Actions and the Research Topics; some topics are very actual and under development now, so in a few years they will be already explored. Other topics instead are of interest of longer time spans, or have to be researched after other topics whose are prerequisite.

7.1 List and Timeline of Research Actions and Research Topics

			2011	2012	2013
Scarce Resources Management	RT1.11	Materials re-use optimization.	■	■	■
Scarce Resources Management	RT1.16	Resource Recovery from Alternative Fuels and Raw Materials	■	■	■
Technologies for Sustainability	RT1.01	Quality Embedded Manufacturing	■	■	■
Technologies for Sustainability	RT1.14	Additive forming processes for manufacturing		■	■
Technologies for Sustainability	RT1.20	Sustainable Data Management	■	■	■
Technologies for Sustainability	RT1.24	Integrative Logistics Tools for Supply Chain Improvement	■	■	■
Sustainable Lifecycle of products and production systems	RT1.03	Real-time Life Cycle Assessment	■	■	■
Sustainable Lifecycle of products and production systems	RT1.06	Cost Based Product Lifecycle Management (PLM)	■		
Sustainable Lifecycle of products and production systems	RT1.13	Maintenance Concept for Sustainability	■		
Sustainable Lifecycle of products and production systems	RT1.08	Predictive maintenance		■	■
Sustainable Product and Production	RT1.02	Green Controller for Machining	■		
Sustainable Product and Production	RT1.04	Sustainability Metrics	■	■	
Sustainable Product and Production	RT1.05	Sustainability workshops	■	■	■
Sustainable Product and Production	RT1.09	Sustainable Packaging	■		
Sustainable Product and Production	RT1.10	Optimization of Electronic Sustainability	■	■	
Sustainable Product and Production	RT1.11	Materials re-use optimization.	■	■	■
Sustainable Product and Production	RT1.21	Sustainable Supply Chain Design	■	■	■
Sustainable Product and Production	RT1.25	Management of hazardous substances in manufacturing	■	■	■
Sustainable Product and Production	RT1.07	EOL management supporting technologies		■	■
Sustainable Businesses	RT1.12	Sustainable SMEs.	■	■	■
Sustainable Businesses	RT1.17	Exploiting Disruptive Innovation for sustainability		■	■
Sustainable Businesses	RT1.18	Integrated Service Supplier Development		■	■
Sustainable Businesses	RT1.19	Product-Service Engineering	■	■	■

	RT1.22	Alignment of IT and business strategies	■	■	■
	RT1.23	Multi-dimensional inventory management		■	■
	RT1.26	Lean Management for Service Industries	■	■	■
	RT1.15	New workplaces for Aging and Disabled Workers	■	■	■

7.1 List and Timeline of Research Actions and Research Topics (2)

			2011	2012	2013
Energy Sources for Companies	RT 2.04	Energy Autonomous Factory		■	■
	RT 2.03	Using Energy Harvesting for Powering Electrical Sensors and Devices in Manufacturing Processes	■		
Efficient Production Processes	RT 2.10	Energy Efficient Particle Size Reduction	■	■	
	RT 2.11	Green Manufacturing for Future Vehicles		■	■
	RT 2.09	Emission Reduction Technologies	■	■	
Energy Utilization in Collaborative Frameworks	RT 2.07	Technological Access to Wastes for Enhanced Utilization	■	■	
	RT 2.05	Intelligent Utilization of Waste Heat	■		
	RT 2.06	Framework for Collaboration in the Alternative Fuel and Raw Material Market		■	■
Management and Control of Energy Consumption	RT 2.01	Energy-Aware Manufacturing Processes - Measurement & Control	■	■	
	RT 2.02	Integrating Energy Efficiency in Production Information Systems		■	■
	RT 2.08	Product Tags for Holistic Value Chain improvements		■	

7.2 List and Timeline of Research Actions and Research Topics (3)

Area	Code	Research Topic	2011	2012	2013
Flexible Manufacturing Systems	RT 3.01	Modular Assembly /Disassembly Production Systems	■	■	
	RT3.02	Control for Adaptability	■	■	■
	RT3.03	Mutable Production Systems	■	■	■
	RT3.08	Model Based Engineering and Sustainability	■	■	■
	RT3.09	Cooperative & Mobile Manufacturing Systems	■	■	■
	RT3.12	Mechanical MicroMachining Enhancement			■
	RT3.19	Forthcoming "Brown Fields" Re-Engineering		■	■
	RT3.16	Extracting Higher Potential from Regional Cluster Based on Professional Virtual Collaboration Platforms			■
	RT3.17	Ontology Based Engineering Asset Management	■	■	
Cost Saving Manufacturing Systems	RT3.04	Lower Labour and Energy Cost Performance		■	■
	RT3.05	Interoperable Products and Production data exchange	■	■	■
	RT3.13	High Resolution Total Supply Chain	■	■	■
	RT3.06	Build-to-Order - New Production Planning and Control Models for Complex Individualized Products	■	■	
	RT3.10	High Performance (High Precision, High Speed, Zero Defect)	■	■	■
	RT3.11	Model-based Manufacturing	■	■	■
	RT3.18	Knowledge Generation Systems	■	■	
	RT3.14	High Accuracy Modelling	■	■	
	RT3.15	Semantic Business Processes	■	■	
	RT3.23	Dealing with unpredictability		■	■
Energy Saving Manufacturing Systems	RT3.07	Efficient Use of Raw Materials	■	■	
	RT3.20	Advanced Automation for Demanding Process Conditions	■	■	
Key Technologies Embedded in the Products	RT3.21	Business concept B2C-communities	■	■	
	RT3.22	Knowledge Embedded Products	■	■	■

8. Relations with Innovation, Competences Development and Education

Innovation, Competences Development and Education is one of the Key Technologies defined by IMS. A number of Research Topics (RT5.xx) has been developed to meet challenges in this area.

1. Teaching Factories
2. Cross Sectorial Education
3. Communities of Practice
4. From tacit to explicit knowledge
5. Innovation Agents
6. Benchmarking
7. Serious Games
8. Personalized and ubiquitous learning
9. Accelerated Learning

Table 15 and Table 16 show the Research Topics which are relevant and have been implemented in the other RTs.

IMS2020 Research Topics

Relations with Innovation, Competences Development and Education (KAT5)

	Training and mindset	Teaching Factories RT5.01	Cross Sectorial Education RT5.02	Communities of Practice RT5.03	From tacit to explicit knowledge RT5.04	Innovation Agents RT5.05	Benchmarking RT5.06	Serious Games RT5.07	Personalized and ubiquitous learning RT5.08	Accelerated Learning RT5.09
Sustainable Manufacturing										
RT1.01 Quality embedded manufacturing	x									
RT1.02 Development of Green Controller for Machining										
RT1.03 Real-time Life Cycle Assessment and Cost	x									
RT1.04 Sustainability Labels	x									
RT1.05 Sustainability Workshops	x			x						
RT1.06 Cost-Based Product Lifecycle Management (PLM)	x					x				
RT1.07 Remanufacturing for Sustainable Resource Management	x					x				
RT1.08 Predictive maintenance based on embedded information devices	x				x					
RT1.09 Sustainable Packaging	x			x						
RT1.10 Optimization of Electronic Sustainability	x									
RT1.11 Materials re-use optimization										
RT1.12 Sustainable SMEs	x							x		
RT1.13 Maintenance Concept for Sustainability	x	x								
RT1.14 Additive forming processes for manufacturing										
RT1.15 New workplaces for Aging and Disabled Workers									x	
RT1.16 Resource Recovery from Alternative Fuels and Raw Materials										
RT1.17 Exploiting Disruptive Innovation for Sustainability	x									x
RT1.18 Integrated Service Supplier Development	x				x					
RT1.19 Product-Service Engineering										
RT1.20 Sustainable Data Management	x									
RT1.21 Sustainable Supply Chain Design	x							x		
RT1.22 Alignment of IT and Business Strategies							x			
RT1.23 Multi-dimensional Inventory Management								x		
RT1.24 Integrative Logistics Tools for Supply Chain Improvement	x						x			
RT1.25 Management of Hazardous Substances in Manufacturing										
RT1.26 Lean Management for Service Industries		x								

Table 15: Relations with topics

IMS2020 Research Topics Relations with Innovation, Competences Development and Education (KAT5)	Training and mindset	Teaching Factories	Cross Sectorial Education	Communities of Practice	From tacit to explicit knowledge	Innovation Agents	Benchmarking	Serious Games	Personalized and ubiquitous learning	Accelerated Learning
		RT5.01	RT5.02	RT5.03	RT5.04	RT5.05	RT5.06	RT5.07	RT5.08	RT5.09
Energy efficient manufacturing										
RT2.01 Energy-aware Manufacturing Processes – Measurement and Contr	x									
RT2.02 Integrating Energy Efficiency in Production Information Systems										x
RT2.03 Using Energy Harvesting for Powering Electrical Sensors and Devic										
RT2.04 Energy Autonomous Factory						x				
RT2.05 Intelligent Utilization of Waste Heat	x			x						
RT2.06 Framework for Collaboration in the Alternative Fuel and Raw Materia	x			x						
RT2.07 Technological Access to Wastes for Enhanced Utilization	x									
RT2.08 Product Tags for Holistic Value Chain Improvement										
RT2.09 Emission Reduction Technologies	x			x						
RT2.10 Energy Efficient Particle Size Reduction										
RT2.11 Green Manufacturing' for Future Vehicles	x		x				x			
Key Technologies										
RT3.01 Modular Assembly Disassembly Production Systems										
RT3.02 Control for Adaptability	x									
RT3.03 Mutable Production Systems										
RT3.04 Lower Labour and Energy Cost Performance	x							x		
RT3.05 Standardization of Product Field Data / Interoperable and Standardi	x									
RT3.06 Build-to-Order - New Production Planning and Control Models for C										
RT3.07 Efficient Use of Raw Materials										
RT3.08 Model Based Engineering and Sustainability			x							
RT3.09 Cooperative and Mobile Manufacturing Systems		x								
RT3.10 High Performance (High Precision, High Speed, Zero Defect)										
RT3.11 Model-Based Manufacturing					x					
RT3.12 Mechanical MicroMachining Enhancement										
RT3.13 High Resolution Total Supply Chain Management								x		
RT3.14 High Accuracy Modelling										
RT3.15 Semantic Business Processes	x			x	x					
RT3.16 Extracting Higher Potential from Regional Cluster Based on Profes										
RT3.17 Engineering Asset Management			x							
RT3.18 Semantic Based Engineering	x			x	x					
RT3.19 Forthcoming "Brown Fields" re-engineering										
RT3.20 Advanced Automation for Demanding Process Conditions										
RT3.21 Business Concept B2C-Communities	x									
RT3.22 Knowledge Embedded Products										
RT3.23 Dealing with Unpredictability										

Table 16: Relations with topics (2)

9. Relations with Standards

The usefulness and value of standards supporting sustainable and intelligent manufacturing of the future is undisputed. Hence standardization is not a purpose of its own, it is an essential component of research activities in the fields of “Sustainable Manufacturing, Products and Services”, “Energy Efficient Manufacturing” “Key Technologies” and “Innovation, Competence Development and Education”. Due to this fact standardization activities have to be embedded in the Research Topics (RT) of the above mentioned Key Areas as a "Specific Feature". During an analysis six standards-clusters were identified as mentioned below:

1. Interface standards:
   this comprises standards for electronic information & data standards, communication & semantic standards as well as physical interface standards.
2. Measurement standards:
   this includes standards for the measurement of process, production and manufacturing efficiency. Furthermore standards for the measurement of waste and emission detection are integrated.
3. Process standards:
   integrate standards for the design process as well as for manufacturing and business processes. Furthermore standards for closed loop management are added.
4. Safety standards
5. Product and component standards
6. Material standards

The following tables show the RT-oriented individual need for standardization.

IMS2020 Research Topics Relations with Standardization (KAT4)	Interface Standards			Measurement standards					Process standards						
	Electronic information & data standards (format)	Communication & semantic standards (content)	Physical interface standards	Measurement standards for process efficiency	Measurement standards for energy efficiency	Measurement standards for manufacturing efficiency	Measurement standards for waste detection	Measurement standards for emission detection	Design process standards	Manufacturing process standards	Business Process standards	Closed loop management standards	**Safety standards**	**Product & component standards**	**Material Standards**
RT1.01 Quality embedded manufacturing				x	x	x	x	x							
RT1.02 Development of Green Controller for Machining							x	x				x			
RT1.03 Real-time Life Cycle Assessment and Cost				x	x	x	x	x							
RT1.04 Sustainability Labels		x													
RT1.05 Sustainability Workshops															
RT1.06 Cost-Based Product Lifecycle Management (PLM)	x	x		x	x	x	x	x	x	x	x	x			
RT1.07 Remanufacturing for Sustainable Resource Management	x	x		x	x	x	x	x							
RT1.08 Predictive maintenance based on embedded information devices	x	x													
RT1.09 Sustainable Packaging				x	x	x	x	x	x						
RT1.10 Optimization of Electronic Sustainability		x										x			
RT1.11 Materials re-use optimization		x										x			
RT1.12 Sustainable SMEs	x	x	x												
RT1.13 Maintenance Concept for Sustainability	x	x	x												
RT1.14 Additive forming processes for manufacturing															
RT1.15 New workplaces for Aging and Disabled Workers	x	x	x												
RT1.16 Resource Recovery from Alternative Fuels and Raw Materials												x		x	x
RT1.17 Exploiting Disruptive Innovation for Sustainability	x	x							x	x	x				
RT1.18 Integrated Service Supplier Development	x	x							x		x	x			
RT1.19 Product-Service Engineering														x	
RT1.20 Sustainable Data Management	x														
RT1.21 Sustainable Supply Chain Design	x	x								x	x	x			
RT1.22 Alignment of IT and Business Strategies	x	x									x	x			
RT1.23 Multi-dimensional Inventory Management	x	x									x				
RT1.24 Integrative Logistics Tools for Supply Chain Improvement	x	x										x			
RT1.25 Management of Hazardous Substances in Manufacturing							x	x					x		
RT1.26 Lean Management for Service Industries	x	x							x		x	x			

Table 17: Relations of Standards with Research Topics

IMS2020 Research Topics Relations with Standardization (KAT4)	Interface Standards			Measurement standards					Process standards				Safety standards	Product & component standards	Material Standards
	Electronic information & data standards (format)	Communication & semantic standards (content)	Physical interface standards	Measurement standardards for process efficiency	Measurement standardards for energy efficiency	Measurement standardards for manufacturing efficiency	Measurement standardards for waste detection	Measurement standardards for emission detection	Design process standards	Manufacturing process standards	Business Process standards	Closed loop management standards			
RT2.01 Energy-aware Manufacturing Processes – Measurement and Control					x		x								
RT2.02 Integrating Energy Efficiency in Production Information Systems	x	x		x	x	x	x	x							
RT2.03 Using Energy Harvesting in Manufacturing Processes			x	x	x	x									
RT2.04 Energy Autonomous Factory				x	x	x									
RT2.05 Intelligent Utilization of Waste Heat				x	x	x	x	x				x			
RT2.06 Framework for Collaboration in the Alternative Fuel and Raw Material Market	x	x										x			
RT2.07 Technological Access to Wastes for Enhanced Utilization in Resource Intensive Industries	x	x					x	x				x			
RT2.08 Product Tags for Holistic Value Chain Improvement	x	x		x											
RT2.09 Emission Reduction Technologies	x	x										x		x	
RT2.10 Energy Efficient Particle Size Reduction															
RT2.11 Green Manufacturing for Future Vehicles										x		x			

Table 18: Relation of Standards with Research Topics (2)

IMS2020 Research Topics Relations with Standardization (KAT4)	Interface Standards			Measurement standards					Process standards						
	Electronic information & data standards (format)	Communication & semantic standards (content)	Physical interface standards	Measurement standardards for process efficiency	Measurement standardards for energy efficiency	Measurement standardards for manufacturing efficiency	Measurement standardards for waste detection	Measurement standardards for emission detection	Design process standards	Manufacturing process standards	Business Process standards	Closed loop management standards	**Safety standards**	**Product & component standards**	**Material Standards**
RT3.01 Modular Assembly /Disassembly Production Systems	x		x									x		x	x
RT3.02 Control for Adaptability				x		x									
RT3.03 Mutable Production Systems										x	x	x			
RT3.04 Lower Labour and Energy Cost Performance				x	x	x	x	x					x		
RT3.05 Interoperable Products and Production data exchange	x	x													
RT3.06 Build-to-Order - New Production Planning and Control Models for Complex Individualized Products	x	x													
RT3.07 Efficient Use of Raw Materials										x				x	
RT3.08 Model Based Engineering and Sustainability	x	x							x	x	x				
RT3.09 Cooperative & Mobile Manufacturing Systems	x	x													
RT3.10 High Performance (High Precision, High Speed, Zero Defect)										x				x	
RT3.11 Model-based Manufacturing	x	x													
RT3.12 Mechanical MicroMachining Enhancement													x	x	x
RT3.13 High Resolution Total Supply Chain	x	x													
RT3.14 High Accuracy Modelling	x	x													
RT3.15 Semantic Business Processes	x	x													
RT3.16 Extracting Higher Potential from Regional Cluster Based on Professional Virtual Collaboration Platforms	x	x							x	x	x	x			
RT3.17 Engineering Asset Management	x	x								x	x			x	
RT3.18 Semantic Based Engineering	x	x					x	x	x	x	x	x			
RT3.19 Forthcoming "Brown Fields" Re-Engineering	x	x	x	x		x	x	x	x	x		x	x	x	x
RT3.20 Advanced Automation for Demanding Process Conditions	x	x	x	x	x										
RT3.21 Business concept B2C-communities	x	x													
RT3.22 Knowledge Embedded Products		x													
RT3.23 Dealing with unpredictability									x						

Table 19: Relation of Standards with Research Topics (3)

10. Annex 1: Roadmapping work structure

This chapter presents the methodology used to develop the IMS2020 Roadmap.
The approach has been designed in order to ensure the highest relevance to input coming from the industrial community as well as to ensure the international (IMS Regions) relevance to the results. Moreover, the work has kept into high consideration the work already and recently done both at European and International level on proposing roadmap in the field of manufacturing.
Most of the development has been done through collaborative tools shared with all the Roadmapping Support Group, a growing community that, at the moment, counts 254 participants from 108 mainly industrial organizations (Paragraph 13; Annex4: List of organizations within the Roadmapping Support Group: page **Errore. Il segnalibro non è definito.**).

Starting from the mapping of the existing roadmaps and ongoing researches, an open online survey, two brainstorming workshops and 106 interviews, the IMS2020 team has developed some possible future scenarios for the 2020 manufacturing and a set of 62 research topics to be proposed to the European Commission and the IMS.

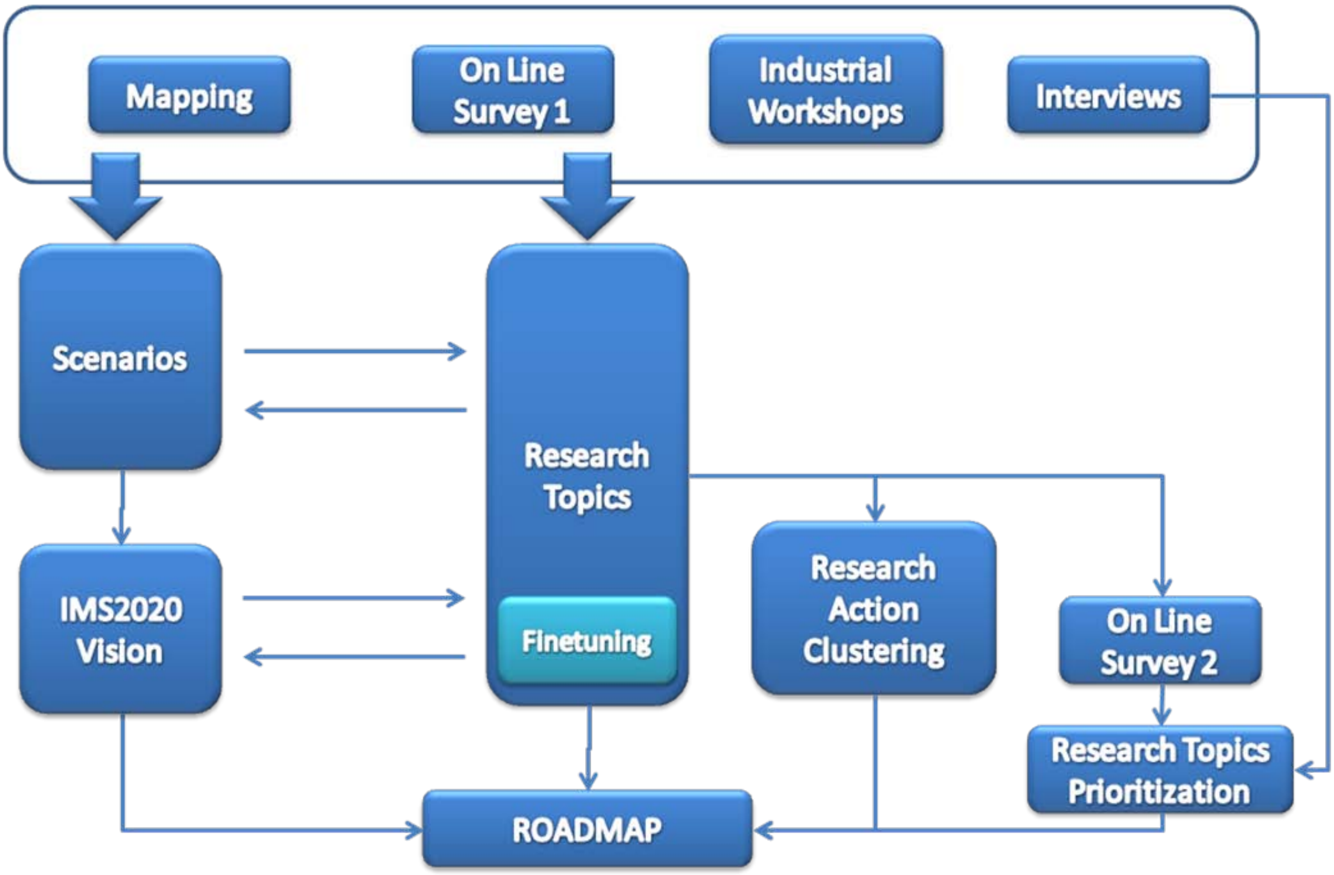


Figure 9: IMS2020 Roadmapping workstructure

The process is currently still ongoing through the wiki; the Roadmapping Support Group is in fact proposing new ideas. In fact 9 new Research Topics have been recently proposed:

- 5 from US Community
- 4 from the European Community
- 1 from inside the consortium

These topics are now under development and will be soon added to the wiki to be further discussed with the community.

10.1 Mapping of Past and Ongoing Research Activities and Mapping of Roadmaps

The objective of this work is to define a detailed and effective state-of-the-art of initiatives involved in the five IMS Key Areas (Sustainable manufacturing, Energy efficient manufacturing, Key technologies, Standards, Education). This mapping exercise focus especially on Research Activities, Standards, Regulations, Laws, Roadmaps and the assessment of present IMS collaboration between IMS regions.

The methodology followed for the state-of-the-art mapping activity is implemented in the form of mapping tables realised in Excel, clustering the past and ongoing researches as well as existing roadmaps into the identified main characteristics.

The work analyzed a total of 754 Research Issues coming from:

- **20 Roadmaps:**
    - FUTMAN (EU)
    - MANVIS (EU)
    - MANUFUTURE (EU)
    - ARTEMIS (EU)
    - CLEANPROD (EU)
    - EUMECHA-PRO (EU)
    - INEMI (EU)
    - I*PROMS (EU)
    - ITEA (EU)
    - MANTYS (EU)
    - UCIM (EU)
    - WiSeNts Roadmap (EU)
    - Artist Roadmap (EU)
    - Once-cs Roadmap(EU)
    - Hipeac Roadmap (EU)
    - Manufacturing Panel 2020 (EU-UK)
    - The Ministry of Economy, Trade and Industry (METI) Roadmap: (Japan)
    - NIST Symposium (US)
    - Canada 2020 (Canada)
    - Koreas Long Term Plan for Science and Technology – 2025 (Korea)
- **13 Past and ongoing projects**
    - AssemblyNet - Precision Assembly Technologies for Mini and Micro Products (Rete Tematica VFP) – Growth;
    - EUPASS - Evolvable Ultra-Precision Assembly Systems (VIFP – NMP/IST);

- IRMA - A configurable virtual reality system for Multi-purpose Industrial Manufacturing Applications (IMS);
- KOBAS Knowledge Based Services provided by a network of High Tech SMEs (VIFP – NMP);
- LicoPro - Lifecycle Design for Global Collaborative Production (IMS – VFP);
- NEXT - Next Generation of Machines (VIFP – NMP);
- ProdChain - Development of a decision support methodology to improve logistics performance in production Networks (IMS – VFP);
- Prominence - Promoting Inter-European Networks of Collaborating Extended Enterprises (VFP – Growth);
- Promise - Product Lifecycle Management and Information Tracking using Smart Embedded Systems (IMS – VIFP – IST);
- RIMACS VI FP;
- SMERobot - The European Robot Initiative for Strengthening the Competitiveness of SMEs in Manufacturing (IFP – NMP);
- Symphony - A dynamic management methodology with modular and integrated methods and tools for knowledge based, adaptive SMEs (IMS – VFP);
- VRL-KCIP EMIRACLE VI FP-NMP.

Moreover a total of nearly 1000 standards and regulations have been considered.

The results of the mapping activity are presented in the form of a summary, summarizing the key findings of the corresponding mapping activity. For a detailed description of the Mapping work, please refer to the following deliverables:

- Mapping of Past and Ongoing Research Activities;
- Mapping of Standards, Regulation &Laws.

10.2 First step of the Survey

The main objective of IMS2020 is the identification of the most important trends for future manufacturing systems. Therefore, the creation of roadmaps highlighting the main milestones of the innovation activities, were of crucial importance. In order to do this, the relevant research topics and supporting actions, which shape the future of manufacturing through international cooperation, had to be identified. As one of different tools to generate ideas used as inputs for the research topic generation, an anonymous survey was set up. Subsequently, this section will briefly describe the structure of this survey.
After a short introduction, which gave information about the background of the IMS2020 project, the participants were invited to provide basic information about their organisations (sector/ number of employees). Afterwards, they were asked to name and to elaborate their personnel innovation idea. These innovative ideas had to be related to one or more specific Key Areas. Furthermore, relevant changes in the business environment, which have a significant impact on the success or the failure of the defined innovative processes, had to be described. In order to collect as many innovative approaches as possible the participants had the possibility to deliver multiple ideas. In order to motivate a high number of experts, especially form industry, to participate in the survey, each project partner of IMS2020 sent out invitations to his relevant contacts. The results of this first

step of the survey served as a profound basis for the creation of the applied research topics in the specific key area of IMS.

10.3 Expert Interviews

With the purpose to provide a sound industrial background to the IMS2020 roadmap, 106 face to face interviews to industrial world-wide experts have been performed. In particular:

- 61 from Europe
- 10 from Japan
- 16 from Korea
- 18 from US
- 1 from Australia

In order to provide comparable results, a detailed interview guideline has been prepared. . The following part, will describe the structure of these expert interviews.
In chapter (A) a short explanation of the content of the IMS2020 project was given as well as a description of the project background and the advantages of the IMS Community. Chapter (B) consisted of general questions that should lead to an identification of the expectations and the main interests of each participant. The third part of the guideline, respectively chapter (C), was divided into five subchapters. Each subchapter was related to one area and gave each area the chance to implement specific questions regarding the relevant key area topics. Additionally, this structure gave the interview partners the chance to select the key area(s), in which they could provide high quality input based on their specific experience and knowledge. In order to define the interdependencies the experts have been asked to describe the links between standards/ education and the other Key Areas. Based on this information, was possible to point out trends for the future manufacturing system in their specific area.
In the last chapter of the guideline, chapter (D), the participants were asked to name and to evaluate their personnel innovation ideas. These innovative ideas had to be related to one or more specific Key Areas. Furthermore, relevant changes in the business environment, which directly influenced the success or the failure of the defined innovative processes needed to be defined. Finally, the expert interviews enabled the participants to describe further ideas that might have been relevant for the context of IMS2020.
As said, in addition to the information taken from the online survey, the results of the expert interviews were used as input for further defining possible scenarios for the future and consequently the roadmap of IMS2020.

10.4 Industrial Workshop

It is important that the process of identifying research topics is as wide and open as possible. The topics to be included should reflect the needs of the industry and at the same time advance the state of the art in manufacturing.

One of the tools to collect ideas for research topics is the workshops. A workshop is a forum where invited representatives are encouraged to bring ideas for discussion and then, through an interactive process, develop research topics. This gives two approaches to obtain new ideas:

- Research topics presented and brought to the workshop by the participants

- Research topics created at the workshop based on discussions and other forms of interaction.

There have been two workshops. The first was held in Brussels on April 23, 2009. The second was held in Zurich on May 26, 2009.

The first workshop in Brussels covered all the topics. The scope was to identify future research topics or actions in each area. The research topics should indicate the industrial needs for the manufacturing industry towards 2020 and beyond. They should be based on collaborative research across geographical regions and cultures and be eligible for public funding. There were 22 invited persons from industry attending the workshop. In addition 17 persons from the consortium were present.
The workshop was split in two sessions. The first one was a plenary session where all attendees were invited to present important problem Key Areas or research ideas. They were given five minutes to present a problem description, potential research topics and a justification for the idea. After each presentation there were allocated time for questions and discussion. In total, there were 18 presentations from different industries. These included a total of 45 proposals for research topics. The second session was based on group work. Four groups were formed to develop new ideas for research topics. During the plenary session, each participant was encouraged to write down ideas inspired from the presentations and discussions from the other attendees. These ideas served as input for the group work sessions. Each group were moderated by an IMS 2020 member. A rapporteur was appointed to produce a report summarising the discussions in each group. The four groups generated a total of 26 proposals for research topics.

The second workshop was dedicated to a specific area. The workshop was included as a half day session at a working conference of a special interest group of the IFIP (International Federation for Information Processing) working group WG5.7. The special interest group work with experimental interactive learning in industrial management. It contains mainly members with an academic background.
After an introduction to intelligent manufacturing systems (IMS) and IMS2020, the workshop objectives were explained and the organisation discussed. Existing research topics and ideas for research in education were presented to the participants as basis for discussion. In the plenum, brainstorming is being conducted to generate new ideas and complement existing ones. There were 20 participants. A total 16 ideas for research topics were developed in smaller group works. They were presented in a plenary and enriched through discussions an clustering.

The ideas obtained at the two workshops were at different level and partly overlapping. They have through later processes been refined and clustered and merged with ideas from the other approaches used to collect ideas.

For a detailed description of the workshops, please refer to www.ims2020.net.

10.5 Second step of the survey

Based on the aggregated ideas for future research collected with the several tools, the IMS2020 team proposed nearly 90 research topics. In order to have these proposed research topics assessed by a maximum number of experts from industry and research organizations a second online survey

was set up. The main objective of this survey was to get an indication for the relevance of the topics and the willingness to participate in global, cooperative research on the topics. Based on the gained information the topics were prioritized and the suitability for research on IMS-level was pointed out. Therefore the survey was promoted to experts all over the whole world.
Until the due date of this deliverable 350 persons from 43 different countries participated in the survey.

Design of the survey
On the initial page of the survey statistical data like the number of employees in the participant's organization, the sector the organization belongs to and the country the participant is from are requested. On the following pages the research topics are presented as short abstracts. Based on the abstracts the participants are asked to assess the relevance for their organization, to evaluate the importance of standardization and competence development actions as well as to indicate their willingness to participate in international collaborative research. Compare the example given in Figure 10 for the design of the survey, the measured attributes and the applied units.

Integrated Service Supplier Development

Today suppliers have to provide both physical products as well as complementary services in order to meet the customer demands. Therefore, it is reasonable to build up networks in which producers and service suppliers work together on the configuration of product-service-systems. In order to realize these networks companies need standardized methods and tools for the definition of the relevant interfaces as a common basis for an integrative development process of products and services.

	very low 1	2	3	very high 4
How relevant is this topic for your organization?	○	○	○	○
To what extent are specific competence development actions required by this topic?	○	○	○	○
To what extent are specific standardization actions required by this topic?	○	○	○	○

Would your organization be open for international (EU, Japan, US, Korea, ...) collaborative research?

Yes, now	Yes, but later	No, never
○	○	○

Figure 10: Example for the design of the second online survey

Analysis of the survey and assessment of research topics
As stated above, the main objective of the survey was to assess the research topics regarding their relevance for different stakeholders and their suitability for research on IMS level. Therefore two concise indicators visualizing these attributes have been designed.

The topic relevance is visualized by a system of green lights (compare annex 1). Three green lights indicate that the respective research topic is among the third of topics with the highest relevance within the area. Two out of three green lights symbolize that the topic is among the second third and one green light expresses that the topic is among the last third according to the relevance.
To indicate the interest of the different IMS regions in doing research on the proposed topics a bar chart was designed. The graph is showing the percentage of participants per IMS region, which are either now or later open for collaborative research on a specific topic, compared to the percentage of participants not open for that kind of research on that topic (cp. Figure 11). A quick look on the described bar chart gives a good impression of the suitability of the topic for research on IMS level.

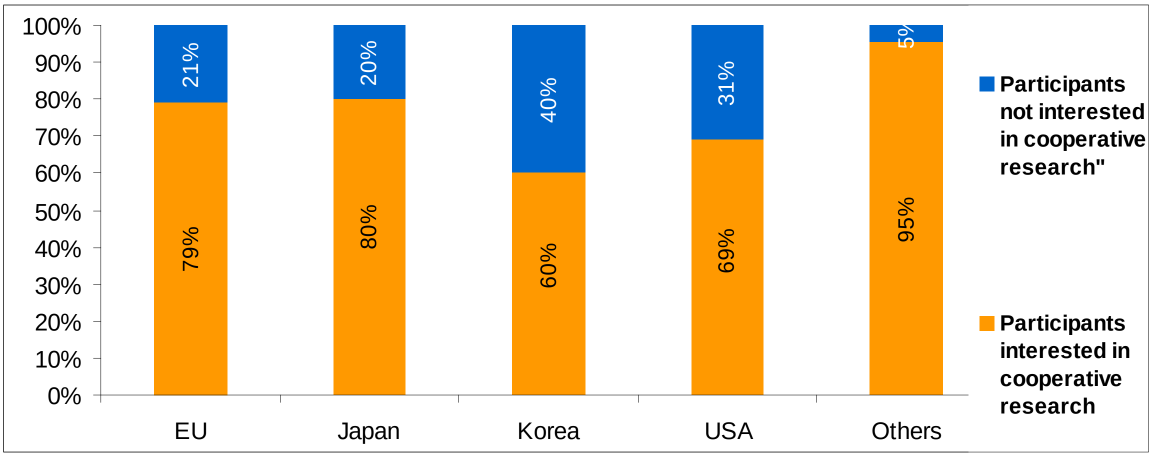


Figure 11: Example for bar chart visualising suitability for research on IMS level

10.6 Wiki

A wiki is a website that allows the easy creation and editing of any number of interlinked Web pages, using a simplified mark-up language or a text editor, within the browser. Wikis are used to create collaborative websites, to power community websites, for personal note taking, in corporate intranets, and in knowledge management systems. The IMS2020 wiki (http://ims2020net.wik.is) is meant to support a collaborative development and improvement of the topics suggested by the interviews, the first step of the online survey and the workshops the IMS2020 project did. As most wikis the IMS2020 wiki serves a specific purpose, and off topic material is promptly removed by the project team.
The purpose of the IMS2020 wiki is to evolve and to specify new fields in manufacturing research. The research topics should gain accuracy and relevance from the experience, knowledge and know-how of industrials and researchers from all over the world. For that reason the research topics are made accessible to a broad community in the state developed so far. The IMS2020 wiki has been announced among all qualified industry and research contacts of the IMS2020 core project partners to achieve the contribution of these experts.
For every visitor of the webpage the access to read a research topic is open, while they have to register (providing just their name and email address) to be able to comment. They can navigate through the wiki by looking for the area which seems most interesting for them. After choosing an area, a list of all assigned research topic abstracts appears. By hitting the link of the most promising topics the visitor can read the whole description and, if registered, of course comment. To offer an

incentive all visitors are informed that if they contribute they can become a part of the Roadmapping Support Group and gain full access to the final results of the IMS2020 project. By taking the comments of experts from the field into consideration not only the relevance of each topic is proofed but the topics can also be improved due to the real requirements. Figure X gives a hint on how the wiki looks like.

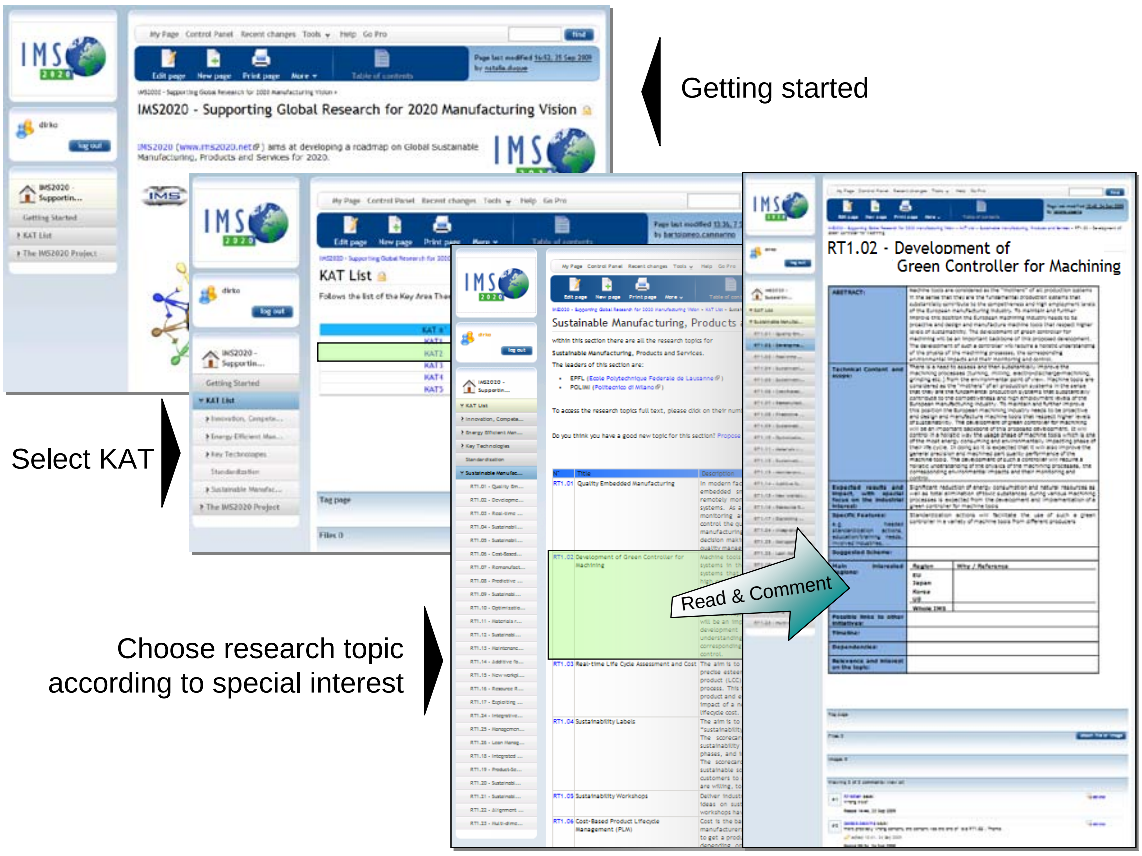


Figure 12: The IMS2020 wiki

11. Annex 1: Research Topics.

11.1 RT1.01 - Quality Embedded Manufacturing

ABSTRACT:	In modern factories, smart products and machines (equipped with embedded smart devices) can be wirelessly networked and remotely monitored in a real-time way under intelligent control systems. As a result, we can do real-time data gathering; remote monitoring and analyzing of all manufacturing operations to control quality of manufacturing and detect quality degradation which will allow predicting exceptional cases and consequent taking of appropriate corrective actions through decision making. This provides a new framework and environment for enhanced real time quality management in manufacturing and requires the development of new quality management methods and tools that will support faster and more efficient delivery of high quality products while keeping the whole manufacturing system at a permanent high level of quality. This will contribute to achieve a manufacturing system with high sustainability characteristics because a manufacturing system maintained in high quality does not only produces high quality products but it also has an extended lifecycle, produces less waste and requires less energy.
Technical Content and scope:	So far many companies have improved quality by capturing, measuring and eliminating defects in manufacturing processes with the Six Sigma approach. However, over the last decade, a rapid development of internet, wireless mobile telecommunication technologies such as the Zigbee standard, wireless sensors, machine-to-machine communication, RFID (Radio Frequency IDentification), micro-electromechanical systems (MEMS), various sensors, and several product identification technologies such as *smart tags*, *Auto-IDs*, *PEIDs* (Product Embedded Information Devices), and *intelligent products* have changed the traditional environment for manufacturing operations. Now, the information about the status of products, processes, and resources (machines) within a manufacturing plant can be continuously provided on a real-time basis through the wireless networks of manufacturing assets. The wireless network environment will enhance the speed, quality, and integrity of communication and information flow among objects in a plant. In particular, we can have the opportunity to enhance the quality of manufacturing by doing remote diagnosis of their status; predicting their abnormalities; and executing appropriate actions for exceptional cases. As a result, much attention has been paid to research for enhancing the performance of manufacturing operations using these benefits, however, until now, there is no tangible answer or standard to the approach for Quality Embedded Manufacturing.
Expected results and impact, with	Enhanced integration and distribution of production -and product- related information (quality of assembly, re-supply of components, reliability, usability, etc.), empowering the customer and allowing for better integration

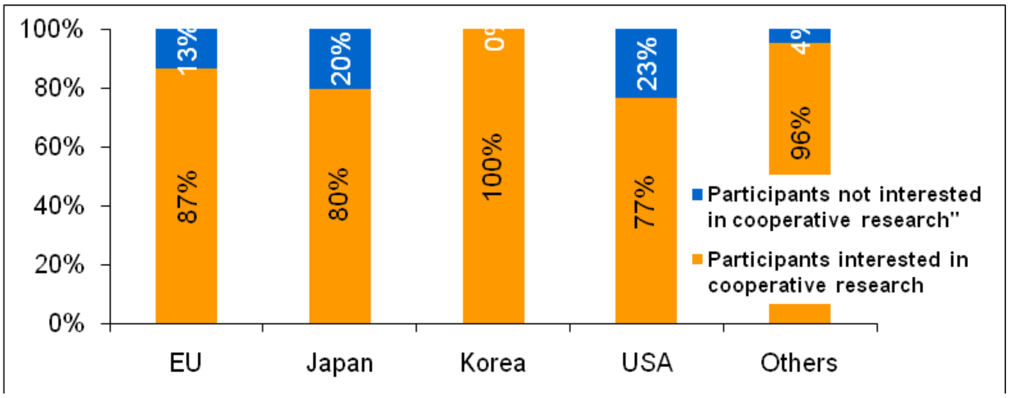
<table>
<tr><td>special focus on the industrial interest:</td><td>between customers, OEM and suppliers.

Ability to tackle new customisation requirements and to cope with small lot sizes will be improved by providing the operator with product -and component- related information and adequate instructions.

The integration and return of information along the supply chain will enable new business chain models and improved interoperability, regardless of the dimension or ERP/MES systems adopted by the supply chain actors including SMEs.</td></tr>
<tr><td>Specific Features:</td><td>Standardization actions will facilitate the use of such technologies. Therefore existing standards for controlling the quality of manufacturing should be taken into account. New standardization activities regarding the exchange of information and electronic documents need to be initiated.

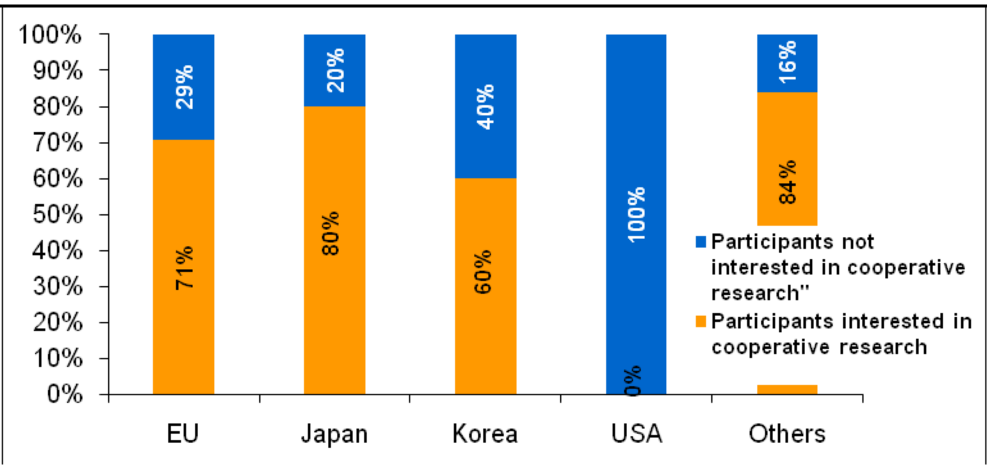
Intelligent use of this technology will create innovative solutions for monitoring and managing of manufacturing processes. Production people need to learn how to implement and use the technology. Training and sharing of knowledge between product development (using embedded devices in the products) and manufacturing will increase the competitiveness. Tools, cases and demos to visualize and perform good training need to be developed and evaluated.</td></tr>
<tr><td>Suggested Scheme:</td><td>Large / Small</td></tr>
<tr><td>Maininterested Regions:</td><td><table><tr><th>Region</th><th>Why / Reference</th></tr><tr><td>EU</td><td></td></tr><tr><td>Japan</td><td></td></tr><tr><td>Korea</td><td></td></tr><tr><td>US</td><td>Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of Smart Sensoring for product quality and workforce safety; Wireless technology /Ubiquitous computer (Sensor interoperativity)</td></tr><tr><td>Whole IMS</td><td></td></tr></table></td></tr>
<tr><td>Possible links to other initiatives:</td><td>From now on.</td></tr>
<tr><td>Timeline:</td><td></td></tr>
<tr><td>Dependencies:</td><td>none</td></tr>
<tr><td>Topic Relevance Indicator:</td><td></td></tr>
</table>

Regional Interest for Collaboration:



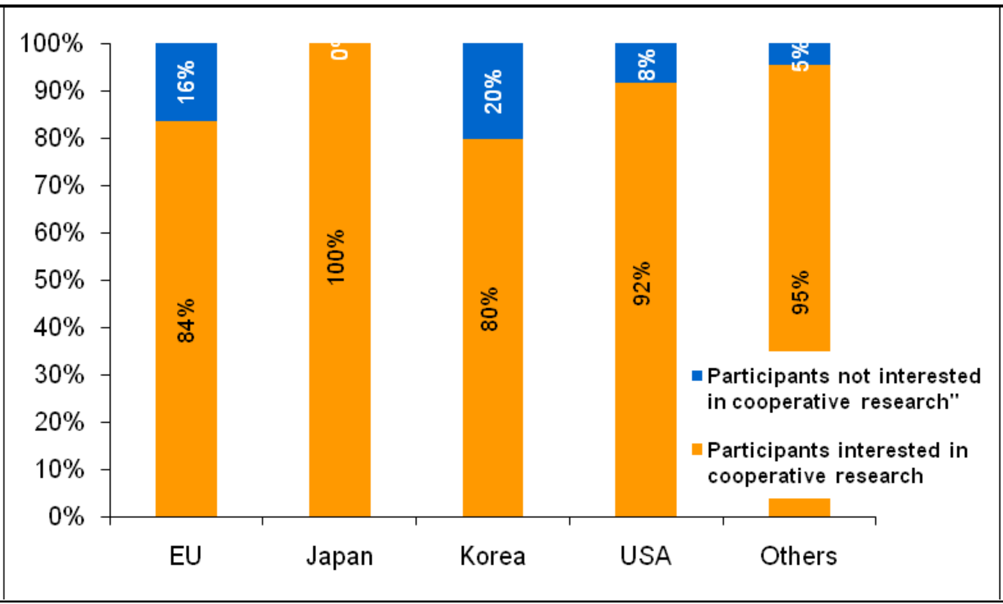
11.2 RT1.02 - Green Controller for Machining

ABSTRACT:	Machine tools are considered as the "mothers" of all production systems in the sense that they are the fundamental production systems that substantially contribute to the competiveness and high employment levels of the European manufacturing industry. To maintain and further improve this position the European machining industry needs to be proactive and design and manufacture machine tools that respect higher levels of sustainability. The development of green controller for machining will be an important backbone of this proposed development. The development of such a controller will require a holistic understanding of the physics of the machining processes, the corresponding environmental impacts and their monitoring and control.
Technical Content and scope:	There is a need to assess and then substantially improve the machining processes (turning, milling, electro-discharge-machining, grinding etc.) from the environmental point of view. Machine tools are considered as the "mothers" of all production systems in the sense that they are the fundamental production systems that substantially contribute to the competiveness and high employment levels of the European manufacturing industry. To maintain and further improve this position the European machining industry needs to be proactive and design and manufacture machine tools that respect higher levels of sustainability. The development of green controller for machining will be an important backbone of this proposed development. It will control in a holistic way the usage phase of machine tools which is one of the most energy consuming and environmentally impacting phase of their life cycle. In doing so it is expected that it will also improve the general precision and machined part quality performance of the machine tools. The development of such a controller will require a holistic understanding of the physics of the machining processes, the corresponding environmental impacts and their monitoring and control.
Expected results and impact, with special focus on the industrial interest:	Significant reduction of energy consumption and natural resources as well as total elimination of toxic substances during various machining processes is expected from the development and implementation of a green controller for machine tools
Specific Features:	Standardization actions will facilitate the use of such a green controller in a variety of machine tools from different producers
Suggested Scheme:	Small
Main interested Regions:	**Region** — **Why / Reference** **EU** **Japan**

	Korea **US** **Whole IMS**
Possible links to other initiatives:	
Timeline:	
Dependencies:	None
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

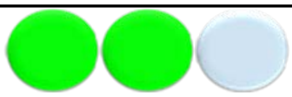
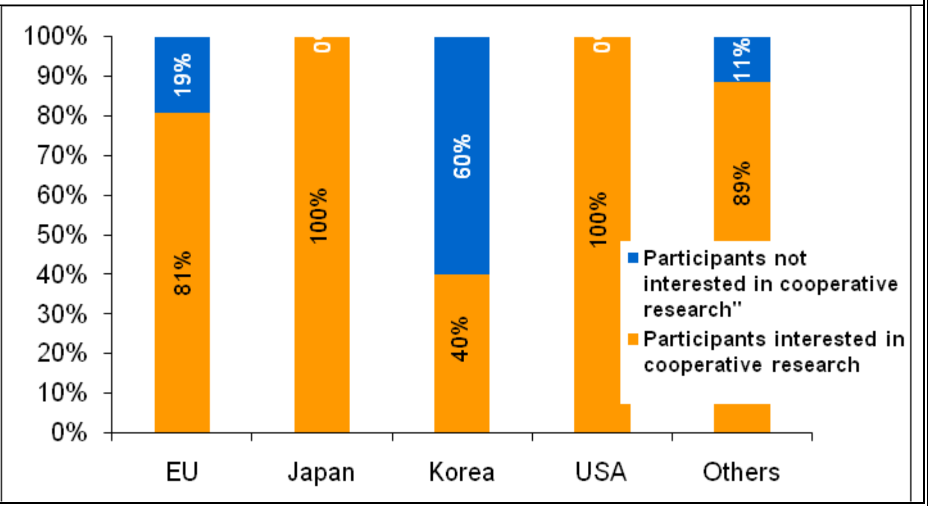
11.3 RT1.03 - Real-time Life Cycle Assessment

ABSTRACT:	The aim is to develop a methodology and a set of tools to allow a precise esteem of the whole lifecycle environmental impact (LCA) and costs of a product (LCC) to be used in real-time by designers during the design process. This tool will use lifecycle data information from previous products and esteems to do a precise evaluation of the full lifecycle impact of a new product during its development as well as its full lifecycle cost.
Technical Content and scope:	The project has to develop ways of using data and information existing in various sources within the enterprises in order to understand the whole lifecycle impact and cost of the products. It has also to develop proper methodologies and algorithms to manage, extract and evaluate this data and information. The project should also aim at developing methodologies to modify the design process so that these new information can be taken into account and can be integrated into the design process. ad-hoc delivery mechanisms (tutorials, practical examples, serious games, etc.) have to be developed to allow designers to understand the importance of the new tools and how to use them.
Expected results and impact, with special focus on the industrial interest:	The impact is to allow designers to focus not only on technical aspects (weight, performances, etc.), but also on soft aspects like the environmental and sustainability impact and the whole lifecycle cost of a product. This will also be an enabler for extended products (product+service), since it will allow an optimization of "MoL" (Middle of Life) costs. Esteemed impact due to the better knowledge provided by the tool is a reduction of 10-20% of lifecycle costs of long life products as well as a reduction of 20-40% of environmental impact.
Specific Features: e.g. Needed standardization actions, education/training needs, involved industries, …	Existing standardization activities on product lifecycle data and lifecycle environmental impact have to be taken into account. If possible the environmental impact has to be expressed in such a way to be comparable with other products produced by other companies. This impact evaluation function has to be standardized. A tool, such as a "teaching design department" has to be set up to allow training of designers; this can be supported with a serious game/simulation of designing with special problems to be addressed using the new tools. Additionally, the concept of communities of practice should be applied to support knowledge and experience exchange between designers both within and across companies.
Suggested Scheme:	Large with focus on different sectors / Some Small projects each one focused on single area
Main interested Regions:	**Region**: **EU** — **Why / Reference**: There is currently ongoing work on the evaluation of the maintenance costs to help designers to do their choices; industries of long lasting products (airplanes, trains, etc.) are asking for this kind of tools. Complete LCC and LCA are still missing.

	Japan	Some works in this topic are available.
	Korea	Some interviews and discussions with Koreans show interest in this topic.
	US	Some US companies have shown clear interest in LCC; LCA is a growing topic also; a merge of both should be welcome.
	Whole IMS	This topic requires IMS work because of the need of a common procedure for LCA to make it comparable across regions. The interest on the topic is high in all the regions.
Possible links to other initiatives:	Link to standardization activities in Lifecycle data modeling and LCA. It is suggested to use a Cen Workshop agreement to develop a standard for LCA.	
Timeline:	From now, on. Possible follow-up project focused on SMEs after the end of the first project.	
Dependencies:	Can be dependent on a project able to develop an environmental indicator for the products (RT1.04 Sustainability Labels)	
Topic Relevance Indicator:		
Regional Interest for Collaboration:		

11.4 RT1.04 - Sustainability Metrics

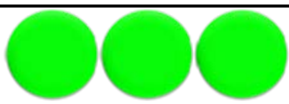
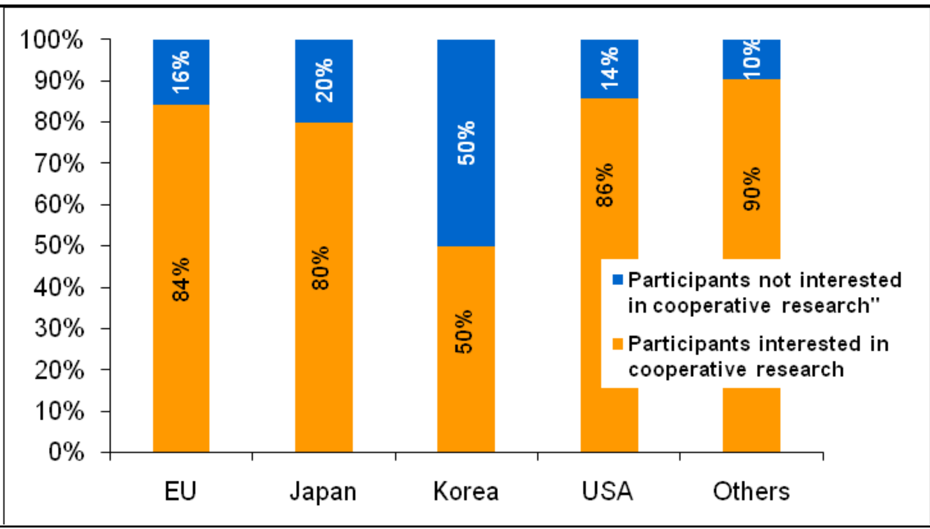
ABSTRACT:	The project has to develop a methodology to assign to each product a comparable and "sustainability index", which will be used by customers to be able to choose a product also considering that index. The index have to take in account all the pillars of sustainability (environment, society, …), lifecycle, design, usage data and information about the company and its behaviour.
Technical Content and scope:	In 1992 the European "Eco-label" has been established while in 2004 a new version has been released. The European Union has also defined several directives for the "Energy Label". The "Eco-label" doesn't allow comparison within "eco-labelled" products, while the "Energy Label" allows comparisons, but takes into account only energy consumption during product usage. Moreover none of them is proposed at worldwide level. This research has to develop a new "Sustainability Label", develop at IMS level, able to consider all the pillars of sustainability, not only the ecological one, allowing also comparison within classes of products.
Expected results and impact, with special focus on the industrial interest:	The index should become something to compete on, it should be seen by consumers as a way of understanding the real "green" and "uprightness" of the product. The index should take into account all the aspect of sustainability and of the product lifecycle; moreover it should be clearly defined and easily measurable. The "sustainability label" has to be applicable to at least 85% of the categories actually covered by the "eco-label".
Specific Features: e.g. Needed standardization actions, education/training needs, involved industries, …	A standardization action to define the "sustainability index" as a globally standardized methodology needs to be incorporated in the research. Involvement of associations, as entities to verify and state the index, as well as promoting it to their associated persons is required. Additionally the development of methodologies raising customers awareness are necessary. Learning to obtain a shift in mindset is needed. Training should be provided to effectively use these new tools.
Suggested Scheme:	Small Project

Main interested Regions:	Region	Why / Reference
	EU Japan Korea US	X (EC)
	Whole IMS	
Possible links to other initiatives:	Eco-label Energy Label	
Timeline:	Now	
Dependencies:	None	
Topic Relevance Indicator:		
Regional Interest for Collaboration:		

11.5

RT1.05 - Sustainability Workshops

Abstract:	Deliver industrial driven workshops to exchange best practices and ideas on sustainability between industries and research. The aim of the project is to organize a series of workshops to allow exchange of ideas and best practices, as well as a better cooperation between industry and research. The project will have to organize 6-8 workshops a year with the participation for 2/3 of non competitive industries and 1/3 researchers.
Technical Content and scope:	The aim of the project is to organize a series of workshops on sustainability technologies, business models and solutions, to allow exchange of ideas and best practices, as well as a better cooperation between industry and research. The project will have to organize 6-8 workshops a year with the participation for 2/3 of non competitive industries and 1/3 researchers. The organization of the workshops should have some rules; the research organizations will define a wide set of topics, on the sustainability issues, among which the industrial partners will select the topic of interest for each workshop. The researchers will deliver papers for the workshop on the selected topic, and will present them to the industrials during the workshop with short presentations. The industrial will have to do very short presentations on their sustainability best practices. Then part of the workshop has to be focused on discussions. The Project will also aim at creating a community of industrials who will participate to the workshops. The members will little by little start to consult each other on various problems they have related to manufacturing. Thus they initiate learning processes in the company contributing to both the tacit and the explicit knowledge of the company. The community could start using formal tools such as collaborative ICT tools. If access to these is allowed also outside the organizations participating in the workshop, there is an opportunity of developing a real learning community. Projects in this domain could include experiments with community building for the topics approached in the workshops. It should use these experiments to draw conclusions on how communities are established and grow, how they work, and what benefit they give to the participating organizations.
Expected results and impact, with special focus on the industrial interest:	Better exchange of best practices and ideas between industries and research. Verification of learning communities for manufacturing comptence development.
Specific Features: e.g. Needed standardizatio	Deliver of a book every year; KPI on the satisfaction and the interest of the industrial participants for every workshop. Designers and production engineers should be trained to adopt developed

n actions, education/training needs, involved industries, …	standards and procedures and identify what kind of standards are still missing. It is relevant to initiate citizen awareness actions to make the consumers aware of the importance of the topics.
Suggested Scheme:	NoE / CSA
Main interested Regions:	**Region** / **Why / Reference** **EU** **Japan** **Korea** **US** **Whole IMS** — **X**
Possible links to other initiatives:	Tbd
Timeline:	Now
Dependencies:	None
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

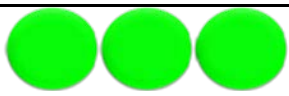
11.6

RT1.06 - Cost-Based Product Lifecycle Management (PLM)

ABSTRACT:	Cost is the basic criteria for the product related decision making; manufacturers try to reduce the production cost, customers want to get a product in low cost, used products are differently handled depending on its estimated cost. But each participant in the product life cycle does not consider the cost from the global perspective but only from the local perspective. Hence an integrated cost management over the whole product life cycle would be beneficial for the products' ultimate value maximization.
Technical Content and scope:	To manage a cost from the whole product lifecycle perspective, it is necessarily to integrate each product's value addition/deduction information in real-time. Hence the value chain of each product should be analyzed from the design phase to the disposal phase, and at the base of the framework should be information technologies for tracking and monitoring each product. The recent developing RFID (Radio Frequency IDentification) and sophisticated sensor technologies and the solid settled wireless network/internet infrastructure can enable each used product to be tracked, monitored, and maintained. To utilize the technology and handle many products individually depending on their states, multi-agent approaches is appropriate, where each product is defined as agent, each agent collects and maintains the product state and environmental information, and it decides a proper action at a certain moment; for example, a product is better to be sent to its EOL (End-Of-Life) phase and remanufactured with simple refurbishment from the perspective of the value over the whole product life. Measuring environmental effect or design effect in a quantitative way is found frequently, hence based on the research we can develop an integrated way to measure all required elements comprising cost. There was much research focusing on manufacturing cost, recycle cost, and so on, but no method is found for the integrated management of product value from the whole product lifecycle perspective, which is beneficial for all the participants: producer, user and environment. Use of multi agent approaches to obtain cost data from a complete product life cycle will involve different types of agents - innovation agents (human resources) as well as product agents. Methodology to retrieve, analyze, manage and reuse of this data will result in cost effective products and benefit for the users.
Expected results and impact, with special focus on the industrial interest:	The ultimate objective of the research is to maximize the product value with consideration of whole product lifecycle. The integration of whole product lifecycle information itself can support decision making of each participant from the perspective of cost reduction; user can find a proper time of maintenance, designer can identify an important part for the product value increase, and so on. The cost management over the whole product life cycle definitely requires integration of all basic information for the design, production, delivery, usage and recycle/remanufacturing/disposal. Hence this information schema

<table>
<tr><td></td><td>can be utilized as the basic information structure for the industrial systems supporting PLM (Product Lifecycle Management), SCM (Supply Chain Management), PDM (Product Data Management), and so on.

To integrate whole element involved in product lifecycle, all information should be quantitative. Hence we can get a conversion framework of qualitative elements into quantitative ones; for example, we can consider an environment effect of product disposal, design effect on product life time, and so on in an integrated way from the perspective of cost.</td></tr>
<tr><td>Specific Features:

e.g. Needed standardization actions, education/training needs, involved industries, …</td><td>Stakeholders and users along a product life cycle (design, production, maintenance, user, recycling etc) need to be trained in cost relevant perspectives to obtain new mindsets.</td></tr>
<tr><td>Suggested Scheme:</td><td></td></tr>
<tr><td>Main interested Regions:</td><td><table>
<tr><th>Region</th><th>Why / Reference</th></tr>
<tr><td>EU
Japan
Korea
US</td><td>This subject was of special emphasis during the interviews conducted in the US, especially how to break the compromise between the application of sustainable practices throughout the lifecycle and their cost.</td></tr>
<tr><td>Whole IMS</td><td></td></tr>
</table></td></tr>
<tr><td>Possible links to other initiatives:</td><td></td></tr>
<tr><td>Timeline:</td><td></td></tr>
<tr><td>Dependencies:</td><td></td></tr>
<tr><td>Topic Relevance Indicator:</td><td></td></tr>
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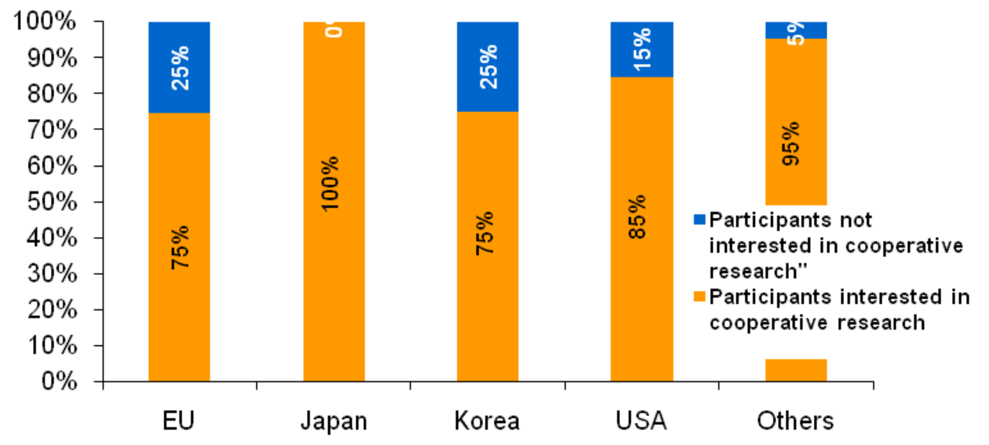
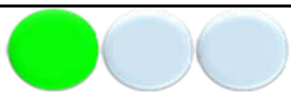
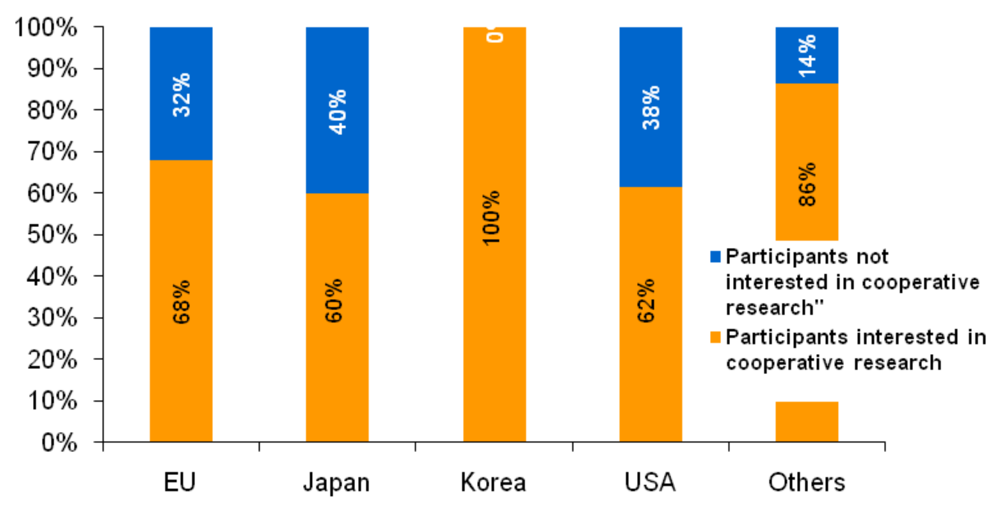
Regional Interest for Collaboration:	

11.7 RT1.07 – EOL Management Supporting Technologies

ABSTRACT:	Remanufacturing is becoming more important as many countries are tightening environmental regulations or legislations in economic activities. The arrival qualities of used products are different and they even change during their remanufacturing processes. Hence, individual handling of used products depending on their dynamic quality can enhance the whole remanufacturing system performance. Optimization of remanufacturing processes will lead to higher efficiency of remanufacturing systems that will allow for the cost effective re-use of remanufactured components while satisfying required quality specifications at the same time. This will contribute in a significant manner in the optimization of resources usage which is one of the main objectives of sustainable manufacturing.
Technical Content and scope:	Multi-agent approaches has been recognized as a promising paradigm to overcome the limitations of conventional centralized systems in the abilities of the expansion, reconfiguration, maintenance without shutting down, and so on. In addition to them, defining used products and parts as agents can support a good framework to handle each used product and part individually. To realize the multi-agent framework, it is necessary to synchronize the agents in the control system with the elements in the real-world; not only fixed facilities like machines but also the floating elements like used products, disassembled parts, and AGVs (Automated Guided Vehicles). Highly developed network/internet technologies enable the agile control of the fixed elements even in the distributed environment, and recent developing RFID (Radio Frequency IDentification) technology can enable the floating elements to be tracked and controlled automatically. In addition, sophisticated sensor technologies can gather gradually or eventually changing quality of resources and parts. The remanufacturing control system can collect the real-world information in real-time by the aid of those technologies and react on the system state change, skip an operation which is not required for a specific part quality, dispose of a part which is highly expected to be unrecovered after all refurbishment operations, and so on. Use of multi agent approaches to obtain data for sustainable remanufacturing involves innovation agents of different kinds. Also human agents will be needed to modify, evaluate and conclude on optimal solutions and decisions. Methodologies to retrieve, analyze, manage and reuse of this data will result in benefit for the users and the society.
Expected results and impact, with special focus on the industrial interest:	As described above, this research focuses rather on the remanufacturing system control depending on the quality change than the quality enhancement itself. Hence it can directly affect the system performance enhancement based-on the real-time information collection without considering resource upgrade, product design change, and so on. The collected real-time information itself can be utilized in various ways; for

	example, by analyzing the statistical information of the success/failure or processing time of disassembly operations, proper resource running time can be examined, profitable/unprofitable used product can be classified, product design can be improved to the direction of efficient disassembly, which is called DfD (Design for Disassembly). By utilizing the extensibility of multi-agent framework, the remanufacturing control system can be expansively applied to the whole supply chain of the product EOL (End-Of-Life) phase. It maybe definitely helpful to planning and scheduling of each dismantling, remanufacturing, and recycling plant.
Specific Features: e.g. Needed standardization actions, education/training needs, involved industries, …	Stakeholders need to be informed and trained in perspectives of remanufacturing to obtain new mindsets.
Suggested Scheme:	
Main interested Regions:	**Region** / **Why / Reference** **EU** **Japan** **Korea** **US** **Whole IMS**: X
Possible links to other initiatives:	
Timeline:	
Dependencies:	
Topic Relevance Indicator:	

Regional Interest for Collaboration:	

11.8

RT1.08 - Predictive maintenance

ABSTRACT:	Traditionally, PLM has been based on integration of a number of centralised ICT tools (CAD, ERP, PDM...) predominately operated and used by manufacturers and suppliers, and hence impossible to have meaningful input by product users. With the development of distributed Closed-Loop PLM based on Embedded Information Devices that facilitates users to provide detailed and valuable information about the use stage of product, it is expected that distributed knowledge with an extended value chain demand including users/operators will be generated and used to support predictive maintenance applications for the optimal operation of an asset through its lifecycle.
Technical Content and scope:	In the coming years the use of Embedded Information Devices (including RFID) will be extended from the current use in identification and logistics applications (mainly in the retail sector) to a wide variety of other applications through generalised tagging of product (or artefacts). These wider applications almost inevitably include the involvement of consumers and users beyond the traditional interpretation of existing product life-cycle management (PLM), to promote holistic information exchange between designers, producers, users and recoverers of future complex products. Therefore, the management of data and information flows and D-I-K (Data-Information-Knowledge) transformations all along the lifecycle of products will involve more and more consumers / users and service providers' interactions. Among them, the generation of information and/or knowledge from the data gathered by embedded information devices for the predictive maintenance is one of the mostly interested areas of manufacturers. However, the data transformation for the predictive maintenance is still vague and in its infancy in spite of its usefulness. Additionally, stakeholders along the product life cycle (e.g., consumers and users) possess extensive and valuable tacit knowledge concerning predictive maintenance aspects that can be attempted extracted for inclusion along with information generated by embedded devices. Combining the technical information provided by embedded devices with valuable tacit knowledge related to usage and maintenance may for example support the analysis for root cause analysis pertaining to problems detected by embedded devices.
Expected results and impact, with special focus on the industrial interest:	The predictive maintenance base on more accurate estimation of product status by the embedded information devices reduces required time and cost for maintenance. Also, it enhances the reliability of product by preventing failure in advance of its occurrence.
Specific Features: e.g. Needed standardization actions, education/training needs, involved	Education will be required to train designers, production engineers and business managers to adopt developed methods and tools.

<table>
<tr><td>industries, …</td><td></td></tr>
<tr><td>Suggested Scheme:</td><td></td></tr>
<tr><td>Main interested Regions:</td><td>
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<tr><td>EU</td><td>X</td></tr>
<tr><td>Japan</td><td></td></tr>
<tr><td>Korea</td><td></td></tr>
<tr><td>US</td><td>Interviews conducted in the US, evidence also the need for advances in this topic, especially on the area of Real-time sensing</td></tr>
<tr><td>Whole IMS</td><td></td></tr>
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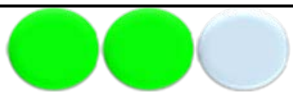
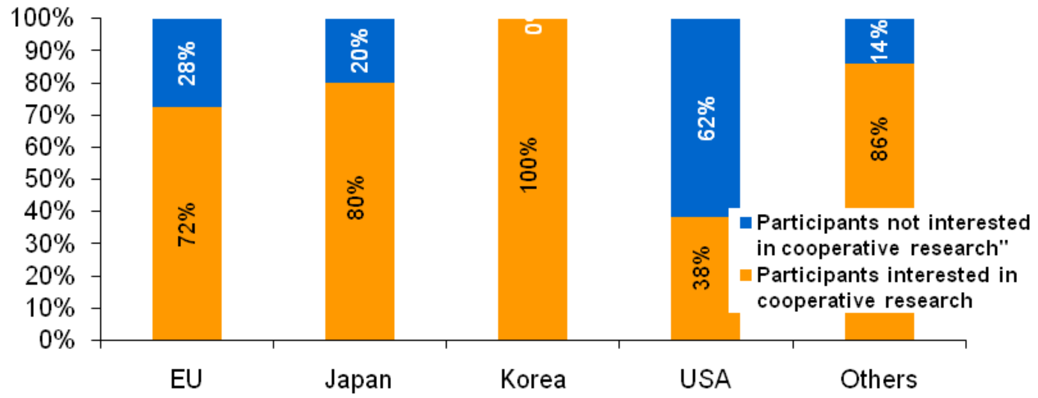
<tr><td>Topic Relevance Indicator:</td><td></td></tr>
<tr><td>Regional Interest for Collaboration:</td><td>
</td></tr>
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11.9 RT1.09 - Sustainable Packaging

ABSTRACT:	Packaging (primary, secondary and transit) is an important part of wastes for both industrial and consumer goods. For this reason it is important to reduce its impact by developing re-usable, biodegradable, environmental friendly or even edible packaging. The development of these issues has to take into account existing standards and regulations, finding optimization for sustainable packaging (both ecological aspects and business aspects need to be included).
Technical Content and scope:	Main objective of the project is to promote and find viable solutions for the packaging lifecycle management. This means considering several aspects of packaging. Issues like packaging prevention (use of packaging only where really needed), minimization (reduction of mass and volume per unit of content), reuse/return (reuse of a package or component for other purposes), recycling (reprocessing of materials into new products), energy recovery (Waste-to-energy and Refuse-derived fuel policies) and disposal must be faced properly through a approach. An extended product lifecycle approach should consider the following aspects in particular: • Development of evaluation, assessment and decision support methodologies to help the packaging designers to calculate packaging sustainability impact and minimize it. • New materials have to be used in packaging. The innovative use of already existing materials is particularly challenging, especially when considering the actual possibility of use in industry. The choice of such materials should take specific characteristics into account, as packaging features (protect and handle products), environmental compatibility, reusability and recyclability. • Standards and regulations for packaging have to be supported or, if missing, defined. Packaging is used in most industries and sectors, and some industries have given attention to the sustainability aspects of packaging for some time. In order to develop sustainable packaging systems cooperation between stakeholders throughout the supply chain is required. Such cooperation can be implemented by the use of Communities of Practice, involving both packaging suppliers, packaging equipment manufacturers, users of packaging, government and research organizations.
Expected results and impact, with special focus on the industrial interest:	A reduction in use of packaging by 25% is expected in industries. This will be also reflected in a 30% reduction of logistics cost for manufacturers (less materials, simpler packaging, less waste through “lost” volume for packaging, increased efficiency in transportation). The sustainability of packaging has to be improved by the use of reusable and recyclable materials. Thus, a 20% reduction of packaging volume in disposal is expected.

<table>
<tr><td></td><td>Overall a better cost effectiveness and a reduced environmental impact is expected.
Within the frameworks of the Communities of Practice, cross sectorial education programs should be developed in order to support knowledge and competence development.</td></tr>
<tr><td>Specific Features: e.g. Needed standardization actions, education/training needs, involved industries, …</td><td>Industries have a very important role. Standardization actions are welcome.
A packaging system based on reuse or recycling depends on the end user of the packaging for initiating the return loop. Information and motivation campaigns accompanied by easily accessible re-entry points are required.</td></tr>
<tr><td>Suggested Scheme:</td><td>Large or Small Projects.</td></tr>
<tr><td>Main interested Regions:</td><td>
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<tr><th>Region</th><th>Why / Reference</th></tr>
<tr><td>EU
Japan
Korea</td><td>Many works on this topic are shown both in Academic and Industrial Literature</td></tr>
<tr><td>US</td><td>Great deal of interest given to this topic within the US. Interviews conducted in the US, evidence the need for advances in this topic, especially on the areas of
- Environmentally-friendly product Packaging - reduction/eliminate
- Biodegradable/recyclable, Reuse option
- Take-back methods (EOL standards)</td></tr>
<tr><td>Whole IMS</td><td></td></tr>
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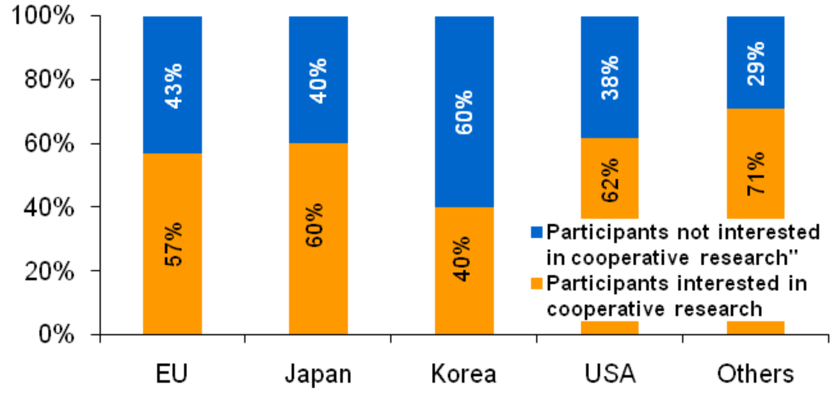
Regional Interest for Collaboration:	

11.10 RT1.10 - Optimization of Electronic Sustainability

ABSTRACT:	Electronic products (such as computers, TVs, IT infrastructures, etc.) are usually prematurely trashed because of obsolescence rather than failures, resulting in a exponentially increasing amount of electronic waste, which represent significant environmental impacts due to their components' content including many hazardous substances such as lead, cadmium or PCBs. Even though their content is mostly metals, the most recycled materials, still electronics as a whole still have low recyclability indexes. Advances in better recycling separation techniques, producer take back systems, materials selection, advanced identification (RFTags) technologies, as well as, systems able closing the loop from the product end-of-life (EOL) to its design are of great importance for this challenge.
Technical Content and scope:	Lately, this sector has been subject to a number of regulations mainly in the EU (e.g. WEEE, RoHS, EuP) to better treat and help reduce electronic waste impact (safe disposal and/or reuse of the product and its materials). These regulations are getting more and more strict and to be able to keep up with their targets, it is imperative to further develop comprehensive lifecycle methodologies to optimize the end-of-life treatments. Advances in materials by considering the materials used and their recyclability on the design stage. Electronic products are widely adopted and used both within industrial and consumer oriented businesses. Within industrial products, electronic components (e.g. electronic boards, intelligent devices, sensors, etc.) have an increasing role, enabling relevant functionalities and substituting more traditional mechanical parts. Other tools, like identification technologies and tracing techniques, could constitute promising elements for reaching a more sustainable management of electronic products. For instance, next-generation PLM systems should allow to take into account environmental constraints from the ground up and help produce better and more efficiently. From resources (which raw material to use that are the most eco-friendly) to processes (automatically computing resulting carbon emissions) and beyond (closing the loop: taking into consideration by-products and recycling)
Expected results and impact, with special focus on the industrial interest:	The application of advanced techniques and methodologies for designing, developing and implementing sustainable electronic products and components will call for a revolution in the entire electronic value chain. Currently, the highest world-wide recycle fraction of contained materials in electronics are cast ions, Pb alloys, Al alloys and Cu alloys between 50-70%. These fractions should be improved at least to 80-90% especially with the fact that the technology is available. On the other hand, materials such as polymers (which most electronics also contain at least by 20% of their total material composition) are only 0-10% recycled. These figures should be improved by at least 50%. Designing methodologies for the recyclability of these materials will aid reaching these industrial targets. Other related results are, for instance, the use of standardised components in manufacturing, which should enable a

<table>
<tr><td></td><td>profitable take-back of end-of-life goods and, after a quality control/repair/remanufacturing of the returned components, their re-use in new goods. This saves material and energy resources, prevents waste, creates skilled jobs and produces substantial savings over new goods with new components. It implies a thinking in multi-functionality, tribology in industrial design. Moreover, a “zero” electronic pollution will have a relevant impact in the worldwide environment, also in terms of better social workers conditions (e.g. in the under development countries, where electronic wastes are often treated in terrible health conditions).</td></tr>
<tr><td>Specific Features:

e.g. Needed standardization actions, education/training needs, involved industries, …</td><td>Many industrial contexts and sectors will be considered, in order to well balance the large diffusion of electronics products and components. In order to provide a relevant impact to the global society, standardization offices and institutions might be involved in the definition of methods and tools for the electronic sustainability.

Standards for the designing, developing and implementing of the relevant materials have to be taken into account to improve the recycle fraction of contained materials. The necessity for new standards should be discussed. In addition, regulations and laws should lead the way to industrial crossing usage of contained materials.</td></tr>
<tr><td>Suggested Scheme:</td><td>Large project</td></tr>
<tr><td>Main interested Regions:</td><td>
<table>
<tr><th>Region</th><th>Why / Reference</th></tr>
<tr><td>EU
Japan
Korea
US</td><td>

Special interest in this topic for US electronics industry and academia. Interviews conducted in the US, evidence the need for advances in this topic, especially on the areas of
- Reverse logistics
- Recycling technologies
- Hazardous materials and substitutes
- Take-back methods</td></tr>
<tr><td>Whole IMS</td><td></td></tr>
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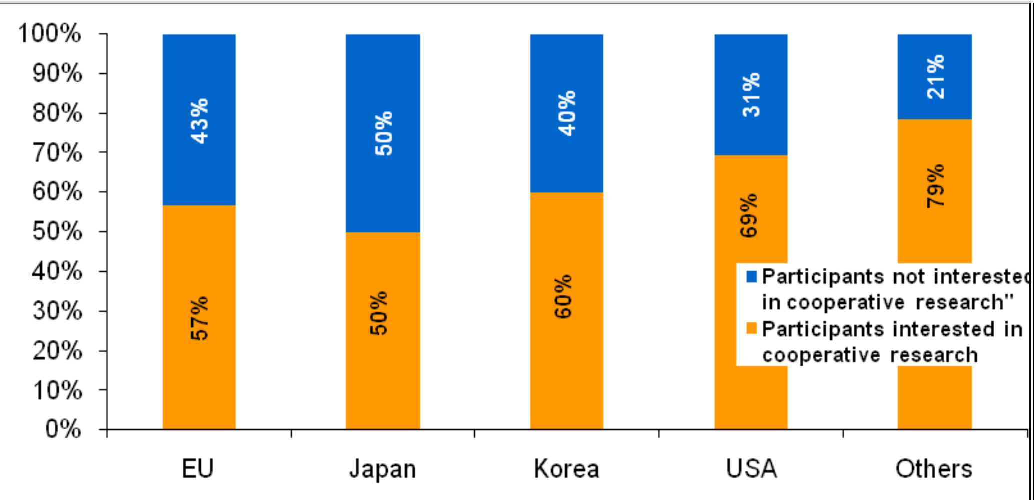
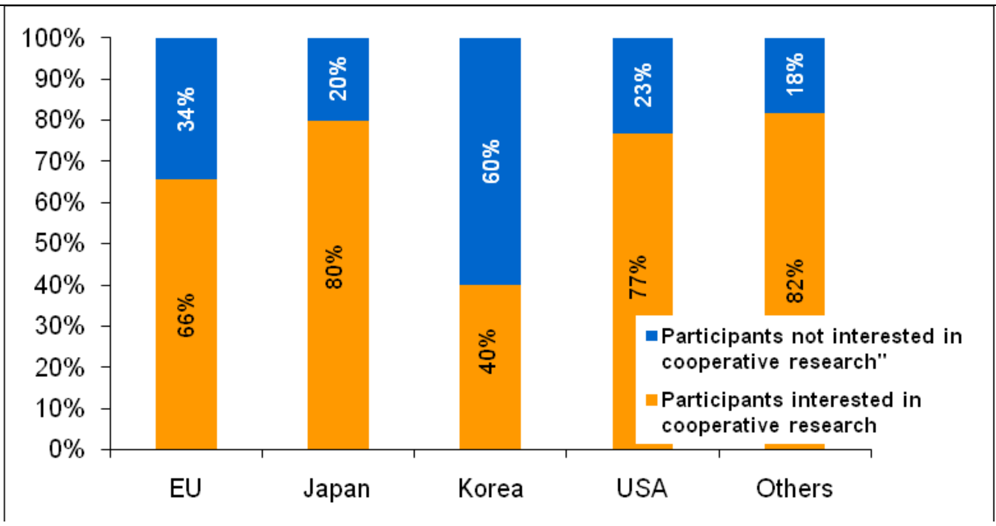
Regional Interest for Collaboration:	

11.11

RT1.11 - Materials re-use optimization

ABSTRACT:	The aim of this research topic is to develop methodologies and tools to improve materials reuse and recycle after products' disposal. The research should include self disassembly technologies, de-manufacture methods, technologies for composite materials, IT tools, methods and best practices to be used by large companies as well as SMEs.
Technical Content and scope:	Reuse and Recycle are means to prevent solid waste from entering the landfill, increasing the material, educational and occupational wellbeing of the society by taking useful products discarded by those who no longer want them and providing them (or part of them) to those who do. Reuse can be performed in many different models and many contexts (industrial and consumer, manufacturing and process oriented, etc.) can benefit from artifacts and raw material reuse and recycle. Reuse and Recycle have environmental as well business impacts as many experiences already demonstrated. Within traditional manufacturing sectors, reusing technologies – like disassembly technologies, de-manufacturing, material recycling technologies – have been already widely investigated. In such a context, a comprehensive approach to material recycle and reuse – in particular in traditional manufacturing sectors (e.g. automotive) – is still missing for reference models and methods. Multidimensional frameworks to material recycle and reuse optimization is not defined, this way limiting the transferring of the already developed technologies to less advanced sectors. The research should so develop these frameworks might include the development of reference techniques, methods, practices, transferring methods and also IT tools. The role of final customers might be particularly considered.
Expected results and impact, with special focus on the industrial interest:	The development of multidimensional frameworks for material reuse optimization will have a relevant impact in the whole European industry: experiences, techniques and technologies developed in the last 20 years in well advanced and financed industries will be transferred to less advanced sectors. A general benefit in the global sustainable development will be reached, reducing the number of material wastes, with the related polluting impacts. Also in term of social benefits, a larger adoption of reuse technologies will improve workers life.
Specific Features: e.g. Needed standardization actions, education/training needs, involved industries, …	Standards defining specific procedures and processes to reuse material, including design for reuse and material separation. Based on these standards, regulations have to be established which direct a quota for re-use of material and the application of the standardized procedures. Establishment of standards needs to base on exisisting standards and close existing gaps. Definition of incentives for advanced industries to pass technology and know-how to less advanced sectors should be highlighted. Creation of a community to share know how and best practices.

Suggested Scheme:	
Main interested Regions:	**Region** | **Why / Reference** **EU** **Japan** **Korea** **US** | Interviews conducted in the US, evidence the need for advances in the area of materials science: Raw materials level - Plastics in particular. Interest is reducing amount of materials reduce amount of materials that goes into current products. **Whole IMS**
Possible links to other initiatives:	to be considered
Timeline:	from now on
Dependencies:	none
Topic Relevance Index:	
Regional Interest for Collaboration:	

11.12 RT1.12 - Sustainable SMEs

ABSTRACT:	SMEs impact is around 70% of the whole manufacturing. The aim of this research is to develop proper methodologies and business models to increase SMEs sustainability, minimizing their inefficiencies and finding a way to make sustainability a value, not a cost. The research will take in account many possibilities as, for example, the use of process modelling languages, standardization, data and procedures integration, new business and evaluation methods development.
Technical Content and scope:	SMEs account for more than 90% of all private sector firms in most industrialized countries [Kerr, 2006]. Sustained development can only truly be achieved through improvement of environmental performance by the SME sector, reportedly the greatest environmental contributors to global pollution [Hillary, 2000]. Although SMEs in certain sectors are catching up on their larger counterparts in reducing their environmental impacts, which are mainly due to supply chain demands, statistics clearly show that the majority of manufacturing SMEs are not incorporating formal environmental management system into their business and when it is present, it fails to lay a link between a company's business strategy and its environmental strategy. The project has to develop new business models for SMEs, capable to integrate the concept of sustainability within business strategies of the company, developing a new paradigm of thinking and acting in order to meet the needed competitive, environmental and social challenges. In other words, the project aims to develop a framework that allow a more holistic business approach capable to capture the concept of sustainability more appropriately seeking an integrate business, social and environmental policy. The new model must mediate between improving environmental performance, business competitiveness and social aspects so that the business really is the sum of all its parts -people, profit, planet- enriching the reputation, corporate value and the sustainability of company and its business. The project has also to develop proper managerial techniques for the sustainable management of all processes within the value chain of the company, focusing particularly on production processes that typically have the greatest impact on environment and energy consumption, taking into account in addition to traditional performances of a production system such as cost, quality, productivity, aspects related to sustainability and energy efficiency in order to guarantee a sustainable management of production facilities (minimizing their inefficiency, taking care of employees, etc.). Sustainable business models for SME framework, methodology and tools to perform simulation of strategies and models of sustainable SMEs are necessary on different levels. Development of serious

	games which allows people to play on alternatives and decision making on conceptual sustainable models will be very useful.
Expected results and impact, with special focus on the industrial interest:	Expected impact on industries is related to a deep transformation of SMEs current business models and managerial techniques. Taking into account the triple bottom line of sustainability (profit, social and environmental) the developed business models allow SMEs to implement strategies capable to address in an integrate manner economical, social and environmental issues, achieving and maintaining a competitive edge depending on this integrated approach. The implementation of the developed managerial techniques for value chain processes will allow an improvement of sustainable performances of SMEs such as: • Less wastes; a reduction of 10% is expected. • Energy and eco-efficiency; energy consumption of around 15% is expected; • Reduction of material intensity; • Reduction of toxic dispersion and substances (such as solvents); • Enhancement of material recyclability; • Maximization of sustainable use of renewable resources.
Specific Features: e.g. Needed standardization actions, education/training needs, involved industries, …	**EDUCATION:** • Enterprises need to recognized and reinforce the benefits and value of educating, training and developing their employees to have long life learning attitude and skills. Sustainability education and training of employees are necessary, also using new methodologies for education/training based on new IT tools. • Develop a sustainable leadership education curriculum to enable business leaders to turn sustainable strategies into a competitive edge with increased revenue potential by intensively working with concepts around the Triple Bottom Line of sustainability, Corporate Social Responsibility (CSR) and sustainability tracking. **STANDARDIZATION:** Develop new standard tools and indicators (KPI) for sustainability tacking, i.e. to monitor and assess 'sustainable' performances of enterprises (products and processes).
Suggested Scheme:	Large-scale Project since the time and efforts needed to achieve the aim are very high.
Main interested Regions:	**Region**: **EU** — **Why / Reference**: There is interest by EU in this topic. A literary review has shown that a lot of studies and projects, also funded by EC, have been made on linked topics.

<table>
<tr><td></td><td>Japan
Korea
US</td><td>US interviews conducted in various SMEs within different industries evidence the need to incorporate this topic in their business, starting from education on the importance and meaning of sustainable practices.</td></tr>
<tr><td></td><td>Whole IMS</td><td></td></tr>
<tr><td>Possible links to other initiatives:</td><td colspan="2">FutureSME (EU-funded project)</td></tr>
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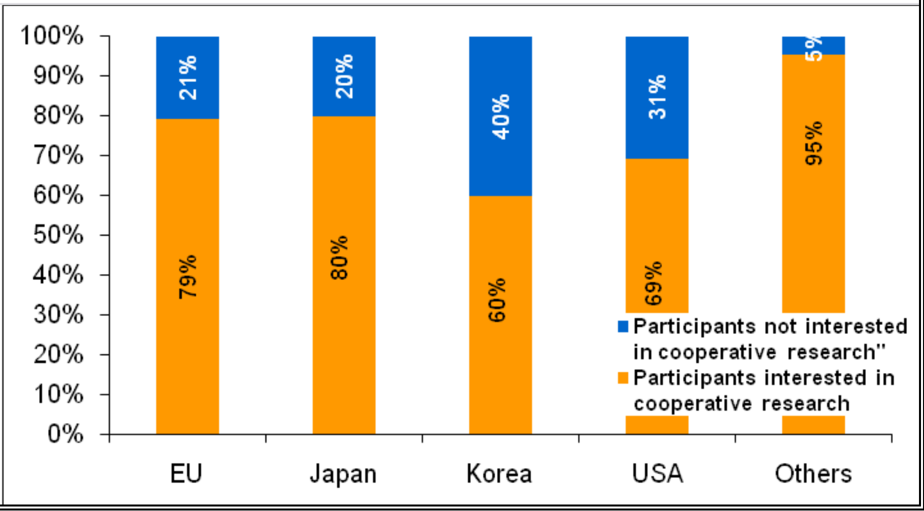
<tr><td>Regional Interest for Collaboration:</td><td colspan="2">
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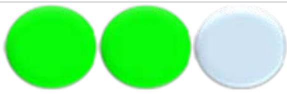
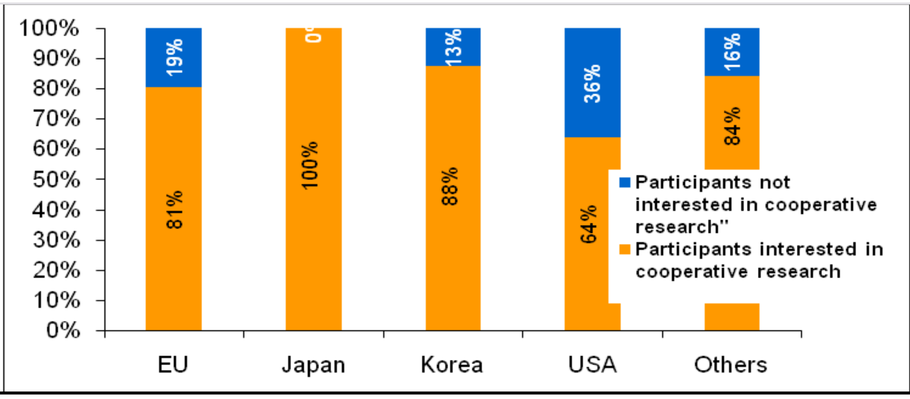
11.13

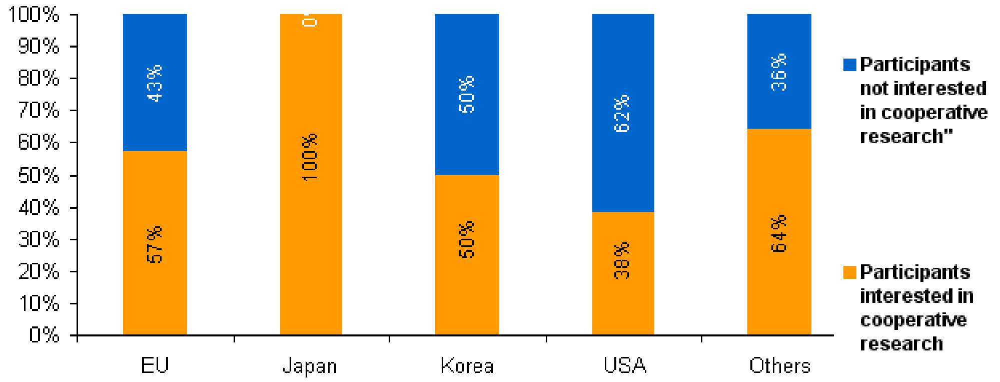
RT1.13 - Maintenance Concept for Sustainability

ABSTRACT:	Longer machine life cycles and higher equipment performance in respect to resource consumption, energy consumption and availability could be achieved through effective and efficient maintenance, making this topic an important issue for sustainability. New maintenance concepts should improve the level of sustainability in manufacturing through innovative and predictive measures. Therefore, new evaluation concepts integrating sustainability related aspects (e.g. Total Cost of Ownership (TCO) calculations, energy efficiency) into maintenance management need to be designed and implemented.
Technical Content and scope:	Since maintenance represents one of the main enabler for high equipment availability, long equipment life cycles and efficient energy and resource utilization, it defines significantly the level of sustainability in manufacturing. However, although in research the positive influence of maintenance on sustainability is widely acknowledged, maintenance in practice often is applied highly ineffectively. Especially, the determination of maintenance scopes and frequencies often relies on incomplete decision models, where in particular sustainability related aspects are not or insufficiently considered. In order to improve the application of maintenance leading to a higher level of sustainability in manufacturing, new holistic evaluation concepts with multiple target dimensions (e.g. minimizing the machine`s total costs & the amount of carbon dioxide production) for maintenance management need to be developed and implemented. These concepts should encompass and quantify all relevant sustainability related aspects. A special attention should be given to the implementation of aspects related to energy and resource consumption. In respect to all identified aspects it will be important to find ways for automatic and real time measurements. Therefore, sufficient sensor technologies and data interfaces to machine data need to be developed. In order to ensure industrial relevance active participation of industrial partners, including SMEs, represents an added value to the activities. This will be reflected in the evaluation. Moreover, the projects are expected to cover demonstration activities, including pilot implementations in industrial settings. Besides validating the achieved research results these industrial settings should reveal optimal approaches of training employees and students in the field of maintenance for sustainability.
Expected results and impact, with special focus on the industrial interest:	Results and benefits of the research on energy efficiency related maintenance will be: • A new holistic evaluation concept for real time determining

	maintenance scope and frequency according to detected machine data, which lead to a more effective and efficient usage of maintenance in production. • Automated measuring systems for maintenance. • Improved awareness of maintenance as a facilitator for sustainable manufacturing.
Specific Features: e.g. Needed standardization actions, education/training needs, involved industries, …	The setup of teaching factories will provide a valuable means of training students and employees im sustainable maintenance concepts.
Suggested Scheme:	
Main interested Regions:	<table><tr><th>Region</th><th>Why / Reference</th></tr><tr><td>EU Japan Korea US</td><td>X IMS MTP X Interview X Interview</td></tr><tr><td>Whole IMS</td><td></td></tr></table>
Possible links to other initiatives:	Any initiative dealing with life cycle assessment of products and machinery
Timeline:	
Dependencies:	MTP "Maintenance for Sustainable Manufacturing"
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

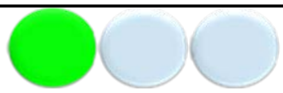
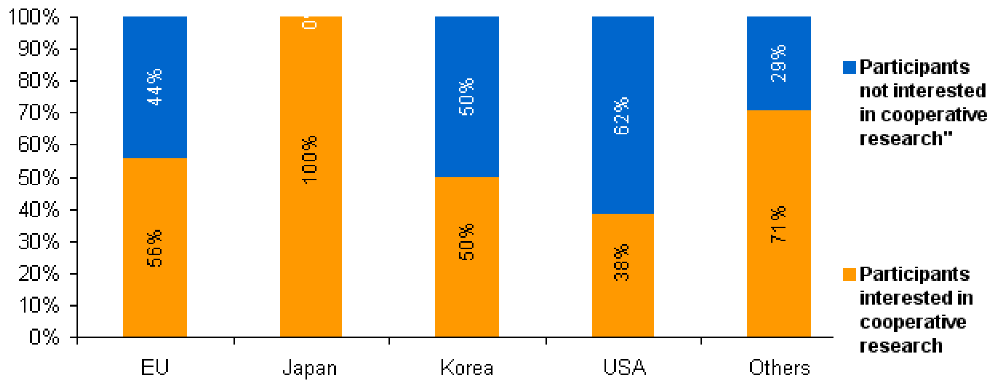
11.14 RT1.14 - Additive Forming Processes for Manufacturing

ABSTRACT:	Traditional manufacturing processes are inefficient from the sustainability point of view. Additive Forming Technologies till now have been used mainly for rapid prototyping. Recently new developments start allowing metal additive forming, opening the doors to additive manufacturing of products components. The research will focus on advancing the state of the art of these technologies, understanding how can be used in manufacturing environments to improve both environmental impact and profitability.
Technical Content and scope:	Traditional manufacturing processes are inefficient from the sustainability point of view; Additive Forming Technologies have been researched for 20 years, developing many different technologies and processes, till now applied mainly to rapid prototyping. The actual development allows additive forming of parts made of various materials (metals, ceramics, etc), resulting with properties similar to classic manufacturing technologies. These advancements will soon allow not only to prototype parts with additive technologies, but also to produce product and components. The research has to focus on how these newly developed technologies can be applied both now and in the near future. It has to take into account the redesign of current business models, design practices, production methods and supply chains.
Expected results and impact, with special focus on the industrial interest:	The research should develop: • new business models to leverage additive manufacturing technologies; • environmental impact evaluation measures for additive manufacturing; • new methodologies to design for light and performing products with low resources usage; • methodologies and tools for mass customization and consumer design. The research has to achieve a mean reduction of 40% of the material used to manufacture products and a reduction of 25% of the energy required. It has also to reduce by 20% the cost of manufacturing a one piece product.
Specific Features:	The research has to develop proper education/training material for designers and consumers to properly use the new design methodologies and tools.
Suggested Scheme:	Large / Small
Maininterested Regions:	**Region** / **Why / Reference** **EU** **Japan** **Korea** **US** — Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of Smart Sensoring for product quality and workforce safety; Wireless technology /Ubiquitous computer (Sensor interoperativity)

	Whole IMS
Possible links to other initiatives:	From now on.
Timeline:	
Dependencies:	None
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

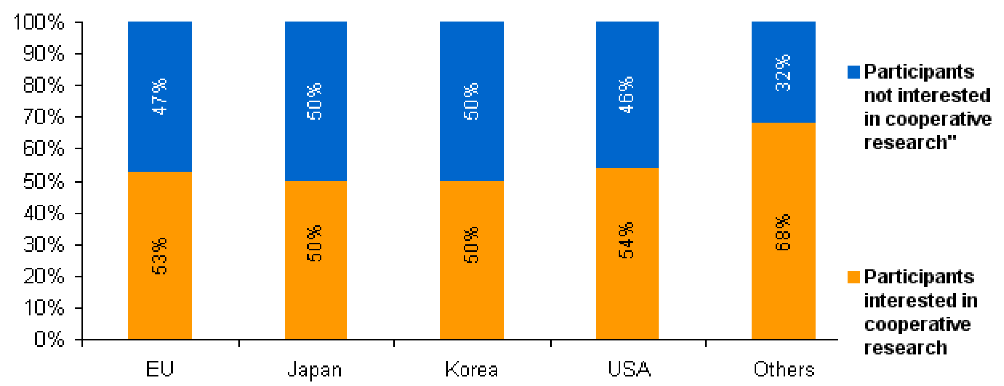
11.15 RT1.15 – New workplaces for Aging and Disabled Workers

ABSTRACT:	In the aging society also workers in manufacturing companies are affected. Moreover disabled people' integration is starting to be an important issue. Considering these social aspects companies have to renew the work processes. For this reason new approaches have to be developed using new tools (design for all), workplaces, working methodologies or special training.
Technical Content and scope:	Two different trends are converging in creating the need for modifying companies workplaces. The first need is related to aging population: age of population is becoming higher and higher and people's working life is being extended. This means that, in the future, companies will have the necessity for managing a greater number of senior workers. At the same time there is a pushing towards a deeper integration of disabled persons into companies in order to give them a qualifying role in modern society. To face these changes, companies need to redesign their working environment and processes. They have to consider the "design for all" paradigm when designing new tools, equipments and machines. New business models have to be developed to include the changes into the companies in a profitable way. To complement the redesigned working environments, personalised learning schemes for aging and disabled workers must be developed. These workers have different learning needs based on for instance medical diagnosis, education and former work experience, thus the learning schemes must be flexible and tailored to the specific conditions and pre-qualifications of the individual worker.
Expected results and impact, with special focus on the industrial interest:	The project has to define guidelines for ageing / disabled workplaces. The new workplaces have to be tested and scored as "more comfortable" by a significant test population. As a result of personalized training and education, industry will access a larger base of qualified potential employees.
Specific Features:	New training material for ageing / disabled workers. Test implementation of the defined workplaces.
Suggested Scheme:	Small
Main interested Regions:	**Region**: **EU**, **Japan**, **Korea** **Why / Reference**:

	US **Whole IMS**
Possible links to other initiatives:	
Timeline:	
Dependencies:	None
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

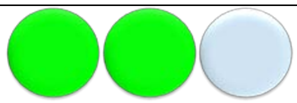
11.16 RT1.16 – Resource Recovery from Alternative Fuels and Raw Materials

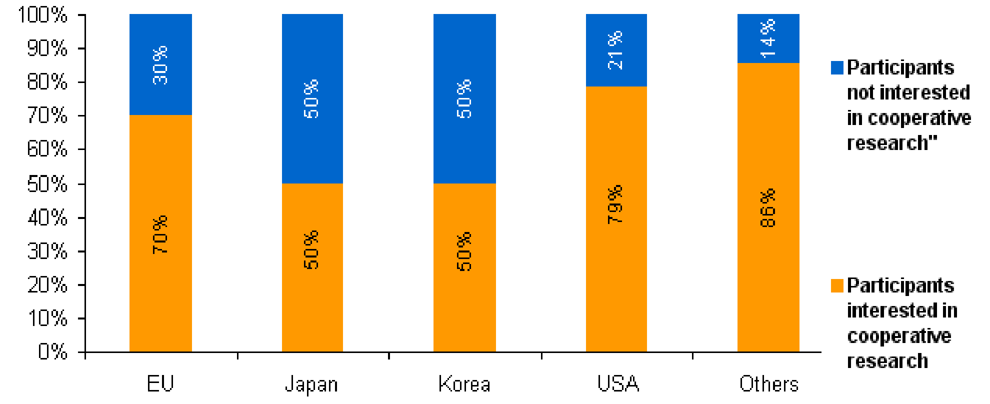
ABSTRACT:	Due to increased utilization of waste materials to substitute either conventional fuels or raw materials in energy intensive industries, the recovery of trace elements contained in such material streams will become a crucial part of future manufacturing processes. Research should aim for technological solutions able to recover such trace elements in an ecological and economical way.
Technical Content and scope:	Co-processing is the use of waste as raw material, as a source of energy, or both to replace natural mineral resources (material recycling) and fossil fuels (energy recovery) in industrial processes, mainly in energy intensive industries such as cement, lime, steel, glass and power generation. Waste materials used for co-processing are referred to as alternative fuels and raw materials (AFR). Besides a certain energy content and minerals that are used to replace natural resources, AFR as a waste material, also contain valuable trace elements such as phosphorous, nitrates or heavy metals that are worth recovering. Introducing these waste materials into an industrial process offers the opportunity to recover those trace elements and save scarce natural resources. Research should address the development of technologies, and the identification of synergies between AFR utilizing industries, the waste treatment industry and the mineral resource providing industry (e.g. mining). Aim should be the ecologically and economically viable recovery of trace elements.
Expected results and impact, with special focus on the industrial interest:	Using waste streams as either raw materials or fuels is becoming an important element in energy intensive industry, chemical industry, waste industry or minerals industry. Making available technology and collaborative approaches to recover trace elements in an ecological and economical way is therefore crucial in the future. Recovering of trace elements contributes to the value creation of a manufacturing process in two ways: • The recovered substances are likely to be retailed or direclty used on site for auxillary purposes. • Certain trace elements are considered to negatively affect manufacturing processes and their products (e.g. heavy metals). Having them removed beforehand will enhance process control and thus product quality.
Specific Features: e.g. Needed standardization actions, education/training needs, involved	

industries, …	
Suggested Scheme:	
Main interested Regions:	**Region** / **Why / Reference** **EU**: X Interview, Roadmap **Japan**: X Interview, Roadmap **Korea**: X **US**: Interviews conducted in the US, evidence also the need for advances in this topic, especially working towards the zero waste concept, Waste close loop: special interest in recycling technology and creating incentives for energy alternatives **Whole IMS**: X
Possible links to other initiatives:	
Timeline:	From now on
Dependencies:	
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.17 RT1.17 – Exploiting Disruptive Innovation for Sustainability

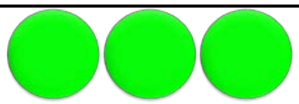
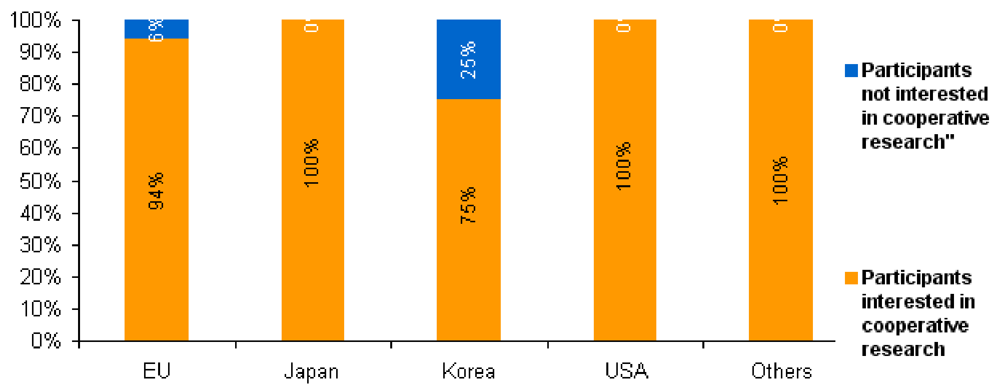
<table>
<tr><td>ABSTRACT:</td><td>Manufacturing companies need to change their approach to innovation if they want to face the current turbulent market. When developing new solutions companies need to take into account sustainability issues. The aim of this research is to develop methodologies and tools to manage and run simultaneously incremental and disruptive innovation, to exploit their potential for sustainability.</td></tr>
<tr><td>Technical Content and scope:</td><td>The challenge for companies is to develop sustainable product and service solutions which capture different dimensions of changes (social, political, environment, etc.) and integrate society needs. It is necessary research on developing tools and methods to support companies to run in parallel:
exploiting activities typical of the incremental innovation to improve products and processes and
exploring activities typical of disruptive innovation to introduce breakthrough in the market.
This means for companies to have the capability to create and manage an idea portfolio characterized by different degree of innovativeness, risk, knowledge, value network and costs. The management of this portfolio can be supported with:
Methodologies for analysis of the market fringes, existing technologies and existing corporate activity.
Methodologies for recognizing discontinuous events and disruptive technologies.
Methodologies and tools for developing alternative strategic frames: build scenario planning into the firm's strategic planning process in order to consider alternative futures.
Methodologies for decentralised resource allocation strategies that encourage risky innovation.
Tools to monitor idea portfolio according to sustainability parameters and support decision on go-no go process integrating qualitative and quantitative criteria.
The new approach to innovation will most probably use workshops to discuss ideas and experience from on-going innovation projects in the organization. This could projects directed at developing new products or services, or projects addressing new manufacturing technology or systems. These projects could be used across the organization and also external organisations to stimulate a learning processes. The learning should be targeted at a special field, for example how to resolve quality issues in assembly of complex products. The participants should exchange ideas, methods and results from their ongoing projects of relevance to the selected learning topic. This will serve as a stimulus for collaborative learning. The approach should take advantage of e-learning technology and site visits to audit and benchmark the</td></tr>
</table>

	projects being studied.
Expected results and impact, with special focus on the industrial interest:	The following results are expected: 1. new organizational methodologies for searching new ideas for generating new products and services; this topic is very important in the context of SMEs that need to balance exploration (radical innovation) and exploitation activities(optimization and incremental innovation) 2. Technological tools for supporting scenario analysis, searching of new idea and internal sharing of knowledge for improving the innovation capability 3. benchmark tool to assess the innovation capability of firm and evalute the gap between the company offer and the market demand. 4. models and guidelines for firms to enable them to improve the innovation capacity according to the dynamism of their markets.
Specific Features: e.g. Needed standardization actions, education/training needs, involved industries, …	Engineers and managers need to be motivated and trained to adopt developed instruments.
Suggested Scheme:	Large or Small Projects.
Main interested Regions:	**Region** / **Why / Reference** **EU** **Japan** **Korea** **US** — Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of reverse logistics, costs compromises, business models and respective standards **Whole IMS**
Possible links to other initiatives:	
Timeline:	
Dependencies:	
Topic Relevance Indicator:	

Regional Interest for Collaboration:	

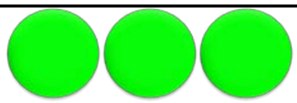
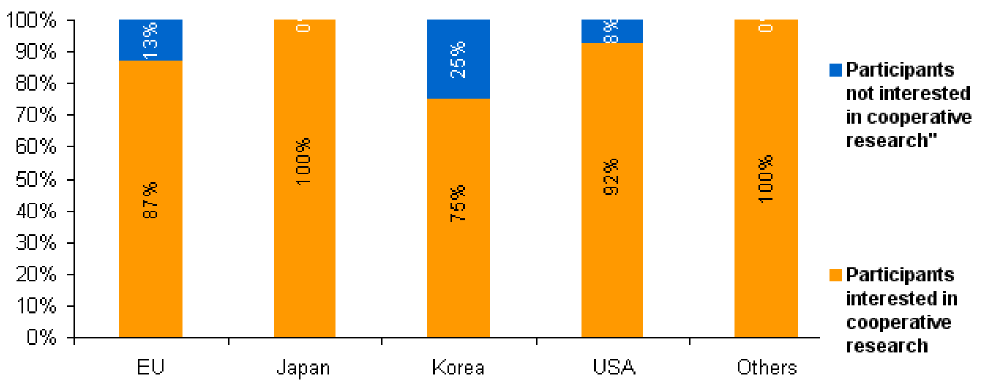
11.18 RT1.18 – Integrated Service Supplier Development

ABSTRACT:	Today suppliers have to provide both physical products as well as complementary services in order to meet the customer demands. Therefore, it is reasonable to build up networks in which producers and service suppliers work together on the configuration of product-service-systems. In order to realize these networks companies need standardized methods and tools for the definition of the relevant interfaces as a common basis for an integrative development process of products and services.
Technical Content and scope:	Increasingly, organizations are involved in integrated global value chains, which link customers and production networks. This integration occurs at both production and support service levels and is facilitated increasingly by new technological means for data processing and transaction coordination. Thus, at the production level, organizations are enabled to better share and/or combine their core production competencies, whereas at the support service level, providers can simpler directly offer to customers and/or pool their service delivery capabilities to enhance operational efficiency and to adapt effectively to customer demands. It is a disconcerting fact that many, if not most, service relationships and networks often have difficulties providing effective support services to production organizations which, in turn, results in lower production efficiencies. Hence, both service providers and production organizations would benefit from practical guidelines that help to improve the delivery of effective services by both single service suppliers and service networks. The set of standards would further support the active and sustainable development and improvement of service supplier relationships. Service supplier relationships offer great opportunities for networking and sharing of knowledge and competence between the network of buyers and providers of services. However, much of the knowledge on what, why and when services arfe needed are not explisitly expressed, rather tacit knowledge held by a limited number of operators. This knowledge cannot lead to service improvements unless it is disclosed. A systematic approach for transforming tacit knowledge to explisit knowledge available to all network members should be addressed.
Expected results and impact, with special focus on the industrial interest:	The final result of work in this field of research will be a practical guideline that leads to significant cost savings and an increase in productivity in service delivery and service network cooperation. This practical guideline provides a basis for systematical standardization activities. Institutionalized standards with such a focus will help market players to develop their individual service network and to build up service supplier relationships.
Specific Features:	Need of institutionalized standardization to guaranty for reference processes, interfaces and common performance indicators.

Suggested Scheme:	Large / Small
Maininterested Regions:	**Region** / **Why / Reference** **EU** **Japan** **Korea** **US** — Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of incentives for new business models (integrate service vs. product) and to support the subject the unification of global standards **Whole IMS**
Possible links to other initiatives:	From now on.
Timeline:	
Dependencies:	None
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.19 RT1.19 – Product-Service Engineering

ABSTRACT:	Due to differentiation needs, companies face tremendous challenges to develop customer solutions as a combination of products and services. The successful application of integrated product and service engineering as a general framework is needed. A set of methodologies, tools, business models and standards for products and services, their interfaces and the underlying processes need to be developed.
Technical Content and scope:	In the past technical high-quality products were key success factors for companies from different branches to establish sustainable leading position on the market. Today the situation has changed. Companies are asked not only for products but also for complementary services. Consequently producers have to advance to solutions provider by integrating products and services into a high value offering. Those offers have the potential to successfully differentiate from competition even in case prices are dictating product markets. However, companies face tremendous challenges to develop customer solutions and proper business models to leverage product-service solutions. Against this background service engineering is considered to be the scientific discipline which supports the design task of intangible offerings and thus a foundation for solution design. The successful application of service engineering as a general design framework requires properly developed: • Business models and KPI measures for Product-Service businesses; • Possible architectures, systems and tools to be eventually used as framework for product-service businesses; • Standards for description of the solution components (products and services), their interfaces and the underlying processes. Product data models and product and process specifications are required as they are common for tangible goods. Standardization is required for implementation and to guaranty for interoperability in solution design and delivery processes. Institutionalized standardization by different IMS regions, like DIN, CEN, NIST and ISO should also be involved.
Expected results and impact, with special focus on the industrial interest:	The final result of work in this field of research will be guidelines respectively diverse business models, KPIs, standards including different methods, architectures and tools. By using these guideline/standards the transferability or the applicability of the product-service engineering concept shall be guaranteed. Furthermore it has to be possible for different companies from variable branches to meet customers´ requirements by supplying individual product-service solutions. In addition the described approach should lead to a decrease of time to market in rapid product-service development processes and to a reduction of transaction costs in solution delivery.

Specific Features:	Need for institutionalized standardization to guarantee for interoperability and later transaction cost and coordination effort reduction in cross country and international trade with product-services. Involvement of at least 2 large companies and 2 SMEs as test cases. The Standardization process, till the end of the project, should have developed a standardization community which involves at least 2 standardization bodies, 5 large companies and a proper number of SMEs, research centres and universities.
Suggested Scheme:	Small Project
Main interested Regions:	**Region** — **Why / Reference** **EU**: Interviews and SOTA analysis in the EU area proved the interest toward the topic as well as the lacking of a fully developed approach to Product-Service issues. **Japan** **Korea** **US**: Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of product and consumer adaptation of new business models **Whole IMS**
Possible links to other initiatives:	
Timeline:	
Dependencies:	None
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.20 RT1.20 - Sustainable Data Management

ABSTRACT:	Nowadays, enterprises fight the problem of inconsistent and redundant data in and between the IT systems. Although knowing about the negative impacts they are not able to avoid the appearance of these challenging effects. As a core competence efficient order processing gains importance. A sustainable management of data and specifying attributes is needed to ensure the electronic exchange of information and order related documents as a precondition of sustainable manufacturing.
Technical content and scope:	The increasing number of multi-site enterprises as well as the necessity of integrated coordination throughout supply chains imposes a tremendous challenge to the order processing performance especially of enterprise resource planning (ERP) systems. Studies proof that the alignment of business and IT is a key factor for successful management while companies struggle in fighting standardization and integration gaps. In fact, the use of different IT systems (such as ERP solutions) often causes physical incompatibility of interfaces. On the other hand compatible (ERP) systems may be used, but semantic differences in the order processing data lead to incompatibilities. These two difficulties can be summarized by the need to close integration and standardization gaps. In both cases companies loose order processing efficiency and competitiveness as long as they do not manage the challenge of closing the gaps. In fact, they are not prepared for sustainable manufacturing. Inhomogeneous landscapes of order processing data, attributes and at last of IT-systems are the root of these problems. To become sustainable in data management the integration and standardization gaps need to be closed. The first step is to run consistent and redundancy free data. Today master data management provides a lot of tools and approaches to fight redundancies and inconsistencies, but none of the concepts works on a long term basis so far. In principle they only ensure one-time benefits but do not include or encourage self-healing processes. In conclusion any new approach needs to contain handling strategies that take aspects of sustainability and long term use into account. A promising approach is to develop standard based concepts that ensure the exchange of data between companies (horizontal integration) and between the different levels of order processing, e.g. between SCM, ERP and MES systems (vertical integration). To become aware of the potential of such concerted actions the value proposition of IT must be analyzed and assessed. Research activities that show the benefit of standardization actions and that provide sustainable approaches to maintain the achieved results are needed.

<table>
<tr><td>Expected results and impact, with special focus on the industrial interest:</td><td>User dimension:
improvement of decision support by determining the value proposition of IT and related projects
increase of process efficiency
less waste of time by reducing activities not adding value
less call backs for clarifying orders
increasing delivery reliability of suppliers
Product service dimensions:
eminent reduction of time-to-market, quality improvement
less missing parts disturbing production flows
enabler for new delivery concepts: incentive driven instead penalty driven (based on increased transparency)
In general:
increase of transparency throughout the whole supply chain
more economic production processes
reduction of bull whip effect</td></tr>
<tr><td>Specific Features:

e.g. Needed standardization actions, education/training needs, involved industries, …</td><td>Sustainable data is generated many places (different companies, different systems, worldwide etc). Cross sectorial training and education on standards and methods of data management is needed.

Intersectorial standardization of exchange data in vertical and horizontal directions.</td></tr>
<tr><td>Suggested Scheme:</td><td></td></tr>
<tr><td>Main interested Regions:</td><td><table><tr><th>Region</th><th>Why / Reference</th></tr><tr><td>EU</td><td>x</td></tr><tr><td>Japan</td><td>x</td></tr><tr><td>Korea</td><td>x</td></tr><tr><td>US</td><td>Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of ICT: Databased decisions (Data to knowledge), interoperatibility, wireless technology. Also, interest on the need for developing guidelines on the evaluation of sustainable projects to support decision making.</td></tr><tr><td>Whole IMS</td><td>Relevant problem for all international enterprises</td></tr></table></td></tr>
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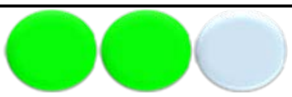
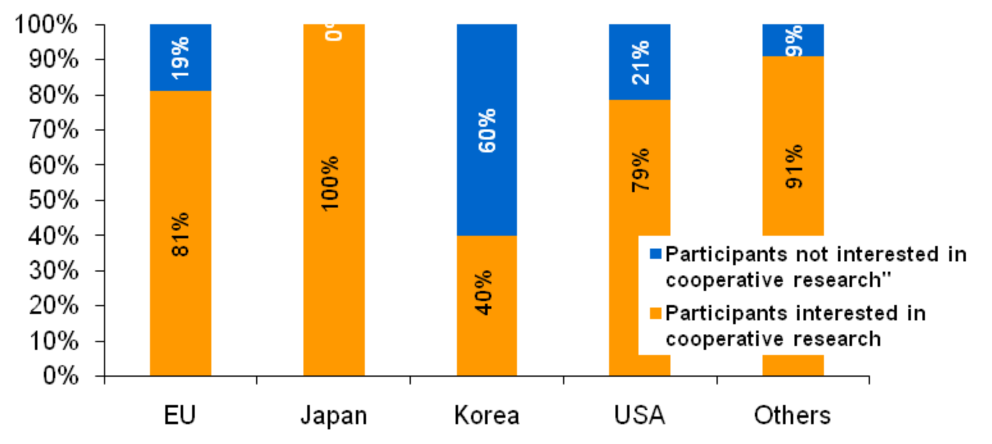
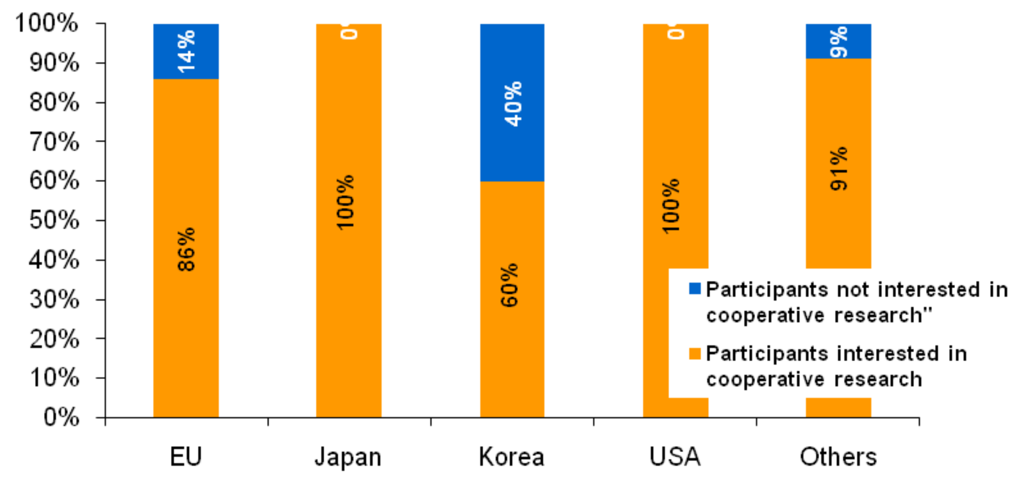
Possible links to other initiatives:	
Timeline:	From now on
Dependencies:	No
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.21 RT1.21 - Sustainable Supply Chain Design

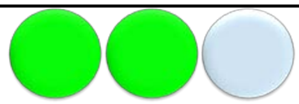
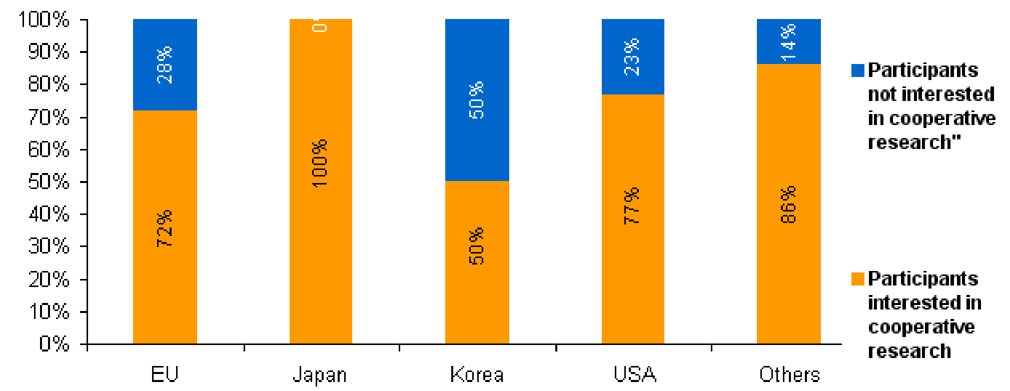
ABSTRACT:	Nowadays more and more companies relocate production sites back to their original location. The reason for the failure of many outsourcing investments is the disregard of facts like skills of the workforce, transportation time and costs as well as ecological issues. Thus the development of a holistic model which is taking all relevant facts into account is necessary to enable sustainable location decisions.
Technical Content and scope:	During the last decade the industrial world changed rapidly. Emerging countries in Asia and eastern Europe have received companies' attention as production sites of consumer and industrial goods. Lower wages are companies' key reason to move from their original sites in America or Western Europe to the emerging countries. Even many small and medium sized enterprises built up production capacities in the so called 'low wage countries'. Nevertheless not all investments in new production sites have been successful. The first companies start to reinvest and reinforce their old production capacities in the western countries of Europe and the US. This is among other reasons caused by the better educated and highly skilled labour that outweighs the low wages within the emerging countries. Beside the better skilled workforce ecological reasons should be taken into account. Less transport and more efficient production technologies reduce the CO2-emissions significantly. This will become an increasing factor for evaluating a production sites quality. Furthermore shorter supply and shipping duration improve the controllability of the production system. This sample of impact factors shows that it's obviously not possible to measure the value of soft factors like a flexible, highly skilled workforce able to cope with the market demand for high variety and complex products. Moreover there are no ways to compare its value in comparison to a less skilled but cheaper workforce. Methods and formulas for the calculation and comparison of all aspects of production are required. Traditional production theory misses the consideration of these soft factors or is underlying too many assumptions making the formula unrealistic and not applicable in practice. Therefore research should focus on developing methods and formulas constituting a new holistic decision model that takes all relevant production factors into account. A set of formulas valuing the requirements for the production system resulting from aspects like product complexity, customer requirements, frequency of changes regarding customer and environment (supplier, technologies, etc.) needs to be developed. An appropriate production system has to meet these requirements without being over dimensioned to be most efficient. Optimally its capabilities should equal the requirements plus a certain security value. To design such a system approaches able to evaluate the abilities of a production system not only in terms of cost but also with regard to e.g. changeability and ecological aspects needs to be developed. As a result

	a decision support tool should be developed to support industrial companies to make a sustainable location decision. Special attention has to be paid to the validation of the formulas and the developed tool in the adequate industrial setting. Therefore enterprises from different stages of the value chain have to be involved in the project. In contexts where a combination of multiple factors influence the outcome, simulation techniques are often found very valuable. A powerful simulation technique is the Serious Games approach where a virtual business environment is established to facilitate playing with different solutions to identify those who will work under different conditions. Moreover, the use of a serious games technique will stimulate learning and reflection.
Expected results and impact, with special focus on the industrial interest:	Especially for SME's relocation of production sites or capacities is both an opportunity and a considerable risk. Providing an analytical basis to support this decision is valuable benefit for any industry. Additionally so called high wage countries benefit by being able to quantify their - in most cases - soft location advantages. This way more companies can be attracted to move to the specific regions or prevented from moving away. Once developed, a serious game technique can be applied irrespective of industry and education level.
Specific Features:	▪ Standardization of indicators, formulas and decision tool to provide a common basis. ▪ Education and competence development measures to support change of mindset away from cost focusing.
Suggested Scheme:	Large/Small
Main interested Regions:	**Region** / **Why / Reference** **EU** **Japan** **Korea** **US** — Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of distribution systems: transportation optimization and Supply Chain modelling **Whole IMS**
Possible links to other initiatives:	
Timeline:	From now on
Dependencies:	No
Topic Relevance Indicator:	From the analysis of the answers, emerged that this topic is extremely interesting for Researchers; the industrials answers instead reveals a relevance

	of 2/3.
Regional Interest for Collaboration:	

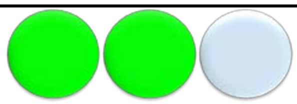
11.22 RT1.22 – Alignment of IT and Business Strategies

<table>
<tr><td>ABSTRACT:</td><td>This research topic addresses the lack of knowledge regarding the ability to measure the indirect contribution of the IT department to the success of an enterprise. How to set up controlling and measurement standards to align IT activities to strategic company goals is the core question to be answered.</td></tr>
<tr><td>Technical Content and scope:</td><td>"You can‘t control what you can‘t measure.“ Tom DeMarco
In times of economic regression, enterprises are at high pressure to low costs in indirect departments. One of these is the internal IT-department. Because of missing structural approaches to measure the benefit IT provides, controlling and optimizing according to the business strategy becomes difficult. Rather intuitional optimizing strategies are implemented. This culminates in unconsidered cuts in IT budgets. First relevant and necessary investments will be deferred and as a result problems in enterprise business occur. In many cases this problem can only be solved with an exorbitant increase of IT budget. With respect to this problem different questions have to be answered in the future:
Does IT create economic benefit at all?
How can IT be controlled to support or fulfil company goals optimal?
How does IT influence business processes and their monetary outcome?
What is the optimal level of IT-support?
Is IT fully outsource able?
To facilitate a good learning process, benchmarking may be applied. However, new benchmarking tools need to researched and developed for this purpose in order to have easy access to best practices.</td></tr>
<tr><td>Expected results and impact, with special focus on the industrial interest:</td><td>Results of work in this field of research will be methods, tools, IT-product catalogues and standards that allow to measure and afterwards control the internal IT-department especially of SME. As a result an improved alignment of IT and business strategy helps to analyze specific invest or disinvest necessities and consequently create or ensure competitive advantages.</td></tr>
<tr><td>Specific Features:</td><td>IT-products and the corresponding model of description of such products have to be standardized.
Measuring the benefit of investments in internal IT is fundamental for SME in each industry.</td></tr>
<tr><td>Suggested Scheme:</td><td>Small</td></tr>
<tr><td>Main interested Regions:</td><td><table><tr><th>Region</th><th>Why / Reference</th></tr><tr><td>EU</td><td></td></tr><tr><td>Japan</td><td></td></tr><tr><td>Korea</td><td></td></tr><tr><td>US</td><td>Interviews conducted in the US emphasize greatly the</td></tr></table></td></tr>
</table>

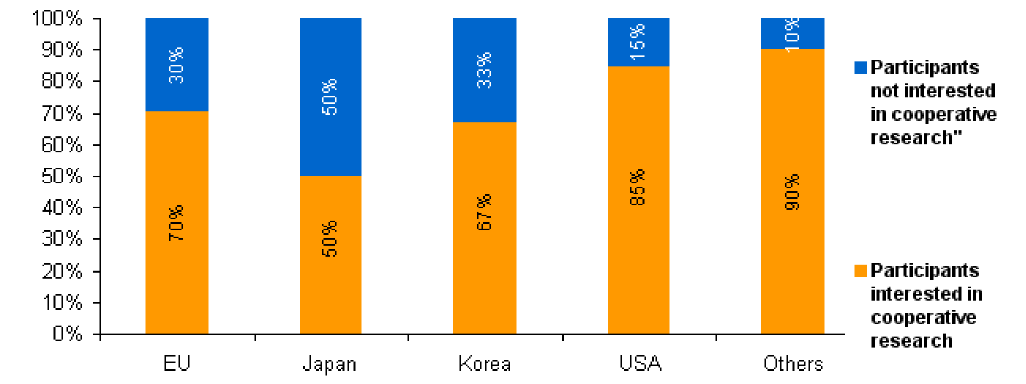
		need for advances in this area of maximizing the advantages of effective IT technology to the strategic plans of each department/company
	Whole IMS	
Possible links to other initiatives:		
Timeline:	From Now on	
Dependencies:	None	
Topic Relevance Indicator:		
Regional Interest for Collaboration:		

11.23 RT1.23 – Multi-dimensional Inventory Management

ABSTRACT:	Companies constantly reduce their depth of value creation leading to inherent but inefficient and ineffective increase of stock echelons in the supply chain. To overcome this, it is necessary to expand the perspective of current supply chain management to a multi-tier view by utilizing higher information flows in future. New multi-stage models for supply chain configuration defining stock keeping echelons and order penetration points to optimize supply chain inventory levels are undisputed required.
Technical Content and scope:	A key feature of present production networks is the idea that supply chains compete, not companies. The success or failure of supply chains is ultimately determined by the availability of products for the customer. The ongoing trend to decrease the depth of value creation per company leads to an inherent increase of stock keeping echelons in the supply chain. Although modern supply chain management approaches target to counteract this development, they are focussing just on the interface between two companies. Beyond that, new information technologies as e.g. auto-id technologies or service oriented architecture emerge and lead to higher information flow. Current research on supply chain management has not incorporated the possibilities to leave beaten tracks by using the prospective information flow, or even to deal with the risk of information overflow. Thus, an applicable multi-echelon approach based on high resolution information transparency is not researched yet and undisputed required. Therefore, the research should focus on expanding the perspective of current supply chain management approaches from a two-tier to a multi-tier view by taking the expected higher information flow in future into account. In particular a general model for the configuration of the supply chain in terms of stock keeping echelons, order penetration points, synchronisation of the material and information flow and finally optimizing of supply chain inventory levels is needed. In order to ensure the industry applicableness of the general model, experience needs to be gathered by simulating industry use -cases on the basis of real master- and transaction data. This experience will assure the validation of the model and its cost-effectiveness and performance leverage. Additionally, an incentive system has to be developed to foster the application of such an cross-company approach. This incentive system has to include a cost-benefit-sharing model to guarantee the fair sharing of benefits and related costs. This topic requires significant demonstration activities taking companies of the whole value chain into account. Besides suppliers, manufacturers and distributors also logistic service providers need to be considered. Demonstration activities need to incorporate the development of a game based tool able to visualize the cost reduction impact of such a general model. Applying this tool in a specific supply chain needs to show the concrete benefits for every single stage. Such a simulator will illustrate the supply chain

	perspective and aid in the work of building a common basis for overall optimization and the use of incentive mechanisms.
Expected results and impact, with special focus on the industrial interest:	Considering the current financial crisis and the resulting practice of granting loans (especially to SMEs) the reduction of assets, specifically working capital, has become most important. The resulting financial scope is badly needed by many companies. Additionally especially SMEs' possibilities to invest in a higher efficiency are limited. In logistics there is often still a high optimization potential which can be realized without high investments. Nevertheless the profit impact is high, since already local optimizations are able to reduce stocks by 30% in several cases.
Specific Features: e.g. Needed standardization actions, education/training needs, involved industries, …	The involvement of companies covering several stages of the supply chain is necessary to ensure the general character of the model.
Suggested Scheme:	IP
Main interested Regions:	**Region** — **Why / Reference** **EU** **Japan** **Korea** **US** — Interviews conducted in the US evidence also the need for advances in this topic, as well as in the area of inventory policies **Whole IMS**
Possible links to other initiatives:	Link to the other RTs on Supply Chain within the timeline.
Timeline:	From now, on.
Dependencies:	Emerging technologies that support higher information flow (e.g. auto-id).
Topic Relevance Indicator:	

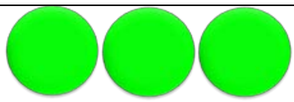
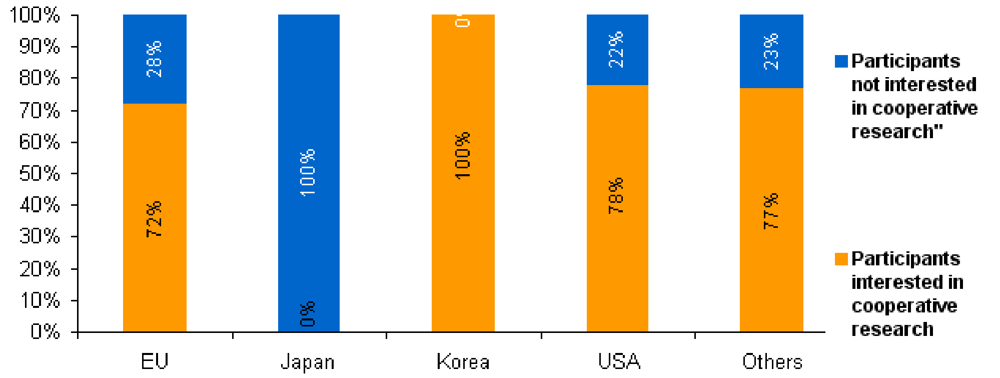
Regional Interest for Collaboration:



11.24 RT1.24 – Integrative Logistics Tools for Supply Chain Improvement

ABSTRACT:	Local optimizations in the logistics chain often lead to inefficiencies at another place. Therefore, tools to cooperate within a supply chain, to harmonize the logistics, and to improve the overall performance have to be found, implemented and summarized in a tool box.
Technical Content and scope:	Today's supply chains frequently are wide networks consisting of many globally distributed companies. Logistics processes are generally optimized locally only. This local optimization brings benefits to single companies, but in contrast, often has a negative impact on other supply chain partners. Therefore, the overall energy consumption and costs have to be decreased. Harmonizing the logistics in the supply chain will result in an overall increase of efficiency. Tools have to be developed enabling to coordinate the requirements and flexibility of the supply chain partners with the 3PLs (third party logistics providers). A number of less integrated tools exist, and while they are applicable in dyadic relationships they fail to consider the wider picture of multi echelon supply chains and networks. Yet the knowledge provided by these tools is valuable and should not be discarded. Eventually, the benefits achieved need to be shared cross companies with the supply chain stakeholders. The research should focus on the inefficiencies in the current logistics processes which occur from the lack of transparency between the supply chain partners. This lack hinders harmonization of single processes taking place between the different 3PLs and their customers. By uncovering the barriers to an efficient logistics structure, partners gain a basis for collaborative improvement. Here, known approaches from production management, such as Systems Engineering, Six Sigma, or Lean Management, are applied and adapted to the needs at hand with the aim to detect waste and increase the overall efficiency. Tools for high level supply chain mapping should be developed to create a common understanding among supply chain participants. Furthermore, tools for mapping and analysis of supply chain planning and control policies should be developed in order to create synchronized decisions across the supply chain. In addition, benchmarking has a clear potential as a systematic learning methodology where a community of enterprises can benefit from practices and solutions tested and developed by others. On this basis, supporting procedures, toolsets and/or software will be developed, which allow for communication and information exchange between the logistics customer and 3PL in order to adapt processes to the specific priorities and requirements. The project is driven by 3PLs as well as manufacturing industries in order to facilitate results relevant for both parties. To gain a holistic picture all common transportation modes have to be included as well as various sectors of industry. Small and medium sized enterprises (SMEs) need to be actively

<table>
<tr><td></td><td>involved as the requirements and the relationship to the 3PLs differ from the big enterprises.
A test and validation period in an industrial setting will show the functionality of the methodologies developed and deliver tangible outcomes on the applicability.</td></tr>
<tr><td>Expected results and impact, with special focus on the industrial interest:</td><td>Today, competition takes place between supply chain networks. In future, this development will advance, so that companies of a value chain have to cooperate even stronger. Eco-friendly (both economic and ecologic) supply chains and logistics will play a crucial role in this development. Enhanced communication will enable increased planning accuracy and a flexible adaptation to changes. On this basis, different modes of transport can be chosen in an efficient and ecologic way with e.g. optimal load factors, consumption of fuels, and delivery times. Overall cost savings up to 10-15% can be reached cross the supply chain whilst reducing the carbon footprint by 10%. A benchmarking model developed as a generic learning system will be beneficial to members of supply networks including the end customers also. A generic learning tool will be applicable across industry sectors.</td></tr>
<tr><td>Specific Features: e.g. Needed standardization actions, education/training needs, involved industries, …</td><td>Optimally, the consortium consists of supply chain partners and 3PLs who already work together so that communication and collaboration are facilitated.</td></tr>
<tr><td>Suggested Scheme:</td><td>Collaborative project.</td></tr>
<tr><td>Main interested Regions:</td><td>
<table>
<tr><th>Region</th><th>Why / Reference</th></tr>
<tr><td>EU</td><td>Actors cross the supply chain need to collaborate to increase efficiency.</td></tr>
<tr><td>Japan</td><td>Ubiquitous manufacturing and communication cross borders need to be realized; the supply chains have to be redesigned for optimized transportation; Ideas for new transportation and energy efficient production systems have to be generated, and best practices for green logistics systems provided.</td></tr>
<tr><td>Korea</td><td>Green logistics need to be realized by integration of several industries and with support of "ubiquitous technology" containing product characteristics and life cycle information</td></tr>
<tr><td>US</td><td>Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of distribution collaborative systems, reverse logistics / Logistics simulation</td></tr>
<tr><td>Whole IMS</td><td>X</td></tr>
</table>
</td></tr>
</table>

Possible links to other initiatives:	
Timeline:	
Dependencies:	
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.25 RT1.25 - Management of Hazardous Substances in Manufacturing

ABSTRACT:	Adequate management of hazardous substances is needed to reduce the impact of industry activity on the environment and human health and safety. Research focuses on the development of production methods, ICT solutions and recuperation technologies that reduce use and generation of hazardous substances as well as guarantee a safe management of them.
Technical Content and scope:	It is a strong convincement that the future society will require consistent transformations of current industrial practices for a new generation of "environmentally friendly" solutions. In this sense, appropriate management of hazardous substances along the manufacturing chain plays a key role in the way through the reduction of the environmental impact of human activities, the protection of the environment and an efficient use of energy and natural resources. The manufacturing industry continues to be the core of wealth creation and employment in Europe and it is continuously asked, by the pressure of the public opinion and by the constraints coming from regulations, to be the leader in application of new environmentally sustainable methods for producing and managing the total life cycle of the products. Accomplishing environmental issues is an added value in the global markets since cost-based competition is unsustainable. Adequate management of hazardous substances derived from manufacturing activity is also requested to respond to increasing societal concern for human health and safety, both in Europe and beyond. The topic focuses on: ▪ The avoidance of using hazardous materials or processes as well as the generation of hazardous products, wastes and other outputs . ▪ The diligent use of any kind of hazardous materials and processes together with a moderate generation of hazardous outputs . ▪ The mitigation of the use of hazardous materials or processes and the generation of hazardous outputs . ▪ The minimization of the risks derived from the use or generation of hazardous materials, processes and outputs . Approaches should consider an integrated analysis of the product life cycle.
Expected results and impact, with special focus on the industrial interest:	Research results include: ▪ New and improved green production methods that eliminate or reduce hazardous substances/processes from the entire value chain of the products. ▪ ICT based techniques and services that prevent the footprint of hazardous processes and outputs on the environment or human health and safety. ▪ Eco-technologies that prevent damages on the environment or human health and safety resulting from hazardous wastes through their safe treatment or recuperation. Expected impact of the R&D developments: it is expected that substitution of hazardous materials from the manufacturing

<table>
<tr><td></td><td>chain by environmental friendly alternatives, elimination of hazardous processes by new clean and environmental technologies and elimination of hazardous substances from final products will pave the way towards eco-label certification. The developed ICT solutions will bring by the next 10 years significant progress towards a new production paradigm which is footprint-free on the environment, human health and safety. The R&D developments will lead to a 35% cut in hazardous wastes of the manufacturing chain while treatment and recuperation technologies will guarantee a 100% safe management of the generated hazardous wastes.</td></tr>
<tr><td>Specific Features:</td><td>The topic is well suited for international collaboration within the IMS scheme regarding environmental and safety issues, in particular at the following levels:
Creation of standards that enhance global innovation in terms of clean and environmental manufacturing technologies and products.
Definition of technologies and methodologies to measure and assess footprint of manufacturing on the environment, human health and safety.</td></tr>
<tr><td>Suggested Scheme:</td><td>Small or Medium scale focused research projects</td></tr>
<tr><td>Main interested Regions:</td><td><table><tr><th>Region</th><th>Why / Reference</th></tr><tr><td>EU</td><td></td></tr><tr><td>Japan</td><td></td></tr><tr><td>Korea</td><td></td></tr><tr><td>US</td><td>Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of Management of hazardous materials in pharma and medical devices industry</td></tr><tr><td>Whole IMS</td><td>X (also India and China)</td></tr></table></td></tr>
<tr><td>Possible links to other initiatives:</td><td>Eureka, ERA-NET, CRAFT programmes, 7FP Energy theme</td></tr>
<tr><td>Timeline:</td><td>Long term</td></tr>
<tr><td>Dependencies:</td><td>None</td></tr>
<tr><td>Topic Relevance Indicator:</td><td></td></tr>
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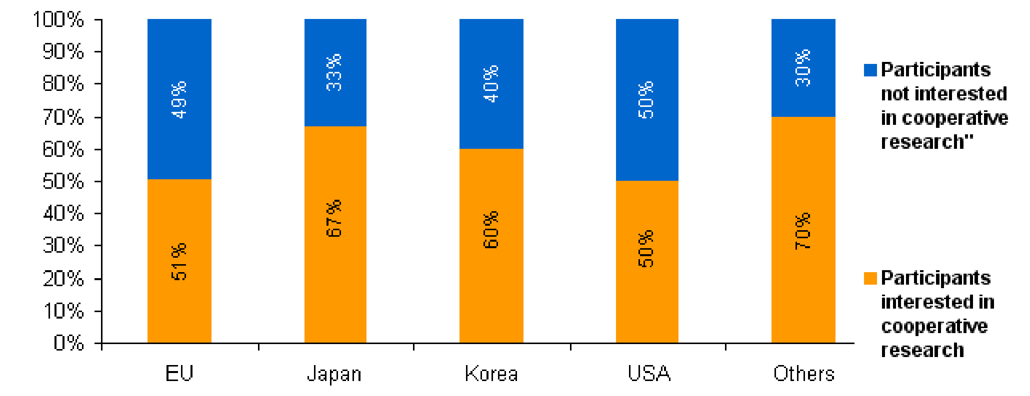
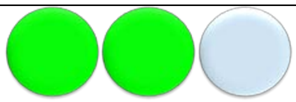
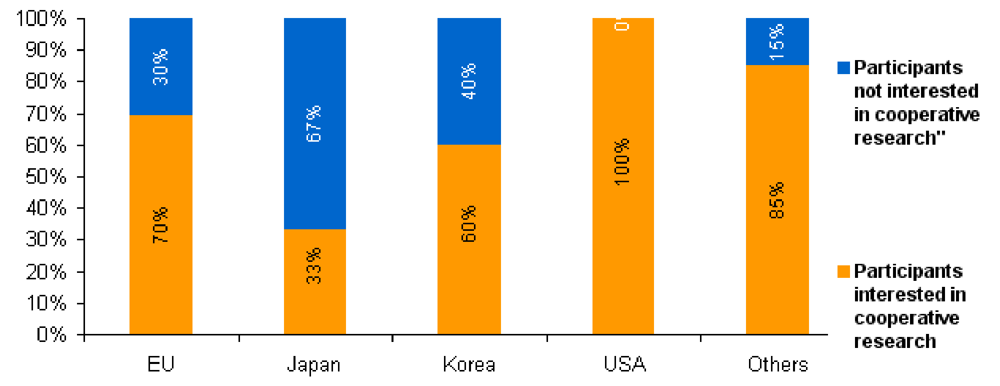
Regional Interest for Collaboration:



11.26 RT1.26 – Lean Management for Service Industries

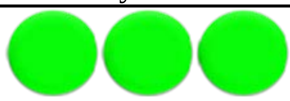
ABSTRACT:	Whereas the business world is constantly changing from a manufacturing into a service dominated world, service management still suffers from significant drawbacks in approaches for an efficient and effective service production. Lean management has considerable changed manufacturing industries and seems to be a promising approach for service industries too. Therefore implementation approaches as well as service-oriented lean management methodologies and tools have to be developed.
Technical Content and scope:	Even though services play a significant role in current and especially in future worldwide economies, until now no holistic approaches for the management of efficient and effective service production are available. The key for a successful service management will lie in lean management approaches tailored to the specific needs and requirements of service production. In this regards a simple transformation of the well known lean management approach for manufacturing industries is not possible due to the characteristics of services like intangibility and inseparability. Based on lean management principles new ways of service production will enable companies to produce and offer their services to their customers in an efficient and effective way. The main developments in this area are: • improvement of accuracy (zero-defect, zero waste); • high robustness to handle unexpected events, adaptively to changes in customer demands and efficient leadership (allowing and motivating people); • the control and configurations of systems in order to provide drastic improvements in process dynamics; • improvement of performances of production systems based on more efficient and effective outputs by high volume, high speed, low capacities and capability of processes. Developing and implementing lean management in the service industry requires both motivation and learning. For such problems learning by doing has proven quite effective. This is well handled by the concept of the teaching factory. A teaching factory should be set up covering management of services. A specific type of service has to be selected and these services have to be developed based on research to a showcase. This should be utilized to train other industries.
Expected results and impact, with special focus on the industrial interest:	Expected results and impacts will focus on the efficiency and effectiveness of all aspects of a service lifecycle. In detail they will take the form of: • holistic approaches for the management of service production; • target-oriented implementation approaches; • tools and methods for management of service production based on service-specific lean principles; • demonstrating for pure service providers, manufacturing service providers and service providing manufacturers.

Specific Features: e.g. Needed standardization actions, education/training needs, involved industries, …	• Pure service providers, manufacturing service providers and service providing manufacturers. • Standardization of terms and structures of service oriented lean management. • Standardization of holistic management approach and of methods and tools.
Suggested Scheme:	Small or Large
Main interested Regions:	**Region** / **Why / Reference** **EU** **Japan** **Korea** **US** **Whole IMS**: X
Possible links to other initiatives:	
Timeline:	From now on
Dependencies:	
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

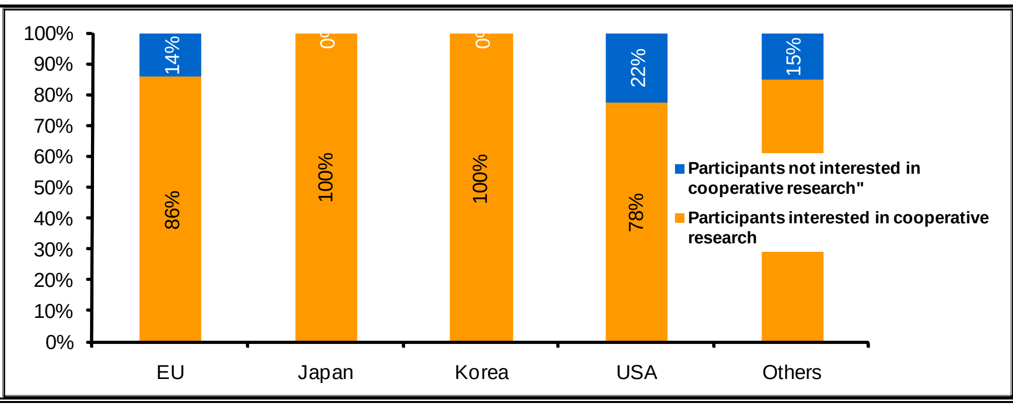
11.27 RT2.01 - Energy-aware Manufacturing Processes – Measurement and Control

ABSTRACT:	An effective energy control system has to be developed, using the information of sensors and in-process measurement and a suitable energy efficiency performance measuring system. This control system focuses on concepts, which facilitate the evaluation, control and improvement of energy efficiency in manufacturing processes.
Technical Content and scope:	In order to implement energy efficiency improvements and to measure and control "energy-aware" manufacturing processes companies need to be equipped with an efficient and effective energy management and control system. Firstly, an energy performance measurement system with suitable and measurable Energy Key Performance Indicator (KPIs) has to be developed. It has to be defined when, where and how Energy-KPIs should be measured and displayed, utilizing new sensors and visual systems for in-process measurement as enabler. Secondly, concepts for evaluating this information have to be developed, followed by decision support, which control mechanisms and improvements measures have to be implemented on the basis of this information. Due to such concepts, factories will know their energy performance in real-time, facilitating more effective business decisions based on accurate and up-to-date information. Research should therefore include: • The definition of effective (specific and quantitatively measureable) Energy KPIs as well as the visualization of these KPIs; Energy KPIs should be developed a holistic way for example looking at trade-offs between Energy KPIs and other KPIs, so that decision-makers could take more effective decisions looking at different perspectives. • The development conceptual frameworks and possibly software to measure and evaluate Energy-KPIs. This also provides the basis for the enhancement of industry prevailing assessment methods (e.g. CMMI, EFQM, and BSC) towards energy efficiency. The measurement should take place in the process and at the machines. It has to be specified which data and parameters have to be measured and how they can be integrated into a measurement system. It has to be defined how embedded systems, sensors and actuators network have to be enhanced in order to include energy performances data and to be able to extract relevant information to be provided within the company to decision-makers (via control systems, decision support systems, etc.). These intelligent systems need to be designed considering energy efficiency as a relevant performance criterion in order to obtain information on energy consumption behaviour of the factory. • In order to manage the energy-aware processes, energy control concepts have to be developed, which can evaluate and control the measured energy consumption of the entire manufacturing process. This energy control system should be able to e.g. control temperatures,

	speed of motors, drives and machines, and the energy supply of machines and devices and other parameters of the production process. Selective switch-off or modulating the power supply on the basis of intelligent machine status observation, allows for further energy reductions (ICT and Energy Efficiency - The Case for Manufacturing). As an example Energy Control Systems could be enhanced with a concept of networked electricity management: all electricity appliances have IP addresses and can be controlled individually (Japan). Companies already working on Energy Measurement and Control Systems should be part of the consortium. One additional objective of this research topic should be to develop the basis for a reference framework for energy measurement and control in manufacturing processes and facilitate its use and implementation in companies of various industries (e.g. for benchmarking and best practices).
Expected results and impact, with special focus on the industrial interest:	Thanks to the development of intelligent systems that are able to collect and analyze relevant energy-related information "energy-aware" processes will be possible. These processes will know their energy performance in real-time, facilitating more effective business decisions and reactions, based on accurate and up-to-date information. The outcome for industry should be an increase in energy efficiency for at least 10-20%, as companies will be able to measure and control energy consumption in order to be more efficient and to implement energy efficiency improvement measures according to a better evaluation basis. Moreover tools and methods developed in this research topic will help end-users become compliant with the new standards "EN16001 or ISO50001" for Energy Management Systems.
Specific Features:	KPI-Standards how to measure energy consumption have to be defined (specific and quantitatively measurable Energy-KPIs) to enable exchangeability and overall efficiency as well as benchmarking and best practice comparison. The new Standard EN 16001 (new European Standard on Energy management Systems) and the analogous upcoming International Standard ISO 50001 should also be taken into consideration when developing these standards. To introduce energy savings intelligent controls are needed, which strongly relates this research topic to the research topic RT1.02 Development of Green Controller for Machining. Training and education is needed for in process measurement, new concepts considering EEM, KPI visualization, and benchmarking.
Suggested Scheme:	
Main interested Regions:	**Region** — **Why / Reference** **EU** — Roadmaps, Interview, Workshop presentation, Online Survey **Japan** — Roadmap, Interview **Korea** — "MES can strongly support efficient and effective manufacturing. Based on right indicators and guiding

	US	management principles, MES are an important tool. For MES there are three important key technology areas: 1. Sensor technology for monitoring and transmitting production asset performance. 2. Software for evaluating performance data 3. Management concepts for deriving appropriate improvement strategies. Only important: how to measure carbon footprint and energy consumption. This needs to be integrated in MES solutions." " supporting IT (control software)" Interviews conducted in the US evidence also the need for advances in this topic, namely related to the standardization of environmental performance metrics, Energy Efficiency KPIs – standardize Supply Chains; and process EE and business performance alignment
	Whole IMS	X
Possible links to other initiatives:	Manufuture	
Timeline:	2011/2012	
Dependencies:	Links to other Research Topics: RT2.04 Energy Autonomous Factory, RT2.02 Integrating Energy Efficiency in Production Information Systems, RT1.04 Sustainability Labels, RT1.02 Development of Green Controller for Machining, RT1.01 Quality Embedded Manufacturing Integrating Energy Efficiency in Production Information Systems	
Topic Relevance Indicator:		

Regional Interest for Collaboration:

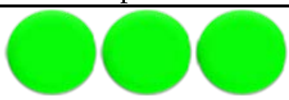
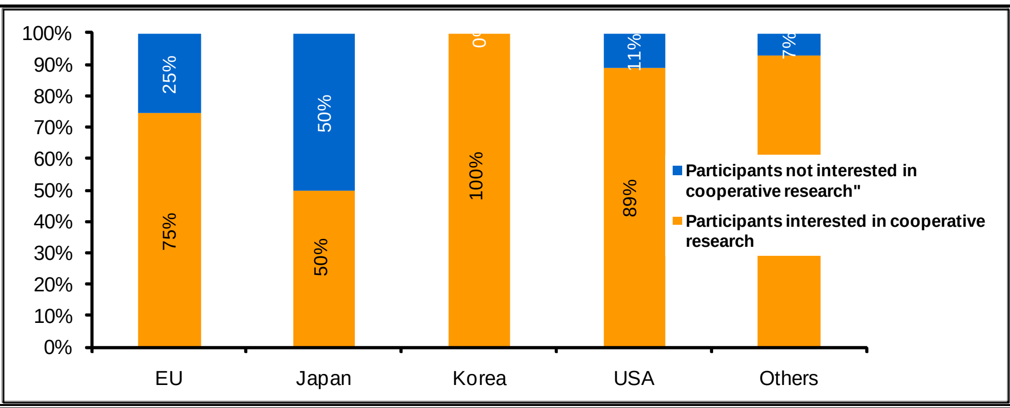


11.28 RT2.02 - Integrating Energy Efficiency in Production Information Systems

ABSTRACT:	A novel framework that manages and optimizes energy efficiency with respect to production planning and control needs to be developed and implemented in

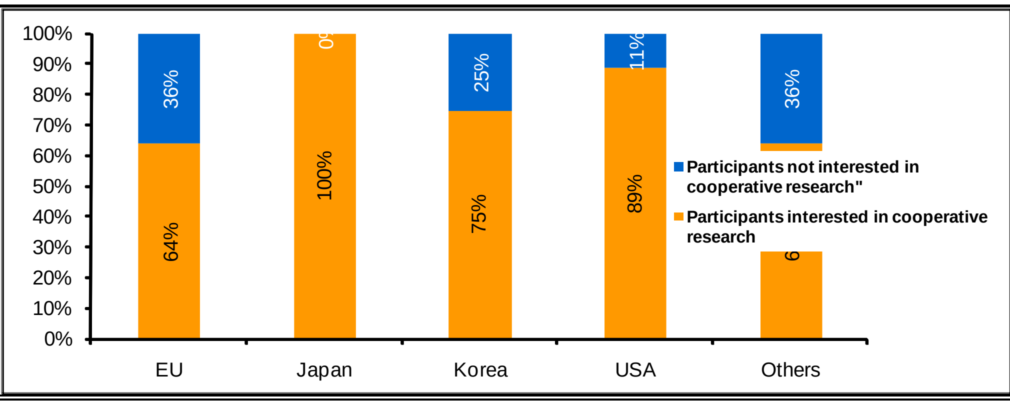
	enterprise control and information systems, such as Enterprise Resource Planning (ERP), Manufacturing Execution Systems (MES), and Distributed Control Systems (DCS).
Technical Content and scope:	Present production planning and control systems, which are used to optimize manufacturing in the planning and control phase, do not take into consideration energy efficiency as a relevant performance criterion. At production system level, ICT-driven optimized production planning allows for a scheduling of energy intensive tasks when the slightest economic and ecological effects occur. ICT plays an enabling role for energy efficiency improvements – either as a tool to help companies track their energy consumption and identify areas where savings can be made, or as the basis for more efficient production concepts and techniques. A novel framework that manages and optimizes energy efficiency needs to be developed and implemented in enterprise planning and control information systems. Relevant ICT components that support manufacturing operations should be considered, such as Enterprise Resource Planning (ERP), Manufacturing Execution Systems (MES), and Distributed Control Systems (DCS) • Modern Enterprise Resource Planning (ERP) systems incorporate resource planning and business processes of the entire enterprise. Improving the shop-floor scheduling and production planning of the manufacturing system contributes to optimizing the energy efficiency of a manufacturing system, which still remains to be a big challenge for ERP systems. Furthermore, ERP systems often provide both Supply Chain Management (SCM) modules and interfaces for interacting with external information technology systems in an integrated way. The optimization that is performed by these software tools could also take into consideration the implications in terms of energy of different batch sizes, stock levels, etc. • Research should aim at extending the scope of Manufacturing Execution Systems (MES) to achieve energy efficiency goals. MES deliver information that enables the optimization of production activities from order launch to finished goods. As MES allow users not only to use fewer resources but also to understand how those resources are being used throughout the production process, they hold great potential to enhance the energy efficiency in production. A framework should be developed, aiming at how MES can be enhanced towards energy efficiency performance and how this can be implemented in software; • CO_2-Emissions and energy consumption should be included as important criteria into strategic and operational decisions in companies. Therefore accounting models have to be enhanced by Energy- and CO_2-KPIs and new evaluation methods. These models

	should be applicable cross industries. In order to incorporate environmental concerns into the production planning systems it is fundamental to establish company cultures of awareness and continuous improvements. Programmes on accelerated learning should be developed where all the processes from product design to assembly and packaging are reconfigured by a lean approach to achieve fewer, faster and more energy efficient solutions. Such programmes will maintain a continuous attention to the environmental concern of the production system.
Expected results and impact, with special focus on the industrial interest:	By orientating enterprise information systems towards energy efficient manufacturing, decision makers will be provided with relevant and effective information about impacts on energy performances due to production planning and business decisions. Hence more energy-aware and effective decisions can be taken, improving the enterprise performances, in terms of energy efficiency.
Specific Features:	Apart from the theoretical framework development, in order to effectively create energy efficient production management systems, standardization action is needed to allow for different enterprise information systems to cooperate for optimizing energy efficiency. Finally, thanks to the adoption of a standardized approach, energy efficient certification for companies will be supported and facilitated. Several industrial players such as business software developers, industrial automation players and manufacturing companies (users) should be involved. Because Energy-KPIs and Measurement and Control Systems are needed in order to integrate energy efficiency into production information systems, this research topic should be aligned to the research topic RT2.01 Energy-aware Manufacturing Processes – Measurement and Control. RT2.02 should optimally start, when first results from RT2.01 are available.
Suggested Scheme:	
Main interested Regions:	**Region** — **Why / Reference** **EU**: Roadmap, e.g. ICT and Energy Efficiency - The Case for Manufacturing **Japan**: "Information standards (ICT, AI)" **Korea**: "Green IT"-Open Information Systems for SMEs, filtering functionalities of ERP/SCM/CRM software for an effective and efficient integration into whole SC. **US**: Interviews conducted in the US evidence also the need for advances in this topic, namely related to the processes Energy Efficiency and business performance alignment, as well as the relationship with mfg dynamic planning **Whole IMS**: X
Possible links to other	

initiatives:	
Timeline:	2012/2013
Dependencies:	Links to other Research Topics: RT2.01 Energy-aware Manufacturing Processes – Measurement and Control, RT2.08 Product Tags for Holistic Value Chain Improvement, RT1.24 Integrative Logistics Tools for Supply Chain Improvement
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.29 RT2.03 - Using Energy Harvesting for Powering Electrical Sensors and Devices in Manufacturing Processes

ABSTRACT:	Energy harvesting is a concept to transform surrounding energy (e.g. thermal, kinetic, waves) to electrical energy. By finding potentials and developing solutions for manufacturing, e.g. sensors' and controllers' energy storage devices can become smaller or even dispensable.
Technical Content and scope:	Energy harvesting will be used to generate electrical energy from environment conditions, such as vibration, electro-magnetic waves, motion, heat etc. with the idea to use surrounding energy available anyway. Today's energy harvesting systems often cannot provide enough energy to fully power cooperating objects (like sensors, controllers, and actuators) still hindering advancement in miniaturization of these devices as well as new applications in manufacturing environments due to the required connection to an electrical power supply. Future yield of energy further needs to reach levels sufficient to fully power more energy consuming devices. The research should focus on the development of new technologies to recover energy from the environment without degrading the energy efficiency of manufacturing processes at another place. Special attention will be required for the analysis of the potentials of the energy sources, as volume flow or velocity, mass or acceleration, potential or kinetic energy, but also thermal or electromagnetic sources, in order to concentrate on developments for energy harvesting at sources with a high recoverability. Particular emphasis may also be given to the specific possibilities to apply the harvesting technologies in appropriate manufacturing processes, as e.g. in highly automated and complex manufacturing environments, or in environments with expensive energy infrastructure and similar. The project requires including both manufacturers of energy harvestings technology, including OEMs (Original Equipment Manufacturers), design and service providers as well as other suppliers, and the potential users of the technologies developed. A strong participation of the industrial partners will secure the development of technologies in beneficial fields of manufacturing and ensure industrial relevance. An expected outcome of the project is a demonstration of the technology developed within a pilot implementation in the manufacturing environment of an industrial partner.
Expected results and impact, with special focus on the industrial interest:	Energy scarcity and global warming will play significant roles in future manufacturing. Generating energy from the environment saves resources, lowers the carbon footprint and therefore reduces Greenhouse Gases. However, with energy harvesting technology developed not only primary energy savings can be reached due to better energy recovery and thus more efficient energy use. Important are the indirect energy savings as e.g. enhanced control in manufacturing processes is possible since sensors and

	controllers can be applied without direct connection to a distant electrical power supply and can be controlled in a wireless way. This allows for an increased use of sensors and controllers in the manufacturing environment contributing to an increased transparency, and approaches to detect sources of waste in manufacturing processes. Further energy savings are accomplished as there is less need to build a "hardware" infrastructure to control and power the sensors and controllers.
Specific Features:	This topic has a need for standardization actions (e.g. considering parameters of the output of an energy harvesting device). As new technologies have to be developed and new materials and approaches will be required, a connection to Key Area "Key technologies" is given.
Suggested Scheme:	Collaborative project
Main interested Regions:	**Region** — **Why / Reference** **EU** — Interview; Literature: Embedded WiSeNts Research Roadmap, Manufuture 2007; Online Survey **Japan** — Heat needs to be reused. Wireless technologies: control system for car electronic components will change (and/or optical fibres) --> substitution of wire harnesses **Korea** — Energy harvesting technology: any opportunity to generate energy (e.g. vibration) is used (e.g. for sensor in the supply chain) **US** — Interviews conducted in the US evidence also the need for advances in harvesting technologies, as well as the incentives for energy alternatives (cost and performance) **Whole IMS** — X
Possible links to other initiatives:	WiSeNts, Manufuture
Timeline:	2011
Dependencies:	
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.30 RT2.04 - Energy Autonomous Factory

ABSTRACT:	In order to reduce energy consumption and to guarantee a reliable energy supply, technologies and frameworks have to be developed for production-sites, which enable self-dependent energy generation according to the actual on-site demand and facilitate the use of renewable energy sources.
Technical Content and scope:	Customers, who are becoming more aware of “green” products and services, future regulations on CO2-emissions and a predictable shortage of fossil fuels, are some of the reasons for companies to develop energy solutions that are sustainable in an ecological and economical matter. Future factories need to aim at having as few emissions and operate as energy efficient as possible. A factory that has its own independent energy generation, mainly using renewable energy sources, is the vision that motivates this research topic. Today electrical energy is provided in a centralized manner from few power plants. This may lead to waste of energy due to two reasons: insufficient alignment of energy supply and demand in manufacturing industries (manufacturing industries consume about one third of world’s energy) and energy losses due to long distance energy transportation. Moreover, factories and companies are dependent on external energy supply which may – at least in some parts of the world - lead to risks of reliability and exposure to increasing and uncontrollable energy prices. In order to generate just the amount of energy that is actually used in manufacturing, to have a reliable energy supply and to facilitate the use of renewable energy sources (wind, solar, etc.) a framework and technologies for the “Energy Autonomous Factory” have to be developed. Research should focus on the following aspects: • Development of factory-optimized on-site energy generation concepts, which includes a consequent application of energy saving techniques and mainly uses renewable energy sources e.g. wind, solar, etc. The focus should lie on the individually analyzed and optimized energy generation in each factory, which in an optimal way is CO_2-neutral; therefore a framework is needed, which provides general and integrative energy generation and supply concepts that can be adapted to specific needs of single factories. • Development of concepts how this energy can be distributed and controlled by the consumer/machine ("smart grid"); • It has to be analyzed which kind of alternative energy sources is optimal for which kind of production site/industry processes; • For the choice of the right mix of renewable energy sources, the concept should also take into consideration the economic evaluation of the mitigation of fluctuations in energy availability and prices due to summer/winter, day/night differences; • Energy efficiency of the individual energy production has to be considered too, as low efficiencies e.g. in biomass systems may lead to

	excessive land use etc.; • It has to be analyzed if concepts for alternative and renewable energy (wind & solar) have to be considered separately (e.g. Composal Air Energy Storage – Capture excess energy of wind/solar/water power plants); • Development of technology for decentralized energy generation and distribution; • In order to enable the Energy Autonomous Factory energy storage technology has to be further developed. Power storage in process integration; facilitate the storage of energy if it is needed at a later point in time; • Further development enables feeding the possible local electrical energy surplus into the grid. The consortium should consist of companies from different manufacturing sectors in order to avoid competition and to encourage collaboration. Moreover companies producing alternative and renewable energy technologies can be part of the project team. A flagship-project as a best-practice example should be implemented. To achieve these goals, it is necessary to create new innovation processes. These processes need to combine different skills in order to boost creativity. A good learning effect in this context could be obtained using the concept of innovation agents. An innovation agent should be appointed in the flagship project. He or she will have a special responsibility of promoting and facilitating innovation. The project should also study this process in order to develop guidelines for how innovation agents could best be applied in changing the manufacturing industry.
Expected results and impact, with special focus on the industrial interest:	Results and benefits of the Energy Autonomous Factory for industry will be: • Improved energy supply coordination (on demand energy supply); • Less energy losses due to shorter energy transportation; • Facilitation of alternative/renewable energy technologies; • Stronger "net-zero-energy-building/plant-culture" (people, education); • Self dependent energy supply (lower risk for single company) autonomous from the energy grid supply • Increase in energy efficiency • Resource optimal energy application • "Green image" as a marketing argument (climate protection) • Less CO2-emission in manufacturing, which can have a great impact as manufacturing sector is responsible for about 38% (or 7.9 GT CO2) (see IEA 2008)
Specific Features:	Competence development: Employees should be trained in "net-zero-energy-culture", and trained to save energy. They should develop knowledge about efficiencies when distributing energy in the factory.

<table>
<tr><td>Suggested Scheme:</td><td></td></tr>
<tr><td>Main interested Regions:</td><td>
<table>
<tr><th>Region</th><th>Why / Reference</th></tr>
<tr><td>EU</td><td>Interview, Online-Survey</td></tr>
<tr><td>Japan</td><td>"Reduction of electricity is in focus, examples: 1. Windmill for power production at plan" "1. Use of daylight in roofs of new factories"</td></tr>
<tr><td>Korea</td><td>"Concrete initiatives are [...], support of solar and wind energy, [...]"</td></tr>
<tr><td>US</td><td>Interviews conducted in the US evidence also the need for advances in this topic, namely related to geographical industrial Collaboration (e.g. Industry parks), incentives for energy alternatives, as well as plant-wide solutions for Energy Efficiency</td></tr>
<tr><td>Whole IMS</td><td>X</td></tr>
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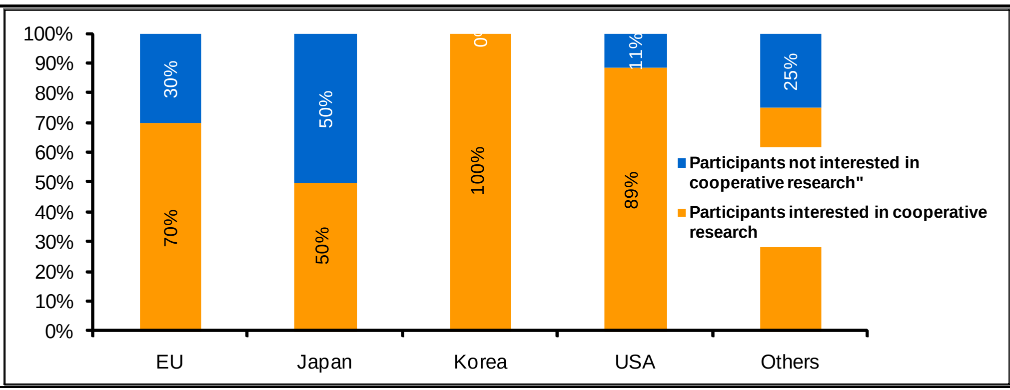
<tr><td>Possible links to other initiatives:</td><td></td></tr>
<tr><td>Timeline:</td><td>2012/2013</td></tr>
<tr><td>Dependencies:</td><td></td></tr>
<tr><td>Topic Relevance Indicator:</td><td></td></tr>
<tr><td>Regional Interest for Collaboration:</td><td>
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11.31 RT2.05 - Intelligent Utilization of Waste Heat

ABSTRACT:	Factories in process industries are point sources of low (below 150°C) and medium (above 150°C) temperature waste heat, which remain widely unused representing environmental and economic opportunities. Expected outcomes are a methodology for cross-plant analysis of waste heat recovery potentials, recovery technologies and demonstrated co-operations between industries/plants for optimized utilization of heat at various temperature levels including low temperature waste heat.
Technical Content and scope:	A significant contribution to anthropogenic carbon footprint originates from energy intensive industries as pulp and paper, cement, steel and ammonia. Processes in energy intensive industries operate at high temperatures and as such produce significant waste heat, which is released unutilized to the environment at different temperature levels. Waste heat recovery in a process saves energy and is as such an economic factor. However, a significant amount of medium (above 150°C) and low (below 150°C) temperature waste heat cannot be recycled to the same process and offering opportunities for low temperature applications. Current approaches focus on medium temperature waste heat recovery on the level of individual production plants and include electricity production or district heating. On an inter-plant/industry level, the intelligent distribution and utilization of especially low temperature waste heat offers opportunities for the increase of overall energy efficiency. Research should address three levels of investigation: • The development of suitable analysis methods (similar to pinch technology in chemical industries) on plant, industry and cross-sector level to identify heat recovery potentials and synergies. Such methods aim at identifying potentials to interchange waste heat between different manufacturing processes based on process analyses. Furthermore, key performance indicators need to be established for comparison; • The development of advanced technology for medium and especially low temperature heat recovery including transport (e.g. transport media) and exchange of waste heat and making it available for other processes as heat, cold or power. This should be done on a cross-sector level to profit from synergies; • Exploration of potential benefits of industrial collaboration in cross-plant networks for process heat exchange on different temperature levels (e.g. low energy industrial parks with various industries). Most promising collaboration partners/industries shall be identified. Cross-plant collaboration networks may be established as communities of practice.

<table>
<tr><td>Expected results and impact, with special focus on the industrial interest:</td><td>The analysis of different industries will provide an overview of the processes in place and their heat requirements as well as their waste heat production capacity. Their summary in some general terms will allow for knowledge transfer between regions and industries. Heat recovery technologies will be developed. Results will be compared in order to identify and discuss opportunities for waste heat recovery cross-industry. The project outcome is facilitated by bringing together representatives from various industries to share best practices and their specific knowledge.

Expected impacts are:

• Efficiency improvement of the thermal cycles by enhanced waste heat recovery;
• Boost the collaboration on heat exchange, foster the application of developed analysis methods able to identify and optimize heat transfer between plants/industries;
• Improving public perception and acceptance of energy intensive industries and diffusing the eco-technological approach at global level;
• Decrease of the overall carbon footprint.</td></tr>
<tr><td>Specific Features:</td><td>This topic requires the collaboration of energy intensive industries as waste heat suppliers and factories, public or private parties as waste heat utilizers. The concepts of Communities of practice should be exploited for this purpose. The applicability of the developed methodologies, technologies and co-operations should be demonstrated. Corresponding standards especially for the analytical methods are required.</td></tr>
<tr><td>Suggested Scheme:</td><td></td></tr>
<tr><td>Main interested Regions:</td><td>
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<tr><th>Region</th><th>Why / Reference</th></tr>
<tr><td>EU</td><td>Interview</td></tr>
<tr><td>Japan</td><td>Reuse of heat from glass production, reuse of heat from data centers; use concept of "super systems" for strategic system design (people to think across borders and use, e.g. heat of data centers for greenhouses)</td></tr>
<tr><td>Korea</td><td></td></tr>
<tr><td>US</td><td>Interview</td></tr>
<tr><td>Whole IMS</td><td>Waste heat is available at all factories of the energy intensive industry.</td></tr>
</table>
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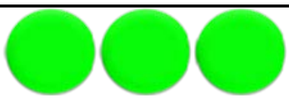
<tr><td>Timeline:</td><td></td></tr>
<tr><td>Dependencies:</td><td>Possible link to other Research Topics: RT2.04 Energy Autonomous Factory</td></tr>
<tr><td>Topic Relevance</td><td></td></tr>
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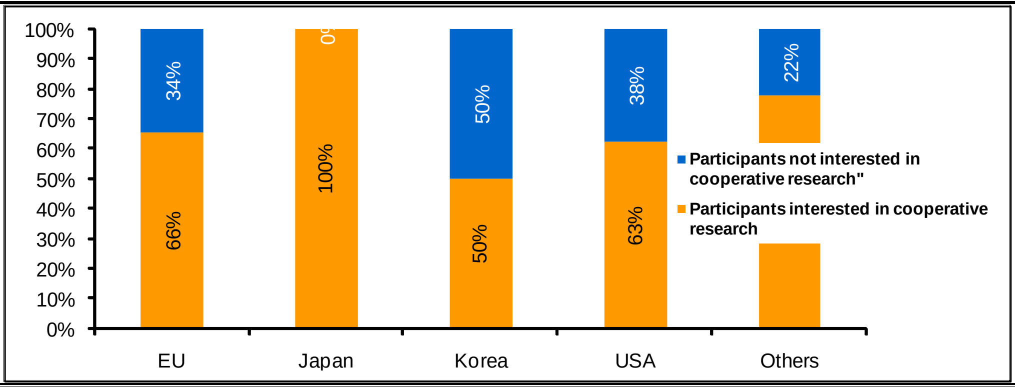
Indicator:	
Regional Interest for Collaboration:	

11.32 RT2.06 - Framework for Collaboration in the Alternative Fuel and Raw Material Market

ABSTRACT:	Resource intensive industries significantly contribute to green house gas emissions making it an important sector for mitigation actions. Here, waste/by-products can be used to replace raw material and fossil fuels in industrial processes. Methodologies and strategies for cross-industry and cross-sector collaboration have to be developed in order to enable increased utilization of waste.
Technical Content and scope:	Reduction of energy consumption and GHG emission applies especially to the resource intensive industries with particular regard to the cement, steel, glass, ceramic, pulp and paper and fertilizers industry. These industrial sectors are facing increasing economical challenges due to the Kyoto protocol application, local political instability and increasing cost of fossil fuels. Co-processing is the use of waste e.g. raw material, as a source of energy, or both to replace natural mineral resources (material recycling) and fossil fuels (energy recovery) in industrial processes. Waste materials used for Co-processing are referred to as alternative fuels and raw materials (AFR). To a certain level, AFR are applied today. One of the limiting factors preventing enhanced utilization, however, is the availability of (well) defined waste streams on the market. Research should address the interaction and collaboration of AFR suppliers and users on a cross-sectorial basis. Integrated process chains across industries should be formed in a network of industrial partners and thus increase the overall availability and usability of AFR. Cross-industry and cross-sector collaboration and the establishment of a network for the exchange of wastes and by-products (ash, slag, cullet, scrap,…) to be used to substitute raw materials and wastes (such as rubbers, waste oils, solvents, industrial sludge) to be used as fuels. The optimization of waste stream utilization and the efficient exchange of materials include the analysis, identification and utilization of synergies in the

<table>
<tr><td></td><td>treatment of the waste materials in a collaborative way.

The cross-industry and cross-sector collaborative networks will exchange information and experience and thus contribute to the development of a learning community (community of practice). The application of alternative fuel and raw material represents a new approach that requires a mind shift and thus a radical new way of developing the necessary competence to effectively manage future manufacturing development.</td></tr>
<tr><td>Expected results and impact, with special focus on the industrial interest:</td><td>Collaboration in networks of industries to establish methodologies for integrated process chains for AFR to maximize their availability. Expected impacts are:
Natural resources recovery by improved utilization of waste materials;
Efficiency of the thermal cycles by introducing new heating technologies, innovative compositions using alternative raw materials and waste;
Increase the sustainability and competitiveness of resource intensive industries by resource savings;
Improving competitiveness of resource intensive industries and disseminating the eco-technological approach at global level.</td></tr>
<tr><td>Specific Features:</td><td>This topic requires the collaboration of resource intensive industries as well as other AFR suppliers/users. The applicability of the developed methodologies and co-operations should be demonstrated. Strategies are discussed to ensure resource intensive industries continue to grow and thrive in the face of uncertainties and global competition. Strategic collaborations are road-mapped to ensure resource intensive industries’ long term sustainability by exploring enhanced application of alternative source of energy and raw materials.

This topic requires the development of competence in waste stream identification and potential reuse.</td></tr>
<tr><td>Suggested Scheme:</td><td></td></tr>
<tr><td>Main interested Regions:</td><td><table>
<tr><th>Region</th><th>Why / Reference</th></tr>
<tr><td>EU</td><td>Interviews</td></tr>
<tr><td>Japan</td><td>Reuse of heat from glass production, reuse of heat from data centers; use concept of "super systems" for strategic system design (people to think across borders and use, e.g. heat of data centers for greenhouses). Further, cut-offs of own products are used for heating (biomass resource) --> More heat power with less resource. Further, orange oil is used as an additive / substitution for tire production</td></tr>
<tr><td>Korea</td><td></td></tr>
<tr><td>US</td><td>Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of geographical industrial Collaboration (e.g. Industry parks)</td></tr>
<tr><td>Whole IMS</td><td>All areas with resource intensive industries</td></tr>
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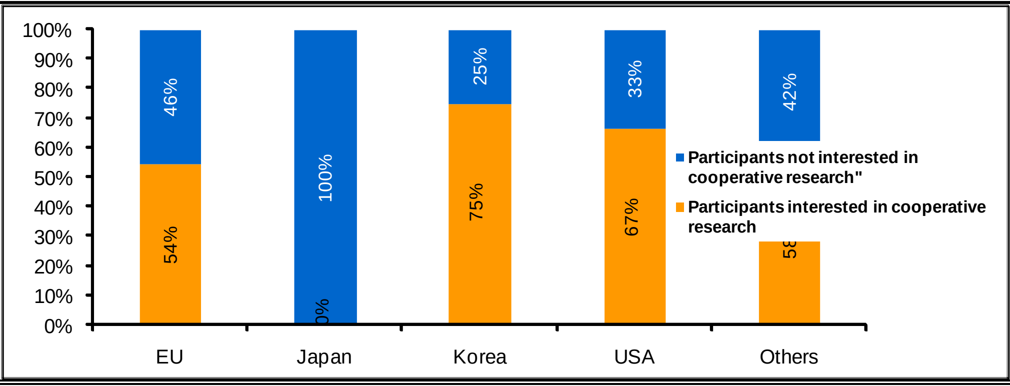
Possible links to other initiatives:	
Timeline:	2012/2013
Dependencies:	This topic is linked to RT2.07 focusing on technological aspects of co-processing.
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.33 RT2.07 - Technological Access to Wastes for Enhanced Utilization

ABSTRACT:	Enhanced utilization of alternative fuels and raw materials, derived from waste, replaces natural resources and as such reduces the environmental impact of resource intensive industries. Technological advances in pre-treatment and upgrade options are required. Adaptation of the main existing processes needs to be demonstrated in a cross-industry approach.
Technical Content and scope:	Resource Intensive Industry (RII) contributes significantly to the use of scarce mineral resources (material and fuels), making the RII an important sector for mitigation strategies such as the enhance utilization of waste material to replace natural resources. Co-processing is the use of waste as raw material, as a source of energy, or both to replace natural mineral resources (material recycling) and fossil fuels (energy recovery) in industrial processes, mainly in energy intensive industries such as cement, lime, steel, glass and power generation. Waste materials used for Co-processing are referred to as alternative fuels and raw materials (AFR). To a certain level, AFR are applied today. For enhanced utilization, however, these materials have to be pre-treated to mitigate negative impacts on processing systems and/or current processes have to be adapted. Research should thus address: • Technological processes to pre-treat and upgrade as well as transport and store AFR enabling higher substitution rates of natural resources

<table>
<tr><td></td><td>and fuels by reducing the impact of these materials on existing processes;
Development of production processes designed to cope with AFR. This will include equipment for the sustainable use of AFR as well as operating concepts to mitigate the impacts of waste materials with respect to energy consumption, product quality and emissions.
Research is based on cross-industry collaboration to share and possibly transfer best practice and benefit from synergies. A demonstrator is to be supplied.</td></tr>
<tr><td>Expected results and impact, with special focus on the industrial interest:</td><td>Making available technology allowing for enhanced utilization of AFR and thus contributing to minimize carbon dioxide emissions, preserve natural resources and reduce operating costs. Expected impacts are:
Heat, energy and natural resources recovery by improved utilization of AFR;
Efficiency of the thermal cycles by introducing new heating Technologies using alternative raw materials and waste;
Boost the application of alternative energy sources;
Increase the sustainability and competitiveness of RII by resource savings, advanced technological options;
Improving public perception and acceptance of RII and diffusing the eco-technological approach at global level.</td></tr>
<tr><td>Specific Features:</td><td>Resource Intensive Industries are small to medium size installations very diverse in nature but generally characterize by high temperature processes, waste, water and air pollution problems. Technologies are addressed to ensure RII growth and thrive in the future in the face of uncertainties and global competition. Strategic R&D outlined to ensure RII long term sustainability by making technology available for enhanced and efficient application of alternative sources of energy and raw materials, Improved or new technologies able to overcome regulatory constrains and price competition.</td></tr>
<tr><td>Suggested Scheme:</td><td></td></tr>
<tr><td>Main interested Regions:</td><td><table><tr><th>Region</th><th>Why / Reference</th></tr><tr><td>EU</td><td>Interviews</td></tr><tr><td>Japan</td><td>Interview</td></tr><tr><td>Korea</td><td></td></tr><tr><td>US</td><td>Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of waste close loop: special interest in recycling - separation technology</td></tr><tr><td>Whole IMS</td><td>Regions with well developed waste markets</td></tr></table></td></tr>
<tr><td>Possible links to other initiatives:</td><td></td></tr>
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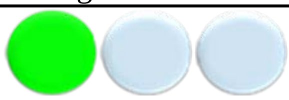
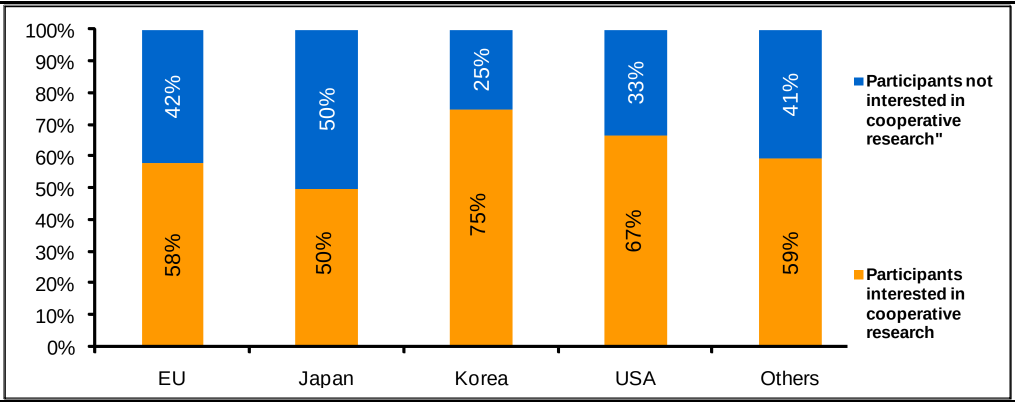
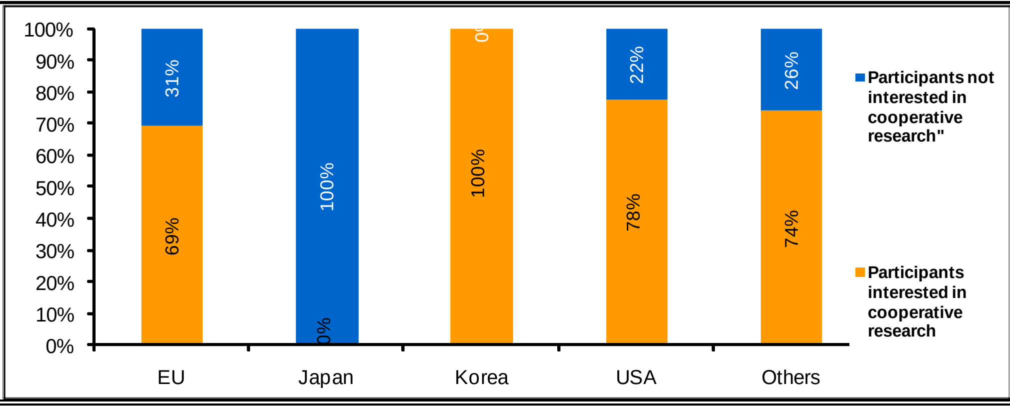
Timeline:	2011/2012
Dependencies:	Defining alternative power sources for specific industries, following RT2.05 Intelligent Utilization of Waste Heat
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.34 RT2.08 - Product Tags for Holistic Value Chain Improvement

ABSTRACT:	Product related information about the in and outputs of manufacturing processes make the value chain transparent for its stakeholders. The transparency allows for process improvements to be coordinated in order to increase the overall value chain performance (in terms of e.g. efficiency, costs, delivery time). Today, process improvements are made often under consideration of locally given data only. Therefore, improvements can lead to disadvantages in other parts of the value chain, resulting in a negative overall impact. Establishing an information system with product related manufacturing data increases the ability to evaluate and improve the processes for a global optimum. This leads to higher energy efficiency and increased competitiveness of the value chain.
Technical Content and scope:	Companies continuously improve processes in production. However, often improvements are undertaken without considering possible negative energy efficiency impact in other departments or stages of the value chain, respectively. With this, process changes potentially lead to an overall suboptimum of energy consumption and costs. In many cases, this issue arises from the lack of transparency between the links of the value chain. The research focuses on the increase of transparency in the production process by providing the possibility to store and access product related manufacturing data which has to relate to direct manufacturing processes and to base on commonly agreed Key Performance Indicators. It has to be determined what level of detail will be practical and approaches to increase applicability in industry have to be developed. An information system with an integrated and

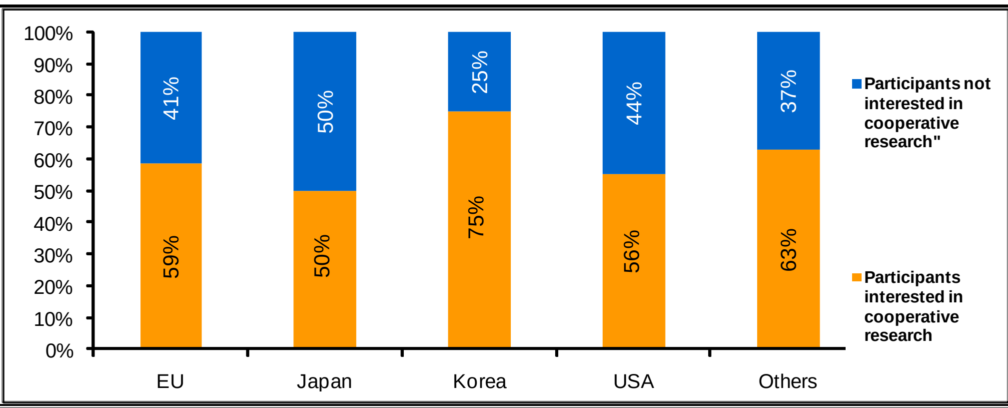
	comprehensive database accessible by all companies involved in the value chain allows for evaluating the manufacturing processes with regards to energy consumption. Standardized approaches for measurement and evaluation regarding energy consumption (and possibly data such as costs, quality or lead time) and data semantics allow for comparable data. Concepts like Life Cycle Assessment (LCA), Life Cycle Costing, Total Cost of Ownership, or Six Sigma serve as a suitable basis for data gathering within the companies with consideration of the later improvement intention. Stakeholders (e.g. customers, employees, as well as investors) have to be included in the development process and eventually be provided with a means to assess the energy efficiency of single processes, of parts or the whole value chain, respectively. Due to the gained transparency, improvements can be planned and implemented in consideration of the overall value chain efficiency. This topic is driven by both industry and academia. The industrial partners in the project provide the manufacturing data required for the value chain information system and ensure practicability and industrial relevance. Complete manufacturing chains are represented within the project, enabling eventual test and validation of the information system. Small and medium sized enterprises (SMEs) actively participate in the initiative, completing the data base. As neutral facilitator, academia provides the project approach, executes the data analyses and evaluation, and the software development.
Expected results and impact, with special focus on the industrial interest:	Today, competition takes place between supply chain networks. In future, this development will accelerate, so that companies of a value chain have to cooperate even stronger. End-customers expect environmentally friendly products. Supply chain partners, therefore, have to globally increase the energy efficiency of the manufacturing processes. Energy related manufacturing data can provide a means for supplier differentiation. Eventually, energy efficiency improvements will be undertaken on the basis of holistic optimization, sharing the benefits among the supply chain partners. Long term cost savings of 10-20% can be reached for the partners.
Specific Features:	This topic should be started after a successful “Energy-aware manufacturing processes - measurement and control” project. Data can be provided from the systems set up and used in this research topic. The companies representing the manufacturing chains may have balanced relationships to facilitate cooperation and, with this, the project outcomes.
Suggested Scheme:	Collaborative project.
Main interested Regions:	**Region** / **Why / Reference** **EU**: Chemical products showing the need for increased transparency cross the value chain and cross company-borders. **Japan**: Design according to requirements to attain an eco-label (e.g. according to ECMA standard) **Korea**: Ubiquitous technology containing product characteristics

	US	and life cycle information; Open information Systems for SMEs, filtering functionalities of ERP/SCM/CRM software for an effective and efficient integration into whole supply chains; Making green technology database for products; Labels for eco-friendliness and eco-product are necessary; consumers must be educated for sustainability issues - especially in Korea customers are just starting to get aware of these issues, labels could increase the awareness of customers
	Whole IMS	
Possible links to other initiatives:		
Timeline:	2012	
Dependencies:		
Topic Relevance Indicator:		
Regional Interest for Collaboration:		

11.35 RT2.09 - Emission Reduction Technologies

ABSTRACT:	Resource and energy intensive industries emit substantial amounts of green house gases and other polluting substances. Secondary emission reduction technologies have to be developed in a coordinated approach across sectors. With this, benefits from implementing similar reduction and capture technologies in different industries can be expected.
Technical Content and scope:	Resource and energy intensive industries release significant amounts of stack emissions such as green house gases (CO2, methane, VOC) and other polluting substances (NOx, SOx, dust, heavy metals). Secondary state-of-the-art emission abatement systems consume considerable amounts of thermal or electrical energy, which lead to reduced energy efficiency of industrial processes and higher cost.

	Besides primary measures (process design and operation), secondary measures include gas scrubbing, transformation, capture and storage of GHG and other polluting emissions. Such concepts are available, under development or consideration in different industries. Development of new emission reduction technologies and cross-sector adaptation of available methods are crucial measures to reduce pollution and fight global warming and further increase the energy efficiency of emission abatement technologies. Research should address the following issues: • New secondary emission abatement technologies (mainly focusing on CO2, NOx, SOx, dust and heavy metals) have to be developed leading to significant reduction of emissions from manufacturing processes; • These new abatement technologies need to strive for increased energy efficiency and thus less consumption of electrical or thermal energy input compared to state-of-the-art systems; • Development of secondary emission reduction technologies by establishing synergies between different industries. Newly developed technologies need to be applicable in different industries and shall not be limited to individual manufacturing processes. Therefore, a cross-sector/-industry approach is required to exchange best practices and share and accelerate R&D efforts. Competence development and education need to be done through Communities of Practice. Researchers and industry may investigate and solve problems, explore innovative solutions, and adapt them across sectors faster than in traditional learning. The set-up of virtual communities must be explored and state-of-the-art approaches to Communities of Practice adapted to engage in mutual learning not constrained by time and space. Tools and methods for sustaining such communities must be explored.
Expected results and impact, with special focus on the industrial interest:	Making available technology allowing for significant reduction of stack emission through development of new and energy efficient emission reduction technologies. Manufacturer will benefit from a cross-sector approach allowing for interchange and adaptation of secondary emission reduction technology in different industries. Reduced emissions will further enhance the competitiveness of manufacturers by complying with local emission regulation and by using energy efficient technology.
Specific Features:	Legislation: This research topic is highly related to local emission regulations. Cross sectorial education and competence sharing is necessary to attain the goals of this research topic. This may be attained by sustaining and expanding the communities established during the research and innovation effort.
Suggested Scheme:	

Main interested Regions:	**Region** / **Why / Reference** **EU** – Roadmap in emission regulations **Japan** – Roadmap **Korea** **US** – Roadmap in emission regulations **Whole IMS** – Especially EU, North America and Japan due to strict emission regulation.
Possible links to other initiatives:	
Timeline:	2011/2012
Dependencies:	Secondary emissions reduction technologies are strongly depending on primary measures. Emissions can be reduced through optimized process control, fuel and raw material type as well as manufacturing technologies and should therefore be optimized before applying secondary measures. Related Research Topics: RT2.07 Technological Access to Wastes for Enhanced Utilization in Resource Intensive Industries, RT2.06 Framework for Collaboration in the Alternative Fuel and Raw Material Market, RT2.01 Energy-aware Manufacturing Processes – Measurement and Control
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.36 RT2.10 - Energy Efficient Particle Size Reduction

ABSTRACT:	Current grinding processes have very poor energy efficiency, as only few percents of power are used for breaking bonds, while the rest is only generating heat. Therefore new particle size reduction principles with higher energy efficiency have a huge potential for energy savings in different industries. New grinding concepts and principles have to be developed (e.g. pre-treatments, flexible grinding systems) and fundamentally new approaches invented.
Technical Content and scope:	Grinding is applied in various industries with processes like raw material exhaustion based on the state of the art grinding principles. With current approaches physical limits are reached and the energy efficiency is very low, making new principles for particle size reduction necessary. New particle size reduction principles with higher energy efficiency have a huge potential for energy savings in industries using grinding as a required processing step for materials. Research should focus on the development of new particle size reduction technologies. Particle size reduction requirements should be consolidated in technical specifications and energy saving potentials in order to set up needs of the various industry sectors. With the specifications for the grinding technologies given, new grinding concepts and principles have to be found whilst considering the whole life cycle of the manufactured product. These concepts may consist of specific process improvements (e.g. pre-treatments, processing steps changed, simulation to adapt to varying requirements, flexible grinding systems) and fundamentally new approaches, which need to be developed specifically. As this issue is very focused, the consortium should include companies representing industries, in which grinding processes contribute to big parts to the overall energy consumption of manufacturing processes. New ways and principles to make grinding more efficient need to be found. However, in contrast to the need for the later applicability in industry, the fundamental research requires a strong participation of academic and research institution partners.
Expected results and impact, with special focus on the industrial interest:	The energy efficiency improvement potential by improving the particle size reduction processes is significant. Size reduction by grinding requires considerable electrical power consumption, e.g. in the cement industry typically more than 50 kWh/ton cement are required. With world cement production of approximately 3 Billion tons/year in 2009 a significant energy saving potential is available. For this industry. Energy savings can bring competitive advantages to all sectors with high energy consumption due to grinding processes.
Specific Features:	With an innovative approach the "Key Technologies" area may be affected. The second survey shows that the interest for this topic lies rather on the research respondents' side than on the industrial respondents' one (difference is higher than 20%).

<table>
<tr><td>Suggested Scheme:</td><td>Collaborative projects.</td></tr>
<tr><td>Main interested Regions:</td><td>
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<tr><th>Region</th><th>Why / Reference</th></tr>
<tr><td>EU</td><td>Relevant for all particle size reducing industries, Literature: MANTY (2005), “Next Generation Machine Tools - 2.011 Technological Roadmaps”; DENA, "Energieffizienz in der Produktion" (Fraunhofer Gesellschaft)</td></tr>
<tr><td>Japan</td><td>Panel/board production: special shape and structure of knives for grinding wood chips</td></tr>
<tr><td>Korea</td><td></td></tr>
<tr><td>US</td><td></td></tr>
<tr><td>Whole IMS</td><td></td></tr>
</table>
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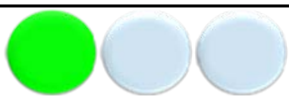
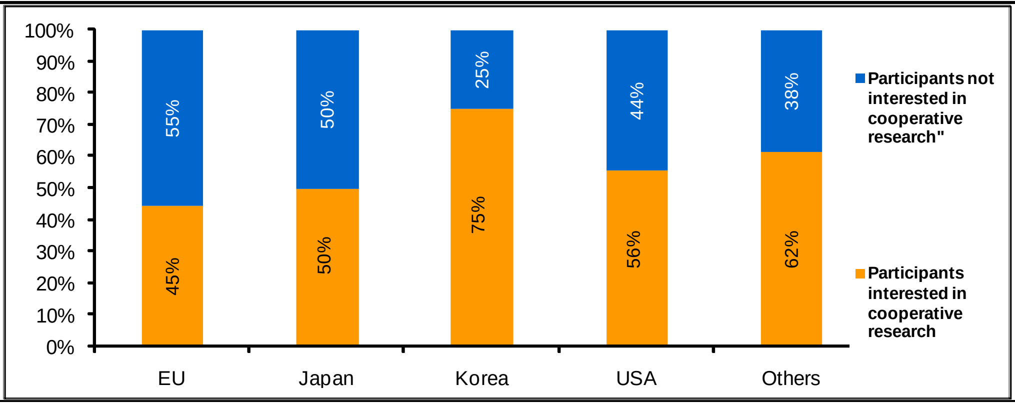
<tr><td>Topic Relevance Indicator:</td><td></td></tr>
<tr><td>Regional Interest for Collaboration:</td><td>
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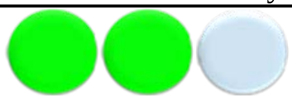
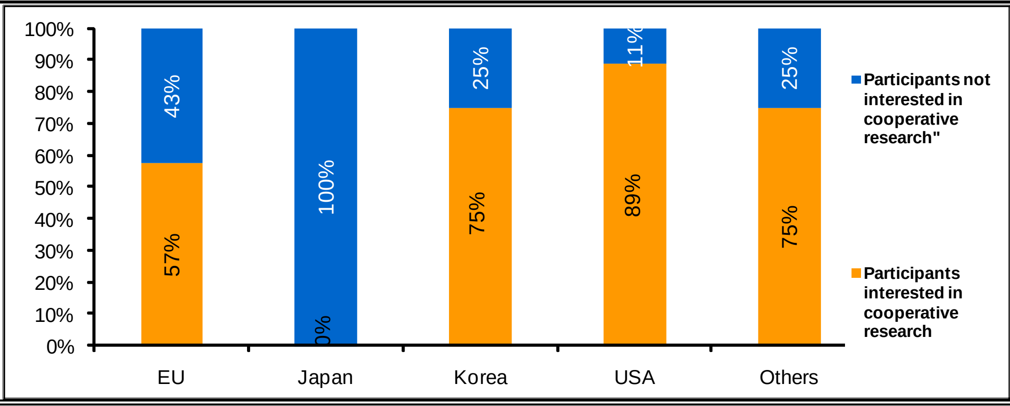
11.37 RT2.11 - 'Green Manufacturing' for Future Vehicles

ABSTRACT:	Taking into account the interdependencies of product design and the manufacturing process, new possibilities of car-manufacturing due to new product architecture of "green cars" (e.g. hybrid, electrical cars) should be analyzed and new energy efficient production concepts developed.
Technical Content and scope:	The car industry is one of the main manufacturing sectors in the IMS-Regions and remains important in terms of production, wealth creation and jobs. The EU, for example, produces 15 to 18 million cars per year, about 1/3 of the world production, and employs 12 million people, directly or indirectly. Many suppliers depend on the automobile industry (steel, aluminium, plastic, glass, textile industries, etc.) and also other sectors benefit from its investment in R&D. As the energy efficiency of cars constantly increases, the manufacturing process has to be adopted, so that it keeps up with the energy efficiency advances of the car itself. Customers becoming more and more aware not only of "green" products but also of the "green" production of these products. A future car may only obtain the label "green", if it is also produced in a "green" way. This research topic focuses especially on the car manufacturing sector and aims at developing new production concepts for 'green manufacturing' of 'future vehicles'. This can have a great impact on energy consumption: in the automotive industry the amount of energy required to manufacture a vehicle assessed on lifecycle bases can be close to 30% of the energy required to drive a vehicle in a lifetime of 150.000 km and is much more concentrated in time (few days vs. several years). The efficient use of energy and resources is becoming an issue in legislation and in the market, and will impact heavily the development of future products and processes. Research should therefore focus on the impact of new automobile architecture/design on manufacturing processes. The aim is to develop a framework that facilitates the green manufacturing of future vehicles. • Different concepts and possibilities for new production processes should be developed and evaluated to answer the following questions: Which are the new possibilities to change the production process that result from new automobile architectures? How can these chances be utilized to make the production process more sustainable and energy efficient and to produce less waste? How can suppliers be integrated into new production processes/concepts? What changes are necessary at the supplier's side and how can these changes be supported? • It should be analyzed if changes in the manufacturing process can include for example industrial use of renewable energy sources, energy recovery, recycle and reuse of vehicle materials, use of recycled materials, use of "Carbon neutral" materials (priority on Biopolymers,

	Natural fibers), improvement / alternatives to energy intensive processes (priority on Painting), carbon footprint based selection of materials, optimization of logistics and sourcing. Furthermore concepts for integration of these aspects into manufacturing processes have to be developed and implemented in a pilot study in the supply chain of the consortium; • A best practice guide should be developed in order to share the new concepts with other companies and industries. The consortium should consist of at least one OEM, a mid-sized system supplier and several small and medium sized 2nd and 3rd tier suppliers. However, in contrast to the need for the later applicability in industry, the fundamental research requires a strong participation of academic and research institution partners. This is also reflected in the relevance research institutes assigned to this topic (3rd most relevant topic from the research perspective). The difference of industrial and research relevance is higher than 20%, which may be due to the fact that this topic is focused on the automotive industry and other industries did not assign a high relevance to it. However, concepts developed may later be transferable to other industries as well. Green manufacturing need focus on different research areas (technology, sustainability, cooperation etc). Benchmarking with other sectors is needed to identify and implement best practice.
Expected results and impact, with special focus on the industrial interest:	In order to fully benefit from energy efficiency improvements of future cars, new and energy efficient ways of car manufacturing have to be developed. These manufacturing principles, rules and technologies should be available to strengthen the car manufacturing industry and prepare the efficient and successful manufacturing of future green cars. The impact will be a stable or even increasing employment in the automotive sector. New job opportunities can be created (not only in the automotive sector, but in other linked industries as well). Moreover by integrating new green production principles, energy and CO_2-emission savings may be around 10-15% per automotive supply chain.
Specific Features:	Tools for sharing of knowledge (cross sectorial education) between car producers and other industries need to be developed for cooperation and identification of new ideas for greener manufacturing. Education and training of engineers and managers on holistic approaches; energy related evaluation competence; energy waste awareness, and green manufacturing mindset are necessary.
Suggested Scheme:	
Main interested Regions:	**Region** / **Why / Reference** **EU**: Workshop presentation **Japan**: Car companies force cost reductions (so: reduce energy use) **Korea**: Cars fuelled with hydrogen **US**: Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of

	development of infrastructure for alternative energies (e.g. hydrogen fuel stations) **Whole IMS**
Possible links to other initiatives:	Industrial sectors: automotive (OEMs, tier1, supply chain), industrial equipment, metals extraction/metallurgy, polymers, agriculture. Similar needs in many other sectors (air, land and sea transports, white goods, light goods, etc.).
Timeline:	2012/2013
Dependencies:	Links to other Research Topics: RT2.01 Energy-aware Manufacturing Processes – Measurement and Control, RT2.04 Energy Autonomous Factory, RT1.04 Sustainability Labels
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.38 RT3.01 – Modular Assembly Disassembly Production Systems

ABSTRACT:	In manufacturing systems, assembly and disassembly of machines and systems are labour-intensive processes that are traditionally linked to customization aspects and variations of the produced products. To respond to the needs of complex products and to change the operations in-situ between automation and human work, depending on the changing volume, the new generation of adaptive production systems, looking to the entire product and process life cycles.
Technical Content and scope:	In manufacturing systems, assembly is traditionally labour-intensive process and is linked to customization aspects of products. So, this process is affected by globalization more than other processes. Disassembly is a end-of-life process that requires a general view to provide viable approaches starting from the design phase. To respond to the needs of complex products and to change the operations in-situ between automation and human work, depending on the changing volume, the new generation of adaptive production systems, looking to the entire product and process life cycles, requires developments for: • modular systems to accomplish flexibility at low cost and achieve adaptation without losses of efficiency; • assembly systems to respond to market needs and changes, reducing the time to market; • disassembly systems, able to contribute to improve recycling and resource use. This topic refers to Evolvable Assembly, a new paradigm that introduces how to modularize the assembly system (based on process info), and exploits distributed, multi-agent control for self-learning capability. The technical development of modular assembly disassembly systems requires: • hybrid systems with mixed automation; • manual operations; • assistance by robots; • and new product architecture; This topic refers to re-engineer – rather than re-develop – the production systems, minimizing time and economic, ecological and social impact meeting the sustainability issues towards green production. To develop new systems for assembly/disassembly, research needs are: • a fully integrated approach to production systems to achieve modularity of architectures; • modelling tools for the strategic planning of the systems evolution; • intelligent cognitive elements to learn, diagnostic features of the actual situation of the systems in real time and develop in-situ simulations.
Expected results and impact, with	Expected results in this field are: • new configurable modular systems for assemblies; • advanced automation and manufacturing control systems;

<table>
<tr><td>special focus on the industrial interest:</td><td>

models for adaptation of modular systems for assembly/disassembly
new assembly and disassembly systems for aging workers and disabled people;
“efficient grinding” for disassembly.

Industrial focus: accomplishment of the flexibility at a low cost, fast response to changing market needs and improvement of recycling and resource reuse (recycling material 50% or more; operating energy consumption at least 25%).
The main impacts of this research area are:

reduction of costs and time, improving service possibilities;
improvement of competitiveness of technological advanced in high labour countries;
transformation from high level production to mass customised production;
change in value chain process and relations;
contribution to green machines development.

</td></tr>
<tr><td>Specific Features:</td><td>
Needed aspects:

interoperability early standards for the global adaptive assembly community;
modularity with module language;
standardization of environmental evaluation methods of manufacturing systems;
design rules and guidelines for the integration of sustainable dimensions.

Modular assembly/disassembly systems have impact on multiple sectors of assembly suppliers: automotive, electric and white products.
</td></tr>
<tr><td>Suggested Scheme:</td><td>STREP, CAs and SSA (for standardization)</td></tr>
<tr><td>Main interested Regions:</td><td>
<table>
<tr><th>Region</th><th>Why / Reference</th></tr>
<tr><td>EU</td><td>It refers to strategic European sector, keeping the European leadership in the global demand ahead of competitors;
Truly modular, re-usable assembly system components. The system components are robust as they are designed for exact process requirements. Economically and ecologically sustainable.</td></tr>
<tr><td>Japan</td><td>Full lifecycle. Design for assembly, disassembly. Virtual factory software. Assembly and configuration information</td></tr>
<tr><td>Singapore</td><td>Sustainable Modular Design and Manufacturing systems.</td></tr>
<tr><td>Switzerland</td><td>Modularization of systems, component-based systems.</td></tr>
<tr><td>US</td><td>Integration of modular design systems, critical aspects of globalisation.</td></tr>
<tr><td>Whole IMS</td><td></td></tr>
</table>
</td></tr>
<tr><td>Possible links to other initiatives:</td><td>EUREKA, ERA-NET, MANUNET, FP7</td></tr>
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Timeline:	Short Term
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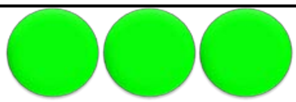
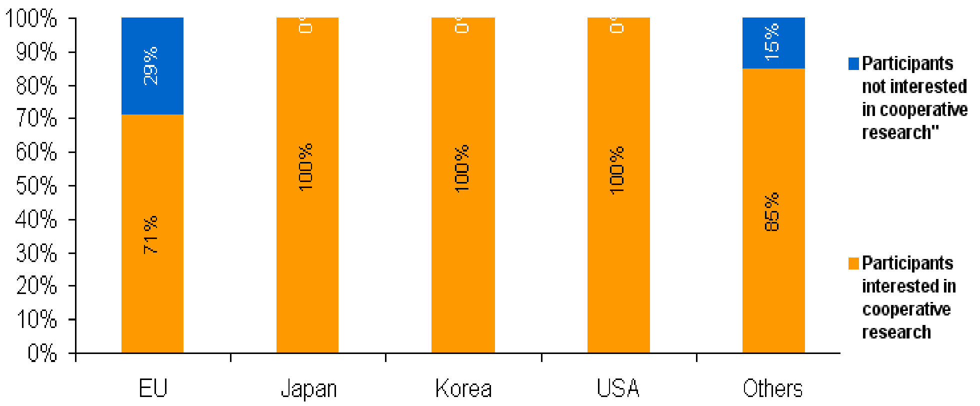
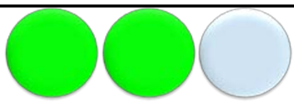
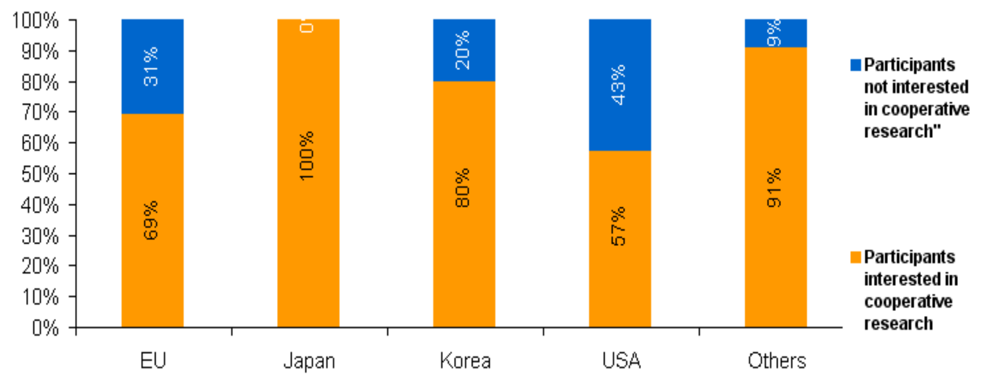
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.39 RT3.02 – Control for Adaptability of Manufacturing Processes

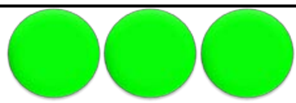
ABSTRACT:	In manufacturing processes, it is essential to integrate process models in the control system for allowing optimal performance under different conditions in an autonomous and adaptive manner. This new generation of control systems will be thus able to overcome the limits of traditional systems and will be able to react in real time to fluctuations during the process, to changes of process parameters and to disturbance variables.
Technical Content and scope:	In manufacturing processes it is essential to integrate process models in the control system for enabling the manufacturing systems react in an autonomous and adaptive manner to fluctuations during the process as well as to changes of process parameters and disturbance variables, allowing thus manufacturers increase the reliability, efficiency and productivity of said processes in a flexible and sustainable way. Within this view, it will be crucial that the current 'assembled' sensor, actuator, and control system architectures evolve into truly integrated mechatronic knowledge-based control systems with embedded intelligence and cognitive abilities. This will require innovative methodologies for analyzing machine signals as well as self-learning techniques for achieving cognitive and adaptive control systems with standardized plug-and-play interfaces that are capable of controlling the whole production system. It will be also of interest that real-time control systems are able to cover different levels from factory level control to machine/process level control as a means to extend autonomy to the different stages of the production system. This will involve Agent Control Technologies such as Holonic Manufacturing systems and service-oriented control architectures (What it is expected to do to achieve what is need) With the aim of fulfilling these identified needs, the technological research in this area should focus on the following actions: • To develop advanced tools for modelling integrated and optimised system configurations that will be based on a mechatronic simulation with respect of the expected performance • To develop methods for representing high-complex production processes by means of adaptive and scalable tools • To develop adaptronic modules with embedded intelligence and with standardized plug-and-play interfaces and integrate them into manufacturing equipment • To develop knowledge-based and self-learning control systems that are based on multi-layer controls and model-based real-time compensation routines that embed knowledge about machining processes. • To conceive flexible signal processing methods as well as wireless communication mechanisms and flexible system busses with integrated

	power supply as means for achieving standardised mechanical, electrical and software interfaces; • To define methods, procedures and tools for data analysis that are open enough with respect to the different manufacturing processes and involved analysis algorithms. • To integrate simulation systems in Manufacturing Execution Systems (MES) as well as in machine and process control - from product innovation management systems, over factory level control down to machine/process level control.
Expected results and impact, with special focus on the industrial interest:	Expected results are: • new robust control systems for flexible, autonomous and adaptive manufacturing systems • innovative control systems at factory level for managing information systems and engineering processes • innovative applications for conceiving mechatronic and adaptronic modules with standardized plug-and-play interfaces for being integrated into adaptive and autonomous machines and production systems; Main impacts are: • 60% reduction in the weight of machines thanks to the light-weighted mechatronic modules that consist the machine and that are based on mechatronic robustness against disturbances instead of mechanical and passive robustness • 30% reduction in the consumption of material resources due to easily assembled mechatronic modules • 30% reduction in machine design and assemble time due to intelligence and monitoring capabilities integrated in the mechatronic and adaptronic modules • 15% reduction in the machine commissioning time thanks to the self-learning techniques integrated in the control system • 20% reduction of down times during product exchange and crash situations • 20% improvement in machine availability
Specific Features:	• Standardised mechanical, electrical, hydraulic and software interfaces with plug-and-play capabilities • education and training measures for technical staff devoted to design, assembly, set-up and maintenance of manufacturing systems
Suggested Scheme:	STREP and CA
Main interested Regions:	**Region** / **Why / Reference** **EU**: • It is a transectorial field of research that responds to sustainability issues (reducing the environmental impact) and has key importance for product and process life cycle; • It refers to strategic European sector, keeping the European leadership in the global demand ahead of competitors. **Japan**: Control unit chip for visual light communication;

	Korea	• Image sensor; • Positioning technology; • Visual communication applications; • Overall control system; • Place and motor efficiency (lighter cars); • AIl for more automated cars (robots).
	US	• Enabling technologies and systems (e.g. software, sensors, control mechanisms). • Continuing advances in key enabling technologies (robot intelligence, mechanisms, sensors, actuators, and control architectures Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of automation: operational efficiency - modelling for flow (Modeling in programming), Wireless technology / Ubiquitous computer (Sensor interoperability)
	Whole IMS	
Possible links to other initiatives:	Factory of the Future, EUREKA, ERA-NET, MANUNET	
Timeline:	Short and medium term	
Dependencies:	None	
Topic Relevance Indicator:		
Regional Interest for Collaboration:		

11.40 RT3.03 – Mutable Production Systems

ABSTRACT:	Short delivery times and the increasing complexity and variety of manufactured products are demanding more than highly flexible production systems. Furthermore production systems need to be mutable enabling the reconfiguration to adapt to changed conditions in a fast an efficient way.
Technical Content and scope:	One key factor for constructing rapidly reconfigurable and changeable production systems, i.e. mutable production systems, will lie in developing self-adaptive machine and equipment structures consisting of knowledge-based and self-learning mechatronic modules. Innovation in this field will lie in moving from current architectures that assemble components, sensors, actuators and control systems to truly integrated mechatronic and knowledge-based systems based on a "plug-and-produce" concept. This concept enables to widen the range of adaptively in order to proceed from flexible to mutable production systems. Main research issues expected in this field are: • to develop tools for configuring production systems and simulating their resulting performance in terms of productivity, quality and reliability; • to develop intelligent and adaptronic modules equipped with standardized mechatronic interfaces and integrated power supply systems; • to embed knowledge and self-learning capabilities in those adaptronic modules by means of multi-layer controls and model-based real-time routines enabling to gain knowledge and learning from previous experiences; • to develop wireless communication mechanisms for communicating productions systems and their consisting mechatronic modules among them; • to integrate the mechatronic modules into multi-functional productions systems that are capable of tackling any manufacturing process for mass customised manufactured products.
Expected results and impact, with special focus on the industrial interest:	Expected results will take the form of: • tools and methods for modelling, developing and using mutable and therefore reconfigurable production systems; • demonstrating applications for mechatronic modules and their use in reconfigurable production systems. Expected impact will focus on improving the productivity, the quality and the lead-time-to-market of manufactured products. More specifically, the combination of the proposed technical developments should result in the following ambitious quantified impacts: • improved Productivity of production systems: o For unforeseen demands on current products, the time to adjust the capacity for changes in production volume will be reduced by 30% o For changing demands of the market that will demand to change the product focus quickly, the time to prepare

<table>
<tr><td></td><td>production to launch a new product or model will be reduced by 30%
improved reliability of production systems: the self-learning and self-adapting capabilities of mechatronic modules will allow eliminating maintenance requirements on production systems;
improved quality of final products: the knowledge-based modules that will allow conducting intense debugging, quality control and improvement activities on the manufacturing processes.</td></tr>
<tr><td>Specific Features:
e.g. Needed standardization actions, education/training needs, involved industries, …</td><td>Within the view of achieving breakthrough progress in flexible and reconfigurable production systems, this research and development approach may focus on large industrial groups and SMEs devoted to producing customized and high added-value products in sectors such as renewable energies and aeronautic sector.</td></tr>
<tr><td>Suggested Scheme:</td><td>Small or medium-scale focused research projects</td></tr>
<tr><td>Main interested Regions:</td><td><table><tr><th>Region</th><th>Why / Reference</th></tr><tr><td>Switzerland</td><td>Mechatronics and Adaptronics applied to machine tool builder sector.</td></tr><tr><td>Japan</td><td>Highly dynamic production systems within a produce-to-order environment.</td></tr><tr><td>Korea</td><td></td></tr><tr><td>US</td><td>Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of Process integration (impact on Energy Efficiency), and the always wanted Flexible/Quick manufacturing</td></tr><tr><td>Whole IMS</td><td></td></tr></table></td></tr>
<tr><td>Possible links to other initiatives:</td><td>Factories of the Future</td></tr>
<tr><td>Timeline:</td><td>Short and Medium Term</td></tr>
<tr><td>Dependencies:</td><td></td></tr>
<tr><td>Topic Relevance Indicator:</td><td></td></tr>
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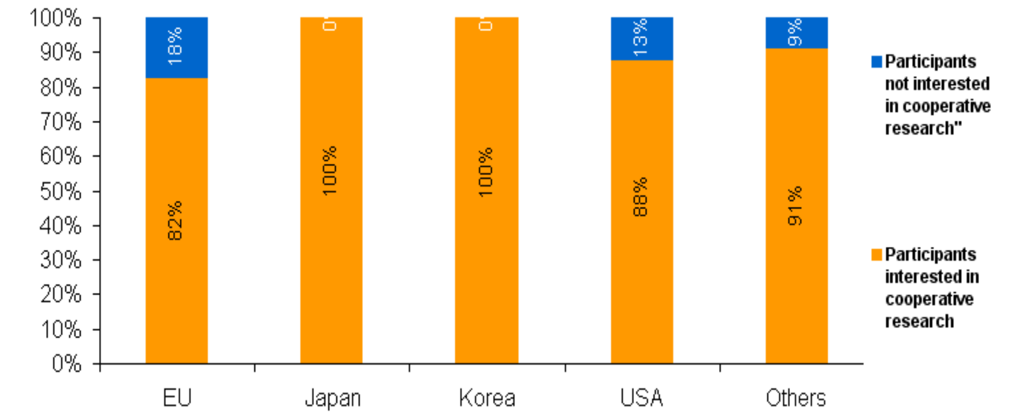
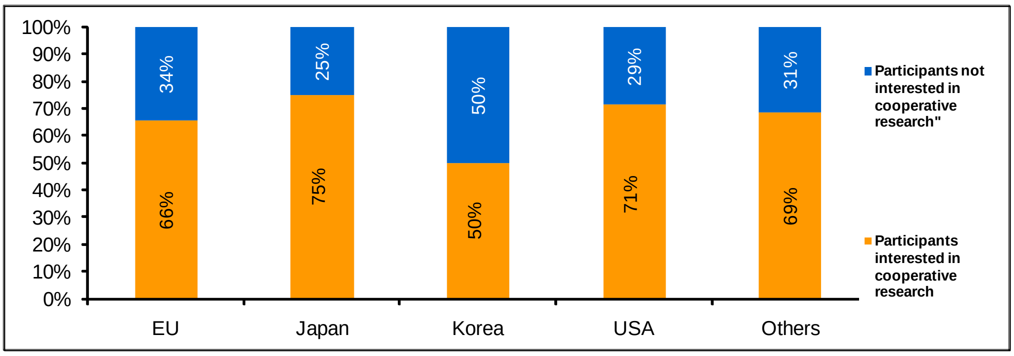
Regional Interest for Collaboration:	

11.41 RT3.04 - New technologies and approaches for competitive sustainable businesses

ABSTRACT:	COST linked to SUSTAINABILITY is the main driver of this research topic. Cost issues are fundamental in the manufacturing industry and when addressing them, two main aspects come in front: the labour cost and the energy cost, which are linked to environmental sustainability and to aspects of human safety at work. This research topic addresses both issues in a combined way: the efficiency, effectiveness and safety of work force (people) involved in manufacturing activities, and the optimised utilisation of energy streams with a low energy consumption level.
Technical Content and scope:	The reduction of COST linked to SUSTAINABILITY is the main driver of this research topic. Cost issues are fundamental in the manufacturing industry and when addressing them, two main aspects come in front: the labour cost and the energy cost, which are linked to environmental sustainability and to the value added by that labour cost. This research topic addresses both issues in a combined way: the efficiency, effectiveness and value added by the human work force involved in manufacturing activities, and the optimised utilisation of energy streams with a low energy consumption level, so that European manufacturing companies pass from competing by low costs to competing by high added value. With the aim of facing this challenge of sustainability costs, Research should address methods and technologies for increasing the efficiency of work force (people) actively involved in the manufacturing process, and also the effectiveness and safety of manufacturing processes and peoples' activities. This challenge will demand a change of the nature of work performed by people in manufacturing organisations through automation and fewer people carrying out routine work, and focusing human work in value adding actions such as decision making and skill-demanding tasks. In addition, it will be crucial that productivity gains through the employment of ICT and the definition of new processes in assisting people in manufacturing activities. In addition, it will be required the construction and design of factory buildings with low energy losses and implementation of energy systems based on renewable energy systems (including solar); which will involve energy monitoring, intelligent control and recovery in manufacturing plants and processes. To overcome the above mentioned challenges, the research efforts should focus on: • Developing methods to improve the effectiveness of human tasks in manufacturing organisations, taking into account both the tasks they currently perform in manufacturing and the systems/tools they use • Developing ICT Technologies such as digital factory models with real time animations for assuring concurrent and distributed engineering activities within networks of companies and research centres.

	• Developing methods to improve the effectiveness of manufacturing processes, machines/equipment and manufacturing systems closely based and employing the new ICT, innovative processes, etc. • Developing energy management software at plant level for assuring energy efficient factories by aspects such as controlling idle components and distributing workloads to avoiding energy demand peaks. In addition to this, the project will include the overall cost optimization problems by establishing virtual business environments.
Expected results and impact, with special focus on the industrial interest:	Expected results are: • methodologies for the definition and evaluation of alternative manufacturing processes, with the capability to evaluate and compare the process efficiency, its energy efficiency and safety aspects • demonstrators of the application of the above methodology in industrial sites • new process definition and set-up with a direct impact in their cost and sustainability Main impacts will be: • reduction of 20% energy consumption, through improved processes and reduction of energy losses by means of energy management systems at plant level • increase in 20% in human efficiency and safety by elimination of accidents and through better manufacturing process and task definition • • Increase in the value added by human activities through digital environments supporting decision-making procedures, concurrent engineering activities etc
Specific Features:	• safety standards • energy labels • training for sustainability consciousness; • training of engineers to adopt developed optimization frameworks
Suggested Scheme:	Large projects with demonstration activities
Main interested Regions:	**Region** / **Why / Reference** **EU** **Japan** **Korea** **US**: Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of competitiveness vs. sustainability “cost" - Sustainable practices and cost benefits compromise (e.g. Costs reduction and Energy Eff. Benefits) **Whole IMS**: Energy efficiency and human safety, related to cost

	aspects, are matters of global concern
Possible links to other initiatives:	Factory of the Future, EUREKA, ERA-NET, MANUNET
Timeline:	medium term
Dependencies:	Links to other Research Topics: RT2.01 - Energy-aware Manufacturing Processes – Measurement and Control
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.42 RT3.05 - Interoperable Products and Production data exchange

ABSTRACT:	Companies can be part of several production networks at the same time thus making the planning, management and optimisation of these networks a very complex task. This requests collaborative planning, management and optimisation of production and logistic resources, including the production planning and capacity management in non-hierarchical company networks. These processes have to be standardized across industries in order to come up with the necessary speed and flexibility in the network integration.
Technical Content and scope:	Non-hierarchical networks and the resulting decentralized planning and control processes also indicate that the supporting ICT systems for planning, scheduling and control have to be decentralised and based on distributed models and tools. The necessary seamless integration of the business processes and the supporting ICT systems require a common understanding of the exchanged information and the shared functions. Therefore the interoperability of production networks requires a common semantic of shared information and exchanged services. The formation and operation of production networks covers the production, distribution, after sales services, and reverse logistics. This requires a strong interoperability between the different business processes, organisational structures but also technical solutions applied by all of the companies in these networks. The main development issues and targets are the creation of interoperable production networks – in respect to reference processes, the semantics of the exchanged information and shared services as well as the application of supporting ICT infrastructures.
Expected results and impact, with special focus on the industrial interest:	Expected results are: • organizational concepts, processes and methods for the collaborative planning, management and optimisation of production and logistic resources, including the production planning and capacity management in non-hierarchical company networks • Information Technologies unifying the monitoring, operation and planning activities across a network and capable of providing the specific functionalities for the needs of a company; • Cross-sectorial and multi-standard product and production field data ontologies; • Pilot implementations in industrial settings of European and global production networks as well as the contribution to standardisation of exchanged information and shared processes. Main impacts are: • enhanced competitiveness of European manufacturing sectors by

<table>
<tr><td></td><td>increasing the capacity of industrial SMEs to operate globally in an agile manner, in order to adapt to the rapid evolutions of existing and future markets;
reduction of 15% of interoperability costs;
new value added logistic services, delivered by network companies, will be designed and enabled.</td></tr>
<tr><td>Specific Features:</td><td>ICT standards;
involvement of supply chains in the projects;
Education and training measures for new skills of production managers and engineers of different companies along the value chain to adopt common standards and mindset.</td></tr>
<tr><td>Suggested Scheme:</td><td>Large / Small projects</td></tr>
<tr><td>Main interested Regions:</td><td><table><tr><th>Region</th><th>Why / Reference</th></tr><tr><td>EU

Japan
Korea
US</td><td>Key importance for product and process life cycle. It is a transectorial field of research-

Interviews conducted in the US evidence also the need for advances in this topic, especially in the area of data availability and reliability, Characterizing behaviours / inputs, Sensing technologies, Data management (Central data Base, interoperability), as well as related standards harmonization</td></tr><tr><td>Whole IMS</td><td>Fundamental when supply-chain and / or product/process life-cycle involves several global regions;</td></tr></table></td></tr>
<tr><td>Possible links to other initiatives:</td><td>Factory of the Future, EUREKA, ERA-NET, MANUNET</td></tr>
<tr><td>Timeline:</td><td>Short and medium term</td></tr>
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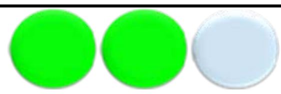
<tr><td>Topic Relevance Indicator:</td><td></td></tr>
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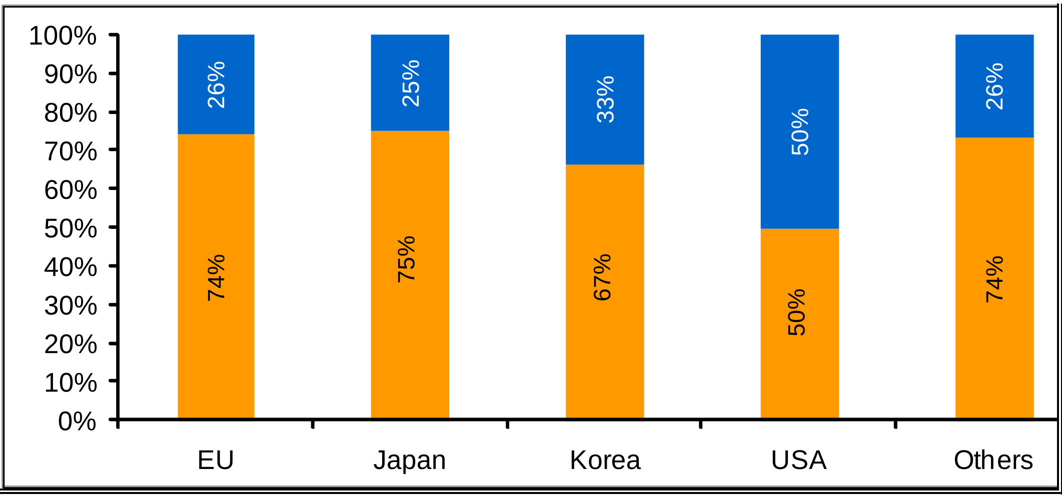
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50%
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Japan
Korea
USA
Others

11.43 RT3.06 - Build-to-Order - New Production Planning and Control Models for Complex Individualized Products

ABSTRACT:	The production of complex products requires the involvement of different partners providing services, materials or manufacturing activities. The demand of individualized products asks these non-hierarchical organizations the ability to quickly respond to customers with high service levels and low overall costs. New production planning and control approaches must be developed to coordinate the production activities and to assure robust production performance against uncertain events and against the propagation of production plan disruptions within the network enterprise.
Technical Content and scope:	The production of modern complex products requires the involvement of different partners providing professional services, raw parts or performing manufacturing activities. The partners, typically legally separated, are organized in a non-hierarchical structure producing value in the form of products or services for the ultimate customer. The demand of individualized products asks these organizations the ability to quickly respond to customers with high service levels and low overall costs. To achieve this aim the partners must cooperate sharing information, negotiating delivery dates and prices trying at coping with conflicting interests and uncertain events steaming from external and internal sources. The research should aim at improving coordination in the network enterprise through the development of new production planning and control approaches able to coordinate the production activities in a highly customer-individualized market environment, aiming at achieving good process reliability, short delivery times and low production costs at a time. Moreover, the production planning and control approaches must be able guarantee robust production performance against external uncertain events and against the propagation of production plan disruptions within the network enterprise. Grounding on a stochastic modelling of the uncertain events and on a risk concept tailored to the specific characteristic of production planning in non-hierarchical systems, the new production planning and control approaches must be able to cope with uncertain events affecting the execution of production activities. The developed approaches must use cutting edge technology of combinatorial optimization.
Expected results and impact, with special focus on the industrial	The research project will aim at the development of new production planning and control approaches for production of complex individualized products in non-hierarchical organizations able to

<table>
<tr><td>interest:</td><td>

consider the influence of external and internal uncertain events through the assessment of risk associated to the devised plans and consequent robustness of the production performances.
consider information exchange and negotiation mechanisms regulating coordination and cooperation in non-hierarchical systems;

Expected results are:

20% reduction of the losses associated to uncertain events affecting the production plans;
a common mechanism for negotiation of bonus and penalty related to production performances among the partners in the non-hierarchical enterprise.

The expected impacts are:

Increasing the capacity of industrial enterprise to operate globally in agile manner, to adapt to the rapid evolutions of existing and future markets.
A significant reduction of logistics costs, high inventories of current assets and lead times of material and information.
Better service towards the customer through the reduction of time to market and reliable progress monitoring capability.
Tools for overcoming the complexity of operating in several production networks.

</td></tr>
<tr><td>Specific Features:</td><td>The new planning models and negotiation mechanisms must be grounded on the existing business and process model standards, in order to facilitate the transfer of the results to the industrial world. Eventually extensions of the existing standard can be proposed to support the developed approaches.</td></tr>
<tr><td>Suggested Scheme:</td><td>Small Scale Research Projects for specific research issues.
One Large Scale Research Projects.</td></tr>
<tr><td>Main interested Regions:</td><td>
<table>
<tr><th>Region</th><th>Why / Reference</th></tr>
<tr><td>E</td><td>to speed up the rate of industrial transformation in Europe through the capability of supply chains to take the form of flexible collaborations, networks of specialised small and medium-sized enterprises (MANUFUTURE)</td></tr>
<tr><td>Japan</td><td></td></tr>
<tr><td>Singapore</td><td></td></tr>
<tr><td>Switzerland</td><td></td></tr>
<tr><td>US</td><td></td></tr>
<tr><td>Whole IMS</td><td></td></tr>
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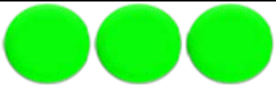
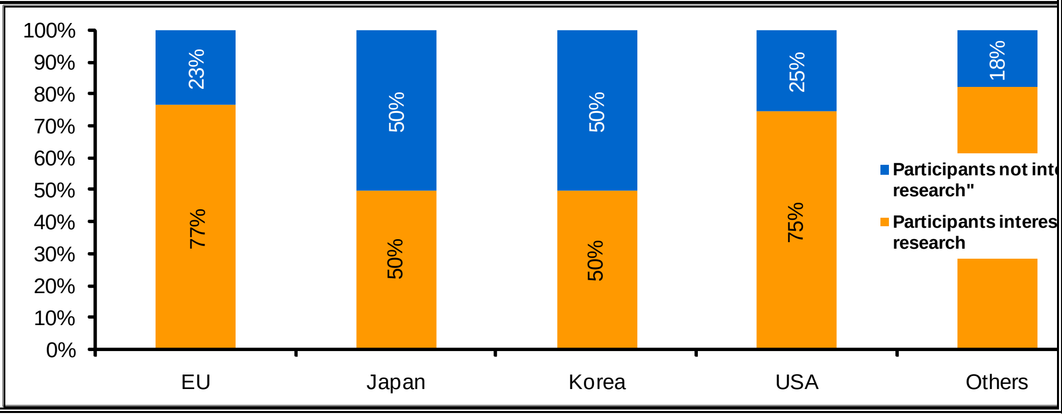
</td></tr>
<tr><td>Possible links to other initiatives:</td><td></td></tr>
<tr><td>Timeline:</td><td></td></tr>
</table>

Dependencies:	
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.44 RT3.07 - Efficient Use of Raw Materials

ABSTRACT:	In manufacturing, using raw materials efficiently directly saves costs and energy in transformation, transportation, and disposal and, therefore, reduces Green House Gas Emissions. By focusing on "zero-waste" and "zero-defect" technology developments, the amount of energy and resources required in manufacturing can be reduced as it is linked to the amount of material processed in the whole supply chain.
Technical Content and scope:	The reduction of raw material consumption in manufacturing processes will increase the efficiency as less material has to be exhausted, transported, transformed, and disposed. Increasing the raw material efficiency will involve both resource efficiency (to use less material for producing one product) and energy efficiency (to supply, transport and process fewer raw materials per produced product). Thus, a paradigm shift will be necessary, passing from "maximum gain from minimal capital" to "maximum gain from minimum resources", in the sense that substituting low efficiency raw materials or processes by more efficient alternatives will generates a higher product output. The research should focus on different kinds of product or manufacturing processes demanding for increased raw material efficiency. Development should include manufacturing equipment, where new technologies increase the accuracy of machines. New production systems can guarantee "zero-defect" parts through the development of new manufacturing methods, the use of modelling and simulation tools and/or the integration of monitoring and control techniques. Information and Communication Technology (ICT) in combination with the manufacturing equipment potentially reduces manmade mistakes in manufacturing processes and, with this, the scrape rate. Also, development of "zero-waste" manufacturing processes has to be driven. Near-net or finishing techniques minimize stock and both non-reusable and re-usable scrape. Application of materials with pertinent characteristics to improve manufacturing efficiency has to be considered, as e.g. new cutting materials can reduce the amount of lubricants, scrap rate, and rework rate. Further, machining, assembly and shaping technologies that allow for making use of new high efficiency materials such as metallic foams, multi-materials concepts or functionalized combination of 3D shapes should be included in research. In addition, research should further aim at finding and using alternative raw materials with lower environmental impact and that could be processed using slightly changed production processes for achieving final products with similar properties and functions than with conventional materials. Such alternative raw materials have to be chosen/developed to increase the total product efficiency: less energy and material consumption in the production process. The project will be driven by manufacturing industry, which is characterized

<table>
<tr><td></td><td>by high volumes of material operations and, thus, high scrap material saving potentials. With this, various parts of the supply chain are affected, as material exhaustion, transportation, transformation, and disposal will be avoided. In order to increase the industrial relevance, the manufacturing companies, including SMEs, have to actively participate in the development of the solutions and benefit from the results.</td></tr>
<tr><td>Expected results and impact, with special focus on the industrial interest:</td><td>Developing countries’ hunger for raw materials increases quickly and their power over the scarce raw material sources grows. In the future, manufacturing industries have to tackle the challenge of rising raw material prices. “Zero-waste” and “zero-defect” will report a 35% cut in raw material consumption in highly automated production lines. A 15% increase in productivity implies cost savings, and with this, a competitive advantage can be expected. Further, a 5-10% reduction of energy consumption can be anticipated as virtually all processes are affected and energy savings gained holistically throughout the value chain.</td></tr>
<tr><td>Specific Features:</td><td>Sustainable manufacturing is affected, as scarce resources are considered. However, the development of new high efficiency materials themselves is not covered by the research.</td></tr>
<tr><td>Suggested Scheme:</td><td>SME-targeted collaborative projects</td></tr>
<tr><td>Main interested Regions:</td><td>
<table>
<tr><th>Region</th><th>Why / Reference</th></tr>
<tr><td>EU</td><td></td></tr>
<tr><td>Japan</td><td>Zero-waste processing; Demand of high raw material effic as of energy efficiency due to highly automatised a production lines</td></tr>
<tr><td>Korea</td><td>Hydroforming technologies allow the manufacturing of on of many parts - this saves energy in the manufactur Simulation tools need to be improved further, this ca number of required crash tests, and fasten the development</td></tr>
<tr><td>US</td><td>Interviews conducted in the US evidence the need for adva the zero waste and material minimization for current products</td></tr>
<tr><td>Whole IMS</td><td>X</td></tr>
</table>
</td></tr>
<tr><td>Possible links to other initiatives:</td><td>Eureka, ERA-NET, CRAFT programmes</td></tr>
<tr><td>Timeline:</td><td>Short term</td></tr>
<tr><td>Dependencies:</td><td>RT3.10 High performance (high precision, high speed, zero defect) RT3.11 Model-based manufacturing</td></tr>
<tr><td>Topic Relevance Indicator:</td><td></td></tr>
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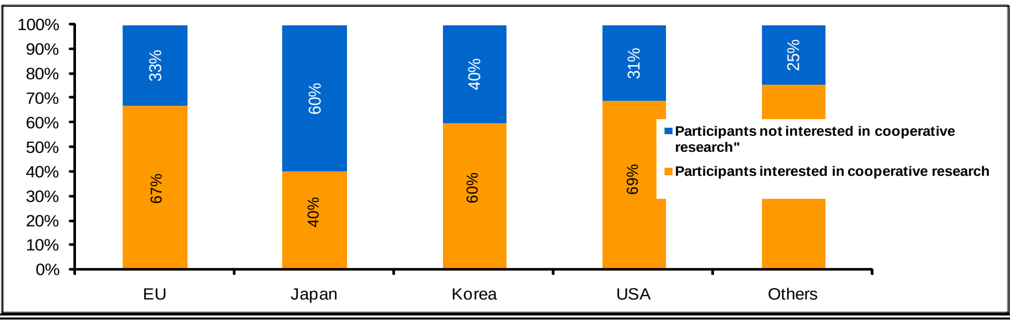
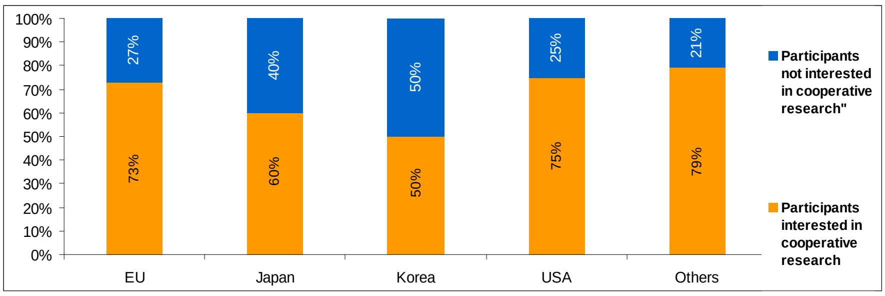
Regional Interest for Collaboration:	

11.45

RT3.08 - Model Based Engineering and Sustainability

ABSTRACT:	The engineering of customised manufacturing systems involves an integrated model-based approach that covers products+services, processes and business models in an integrated way as a means for providing to customers added value along the lifecycle of those machine products+service systems.
Technical Content and scope:	The companies that are facing the challenge of producing productive, reliable and sustainable production systems are lacking novel industrial models that are capable of integrating machine products+services, processes and innovative business models in an integral way, as a means for providing to customers added value along the lifecycle of those machine products+services. Within this view, it will be crucial for those companies to have holistic engineering models that cover the environmental impact and lifecycle costs associated to sustainable production systems integrated with total-lifecycle services and business models. This will demand for technological development in the following issues: • to conceive holistic engineering models capable of supporting design engineers when developing competitive and sustainable production systems that fulfil users needs at minimised lifecycle impacts and costs; • to develop methodologies and tools for analysing and modelling the added-value, the cost and the environmental impact associated to a production system along its entire lifecycle; • to develop methodologies and tools for transforming the actors involved in the manufacturing value chain in dynamic networks that share the information associated to the production system along its lifecycle: design, production, use and end-of-life; • to develop semantic models that integrate product+service systems PSS along the life-cycle of the manufacturing systems as means for passing from customised manufacturing systems to customised machine-service systems
Expected results and impact, with special focus on the industrial interest:	Expected results will take the form of holistic engineering models that will allow companies to conceive sustainable and reliable production systems in a dynamic and sustainable way. Expected impact will focus on improved sustainability of both machine production and manufacturing sector in the following terms: • reduction of lifecycle environmental impacts associated to manufacturing systems and processes by 30%; • reduction of lifecycle costs associated to manufacturing

	systems and processes by 30%; • a dynamic network of companies within the manufacturing value chain that share aims for minimised lifecycle impacts and costs in manufacturing processes.
Specific Features:	Standards for sharing lifecycle environmental impacts among actors of the manufacturing value chain; standards for integrating heterogeneous industrial models within a distributed manufacturing value chain.
Suggested Scheme:	Small or medium-scale focused research projects
Maininterested Regions:	**Region** / **Why / Reference** **EU**: Strategic view for achieving competitive and sustainable manufacturing systems and processes **Japan**: Machine tool product lifecycle management **Korea**: Ubiquitous access to production-related information **US**: Interviews conducted in the US evidence also the need for advances in this topic, especially its relationship with automation: operational efficiency - modeling for flow, wireless technologies and sensor interoperatibility **Whole IMS**:
Possible links to other initiatives:	Factories of the Future; Manunet
Timeline:	Short and Medium Term
Dependencies:	RT3.02 - Control for adaptability RT3.05 - Standardization of product field data / Interoperable & stand production network
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.46 RT3.09 - Cooperative and Mobile Manufacturing Systems

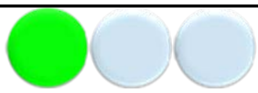
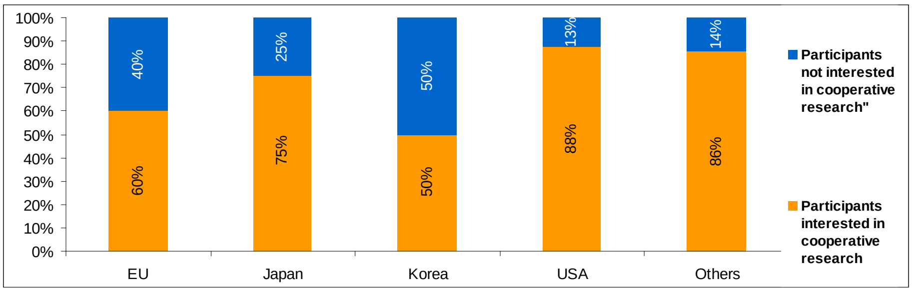
ABSTRACT:	An innovative way for conceiving flexible production plants lies in reconceiving those production plants as dynamic communities of mobile robots capable of cooperating among them and with human workers.

Technical Content and scope:	The implementation of Lean Manufacturing capabilities has allowed manufacturing companies to reinforce their competitiveness and provide a broad variety of products with high quality and at competitive costs. The question is that the increasingly frequent innovation of products and their increasingly shrinking life cycles is compelling these manufacturers to pursue greater manufacturing agility. One innovative way for conceiving agile and flexible production plants lies in reconceiving production plants as dynamic combinations of mobile robots and human workers working together cooperatively, sharing a common workspace in a safe way. Within this view, the main development issues expected for achieving communities of robots and human workers in flexible and agile production plants are: • to develop appropriate tools for modeling the individual mobile robotic members of these Human-Robot Communities working with other robots and workers as well as the interactions among them; • to develop technologies to allow these members of the Community to coordinate, cooperate, communicate and interact among themselves and with human resources in a safe and efficient way; • to develop tools and methodologies for producing mobile and autonomous robots that will work in a collaborative and cooperative way within the robotic community of the production plant. The developed tools and methodologies will have to be tested in an actual manufacturing environment. In this respect, a dedicated pilot plant should be set up for testing and demonstrating the new movements of different robots, their interaction with each other and with humans. Such a facility could have the flexibility of introducing new robots into a human-robot system while maintaining a determined outcome level.
Expected results and impact, with special focus on the industrial interest:	Strong industrial participation is requested, involving core technology and system providers as well as companies from various industrial sectors, to validate developed approach and innovations. Expected results will take the form of: • tools and methods for modelling, developing and using autonomous mobile robots in production plants; demonstrating cases for robots collaborating among them and with human workers in agile and flexible production plants. • •a permanent testing facility where new robot technologies and human interaction capabilities can be tested in a real production environment

<table>
<tr><td></td><td>Expected impact will focus on improving the reactivity and the agility of the production plants. More specifically, the implementation of communities of mobiles robots working with other robots and human workers in a cooperative way should result in the following ambitious quantified impacts:

• Improved Reactivity: For unforeseen demands on current products, the time to adjust the capacity for changes in production volume should be reduced by 40%;
• Improved Agility: For changing demands of the market that will demand to change the product focus quickly, the time to prepare production to launch a new product or model will be reduced by 30%;
• Improved Productivity: the time required to achieve a stable output of a new product with quality and productivity will be reduced by 30%.

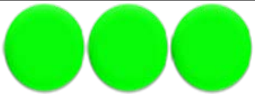
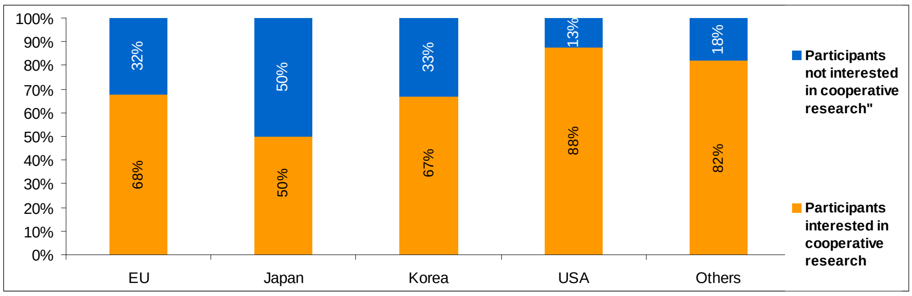
This approach will allow the development of new business models for machinery suppliers, from selling machines to selling agile production services.</td></tr>
<tr><td>Specific Features:</td><td>• Standards for representing mobile robots within Virtual Reality environments;
• Standards for assuring secure and safe interaction among mobile robots and human workers that are working in a collaborative way.</td></tr>
<tr><td>Suggested Scheme:</td><td>Small or medium-scale focused research projects</td></tr>
<tr><td>Main interested Regions:</td><td><table>
<tr><td>Region</td><td>Why / Reference</td></tr>
<tr><td>EU</td><td>This topic covers two strategic European sectors in Europe: the robotics sector and the manufacturing sector.</td></tr>
<tr><td>Japan</td><td>From fully robotized and non-flexible factories to human-robot based agile factories</td></tr>
<tr><td>Korea</td><td>From fully robotized and non-flexible factories to human-robot based agile factories</td></tr>
<tr><td>US</td><td>Flexible robotic systems for renewing production lines within the traditional manufacturing sectors</td></tr>
<tr><td>Whole IMS</td><td>Flexibility in manufacturing is a matter of global concern for sustainable manufacturing in a changing economic environment</td></tr>
</table></td></tr>
<tr><td>Possible links to other initiatives:</td><td>Factories of the Future; Manunet</td></tr>
<tr><td>Timeline:</td><td>Short and Medium Term</td></tr>
<tr><td>Dependencies:</td><td>• RT3.03 - Flexible and reconfigurable Changeable Production Systems</td></tr>
</table>

	• RT3.08 - Model based engineering and sustainability
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.47 RT3.10 - High Performance (High Precision, High Speed, Zero Defect)

ABSTRACT:	To increase efficiency of manufacturing system, this topic covers productivity gains and cost saving to face market changes and eco-society sustainability issues. The aim of this topic is to increase the capability of manufacturing systems to maintain highest standards in the event of frequently changing operating and product-mix conditions. To provide more efficient and productive outputs, technologies for high volume, high speed and new capabilities of processes are needed.
Technical Content and scope:	To increase efficiency of manufacturing system, this topic covers productivity gains and cost saving to face market changes and eco-society sustainability issues. The aim of this topic is to increase the capability of manufacturing systems to maintain highest standards in the event of frequently changing operating and product-mix conditions. To provide more efficient and productive outputs, technologies for high volume, high speed and new capabilities of processes are needed. The main technological development for this area are: • Improvement of accuracy (zero-defect); high robustness to handle unexpected events, adaptivity to changes in customer demands and efficient, safe workplaces (allowing and motivating people) • the control and configurations in order to provide drastic improvements in process dynamics; • optimization of machining cycles and process planning. • more efficient and productive outputs by high volume, high Speed and capability of processes; • cognitive systems, condition monitoring, diagnostics and prognostics to realise intelligent and self-optimising machines for “zero-defect” manufacturing; • improvement of performances of production systems.
Expected results and impact, with special focus on the industrial interest:	The expected results are: • manufacturing systems with higher productivity, flexibility and quality; • increased manufacturing speeds of 3-5 times together with minimised secondary times, process stability and machining quality continuously increase production efficiency; • remote monitoring of status in order to know the performance of manufacturing systems along the time and help on making a

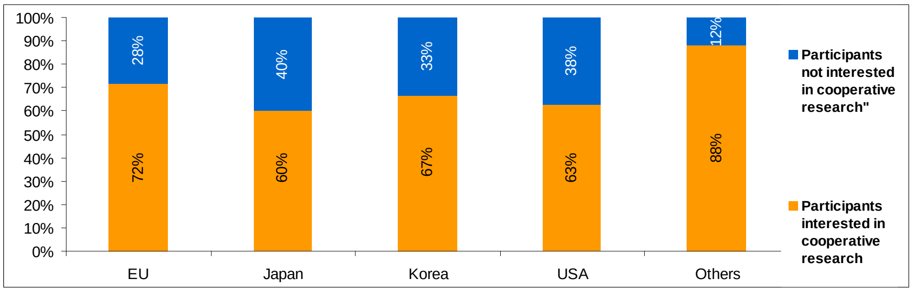
<table>
<tr><td></td><td>predictive maintenance;
drastic improvement of the conventional manufacturing processes, by means of new technological approaches, based on new strategies, tools and machine attributes;
development of processes that substitute the conventional ones or combine with them, provide new productive, economic and ecological ratios;
development of new machine and processes concepts, based on new materials (including nano and smart), new architectures and new control possibilities;
new performance models for real-time control of production system operations, where traditional key performance indicators are expanded to also enable sustainability performance and complete system optimization.
The main impacts are:
industry quick and efficient response to markets;
cost savings;
cost/performance efficiency of the processes;
increase of production systems and company performance;
new business process management.</td></tr>
<tr><td>Specific Features: e.g. Needed standardization actions, education/training needs, involved industries, …</td><td>develop guidelines based on Surveys and case studies, to provide key performance indicators to monitor productivity, cost savings and sustainability impacts;
benefits for automotive supply industries, electric and electronic components;
six Sigma methodology;
lean Production paradigm.</td></tr>
<tr><td>Suggested Scheme:</td><td>CA, STREP</td></tr>
<tr><td>Main interested Regions:</td><td><table><tr><th>Region</th><th>Why / Reference</th></tr><tr><td>EU</td><td>Performance & efficiency oriented technologies
Ultraprecision manufacturing</td></tr><tr><td>Japan</td><td>Performance and efficiency oriented technologies
Zero-defect policy (plant accidents, material losses)</td></tr><tr><td>Korea</td><td>Some interviews and discussions with Koreans show interest in this topic.</td></tr><tr><td>US</td><td>Performance improvements: Across manufacturing in general, needs that drive the adoption of robots in processes include improvements in speed, accuracy, safety, and precision
Interviews conducted in the US evidence also the need for advances in this topic, especially the area of machine auto-diagnosis and the application of current</td></tr></table></td></tr>
</table>

	nanotechnology in ferrous materials **Whole IMS**
Possible links to other initiatives:	PPP "Factory of the Future", FP7, MANUNET, ERANET
Timeline:	Short and medium
Dependencies:	RT3.11 - Model-based Manufacturing
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.48 RT3.11 - Model-Based Manufacturing

ABSTRACT:	Model-based manufacturing refers to the development of virtual manufacturing environments that will allow explicitly integrating knowledge in the manufacturing chain. Expected outcomes are tools for manufacturing environment simulation and information exchange with other production stages.
Technical Content and scope:	Since recent years the old manufacturing paradigm based on pure economic growth is shifting towards a more complex scenario that is no longer driven by cost but by value adding and where sustainability concepts emerge. Under this new scenario where added value technological developments and services or preservation of natural resources are comparable to labour and capital assets, knowledge appears as a key issue since it allows the possibility of value-creation patterns based on intangibles. However, knowledge in the manufacturing chain only exists implicitly within skills of workers, technicians and engineers up to date. Model-based manufacturing, as a component of model-based factories, relies on the development of modelling and simulation tools and it appears as the clue to explicitly integrate knowledge in the manufacturing chain and thus meet current market and companies expectations.

	In model-based manufacturing, the development of the virtual world leads to an effective deployment in the real world since problems are predicted and solved before they occur on the shop floor. As model-based manufacturing has the ability to predict performance of products and processes, in the sense that superior solutions can be delivered at lower cost. On the other hand, making explicit the tacit knowledge that is implicitly within workers will be of special interest. In this respect, research will be required for identifying feasible approaches to externalise and socialise knowledge valuable to the model based manufacturing effort. The topic focuses on the creation of a technology framework for the effective and efficient virtual visualization and simulation of manufacturing processes and the resulting products. The proposed solutions will allow quick, reliable and optimized manufacturing of products and they will contribute to the development of holistic integrable, up-gradable and scalable knowledge-based manufacturing industries. Industrial sectors to be targeted range from manufacturing of micro-applications to large devices and from "one-of-a-kind" and small series to large scale and massive production.
Expected results and impact, with special focus on the industrial interest:	Research results include: ▪ technologies and tools for rapid and cost effective modeling, simulation and virtual prototyping that contribute to a deeper understanding, quick set up and increased optimization of the behavior of machines, manufacturing processes and products; ▪ tools to enhance accessibility and sharing of the information generated in the virtual manufacturing environment in order to integrate it with design and life cycle analysis for holistic approaches. Expected impact of the R&D developments: It can be expected that model-based manufacturing solutions to be developed will bring a 15% reduction in cost and a 15% improvement in productivity due to minimization of manufacturing of defective parts. Minimization of defective parts will also report a lower impact on the environment through a reduction of raw material waste and energy consumption of a 5% at least. The developments will also contribute to reduce ramp-up time of new products in a 30%.
Specific Features: e.g. Needed standardizatio n actions,	

<table>
<tr><td>education/training needs, involved industries, …</td><td colspan="2"></td></tr>
<tr><td>Suggested Scheme:</td><td colspan="2">SME-targeted collaborative projects</td></tr>
<tr><td rowspan="6">Main interested Regions:</td><td>Region</td><td>Why / Reference</td></tr>
<tr><td>EU</td><td></td></tr>
<tr><td>Japan</td><td></td></tr>
<tr><td>Korea</td><td></td></tr>
<tr><td>US</td><td>Interviews conducted in the US evidence also the need for advances in this topic, especially the area of design rules – predictive manufacturing, Machine Auto-diagnosis and the effective application in data management</td></tr>
<tr><td>Whole IMS</td><td></td></tr>
<tr><td>Possible links to other initiatives:</td><td colspan="2">Eureka, ERA-NET, CRAFT programmes</td></tr>
<tr><td>Timeline:</td><td colspan="2">Short and medium term</td></tr>
<tr><td>Dependencies:</td><td colspan="2">RT3.9 Model-based engineering and sustainability
RT3.10 High performance (high precision, high speed, zero defect)
RT3.12 Comprehensive and holistic approaches of multi-scale modeling and simulation of manufacturing systems</td></tr>
<tr><td>Topic Relevance Indicator:</td><td colspan="2"></td></tr>
<tr><td>Regional Interest for Collaboration:</td><td colspan="2">
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11.49 RT3.12 - Mechanical MicroMachining Enhancement

ABSTRACT:	The miniaturization of machine components is unanimously a key issue for the future technological development. However, numerous technological problems prevent the adoption of micro-manufacturing technologies at the industrial level. Cost effective and reliable mechanical micromachining processes must be developed through a deep comprehension of the material removal mechanisms and of the micro structural behaviour of materials and its effects on machining forces, deformations and quality on the work piece. New concepts are also needed for fixturing and handling systems, modular and multifunctional machine tools, process monitoring and control through accurate sensors and methods of data analysis.
Technical Content and scope:	Micro scale manufacturing technologies have been considered a significant research area in the last 15 years. However, besides important advances and applications, the use of micro manufacturing technologies for industrial production is far from being practicable. The current micro manufacturing processes are suitable for accommodating individual components rather than large batch sizes thus preventing their use at the industrial level. Moreover, in-process quality of components is rather difficult to monitor for some of the micro manufacturing processes (lithography). The application of micro components requires the capability of manufacturing 3D free-form surfaces using a variety of metallic alloys, composites, polymers and ceramic materials. The answer to these needs passes through the enhancement of miniaturized mechanical material removal processes. The research must focus on several critical issues associated with micro-fabrication requiring a paradigm shift from macro- to micro-processes: • the material removal mechanism; • the micro structural behaviour of materials and its effects on machining forces, deformations and quality on the work piece; • fixturing and handling systems; • modular and multifunctional machine tools; • process monitoring and control through accurate sensors and methods of data analysis; • interfacing to the macro-domain.
Expected results and impact, with special focus on the industrial interest:	• Manufacturing of 3D micro components using a large variety of materials. Particulary interesting for the biomedical area where complex 3d components and specific materials are required (ceramic composites, special steels). • Advances in micro drilling technologies. Highly significant in the automotive and chemical sectors (injection nozzles). • Manufacturing of complex micro 3D geometries for improved heat transfer interfaces. To be exploited in the chemical and

<table>
<tr><td></td><td>energy sector (fuel cells).</td></tr>
<tr><td>Specific Features:</td><td>Standardization activities are required in the area of
▪ micro features measurement;
▪ assessment of micro machines and micro tools capabilities.
Education/Training: major efforts should be dedicated to the dissemination of the state of micro manufacturing technologies in the industry. Education and training is needed to provide accurate and reliable information on capabilities and costs of micro manufacturing technologies.</td></tr>
<tr><td>Suggested Scheme:</td><td>Small Scale Research Projects for specific research issues (tool-material interaction, measuring systems, fixturing and handling systems).
Large Scale Research Projects for the integration of different aspects towards the integration of micro-manufacturing technologies in the industry (supply-chain and logistic at the micro level, multi-scale production system to integrate macro-micro-nano manufacturing).</td></tr>
<tr><td>Main interested Regions:</td><td><table>
<tr><th>Region</th><th>Why / Reference</th></tr>
<tr><td>EU</td><td>to speed up the rate of industrial transformation in Europe through the capability of supply chains to take the form of flexible collaborations, networks of specialised small and medium-sized enterprises (MANUFUTURE)</td></tr>
<tr><td>Japan</td><td></td></tr>
<tr><td>Korea</td><td></td></tr>
<tr><td>US</td><td>Interviews conducted in the US evidence also the need for advances in this topic, especially the area of machinery accurancy for mechanical components</td></tr>
<tr><td>Whole IMS</td><td></td></tr>
</table></td></tr>
<tr><td>Possible links to other initiatives:</td><td>MINAM – European Technology Platform for Micro- and NanoManufacturing, 4M – Multi Material Micro Manufacturing (NoE FP6), WTEC – World Technology Evaluation Center, MicroBridge - Facilities for Micro-Machining and Micro Fabrication of Non-Silicon Components (Research Project), Nexus (association www.nexus-mems.com).</td></tr>
<tr><td>Timeline:</td><td>10 years horizon for specific technological issues.
15 years horizon for the integration of micro and multi-scale technologies in the industrial environment.</td></tr>
<tr><td>Dependencies:</td><td>No</td></tr>
<tr><td>Topic Relevance Indicator:</td><td></td></tr>
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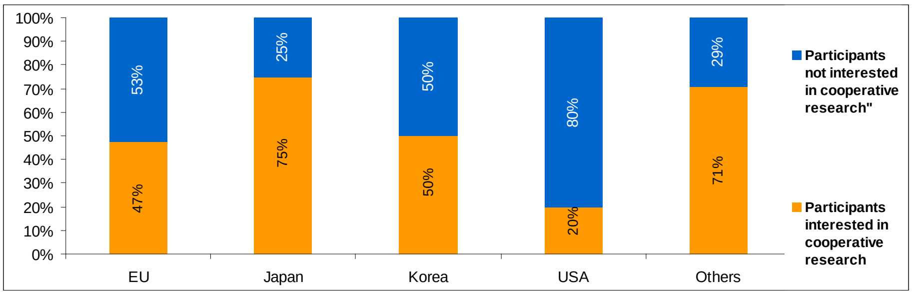
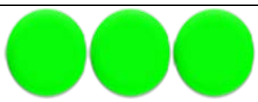
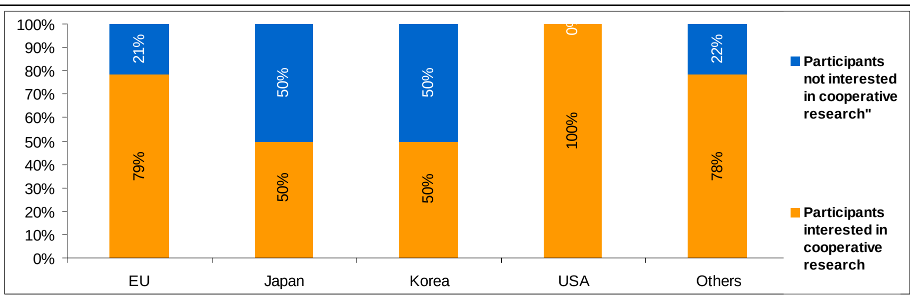
Regional Interest for Collaboration:	

11.50 RT3.13 - High Resolution Total Supply Chain Management

ABSTRACT:	In the current business environment of world-wide manufacturing industries changing markets have a strong impact on supply chains. Being able to adapt processes according to supply chain requirements is a key success factor to cope with these changing environments. To enable this future collaboration of companies in networks should overcome the classic grade. It should be characterized by transparency and synchronized target systems in order to increase service levels and decrease logistic costs.
Technical Content and scope:	Adaptability of production management processes within the company and the supply chain is a precondition for success in the current business environment of changing markets. Therefore future collaboration of companies in networks should overcome the limits of traditional capacity analysis and planning systems. A new level of information transparency, which enables companies to make their organizational structures capable to adjust themselves to the highly dynamic environment, needs to be established. Facilitated by this new transparency level, self-controlled and self-optimizing production units based on decentralized production control mechanisms must replace the classic approach of production planning and control. The decentralized systems embedded in highly integrated supply chains and supply chain processes provide the basis for the required adaptability of production and capacity management. To ensure a high goal synchronization of the decentralized systems a common goal system incorporating aspects like lead time, service level but also sustainability has to be defined. Thereby advantages of centralized and decentralized approaches are combined. The described planning and control methodology is therefore a promising approach to solve the conflict between contradicting goals like cost orientation versus high quality and standardization versus flexibility. In order to contribute to the described scenario the main research areas which need to be addressed are: • A high resolution information infrastructure based on communication standards, intelligent objects and next

	generation IT systems • Collaborative manufacturing data exchange • Material flow management across the entire network • New product life cycle management over multiple levels in a supply chain • Integrated production offering order status information for the customer and the network • Equipment monitoring and maintenance • Integrated Maintenance Systems including real-time monitoring (design, implementation, operation) enabling new and protected services for the production equipment • Planning and control of reverse logistics / recycling Furthermore research needs to focus on: • Supply chain redesign and re-engineer and transportation optimization (consolidation / logistics center) with brownfield planning; • New business models for design of sustainable supply chains; • Development of efficient and effective decision making methodologies intended to optimize operational activities; • Model to include the co-operation with research institutes and academia for sustainable innovation; • ICT to support value creation by globally networked operations including global supply chain management, product-service linkage and management of distributed manufacturing assets (virtual factories), securing of information and knowledge exchange and process synchronization. The topic focus on optimal supply chains. To enhance learning on the design and management of supply chains, serious games may serve as a powerful instrument. In such an approach a virtual business environment is established. Solutions are developed empirically by letting people play against each other using this virtual business environment. In this way various approaches can be tested helping to find a good solution. At the same time the persons participating will enter a learning cycle developing their own competence in making decisions in managing supply chains. A successful project could include experiments with a serious game to help develop a good solutions and to stimulate learning in the participating companies.
Expected results and impact, with special focus on the industrial interest:	Expected results are: • new supply chain system to ensure high quality and high market responsiveness • improved output-driven manufacturing systems to get quickly and efficiently finished products with faster responses to orders, requests, services • enhanced sustainability by supporting and continually improving the performance of the product, the logistics and the manufacturing systems, improving the environmental aspects, the reduction of traffic and pollution caused by transport in the

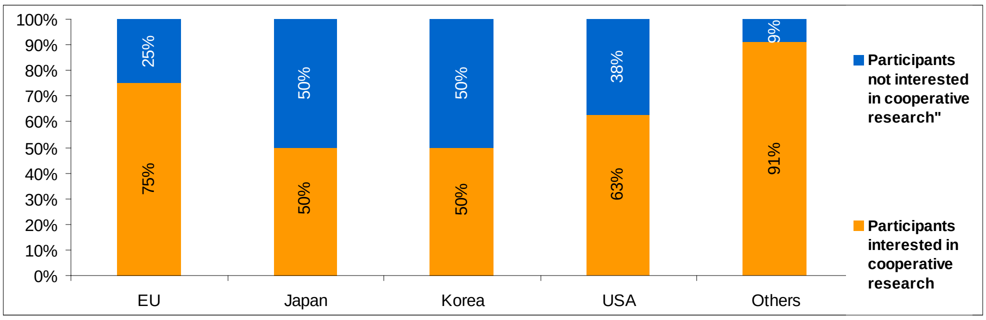
	surrounding area of the plant • tracking and tracing of products to communicate cross company borders, cross branches and even globally • New business models and new enterprise abilities for improved management of global networked operations • Rapid and efficient transfer of information (static, dynamic and field data) along the supply chain. All participants working to same set of performance measures • Integration of production networks Mathematically strong results and managerial phenomena can be also obtained. The main impacts are: • minimization of the expected cost or maximization of the expected profit in a supply chain • improvement of the process performance of the value chain and adoption of new KPI. • improvement of transparency throughout the whole supply chain • virtual horizontal integration of supply chain • new enterprise business abilities
Specific Features:	• A practicable standardized, "semantic near" approach for describing products and product data to communicate cross company borders, cross branches and even globally (communication in global supply chains!) needs to be established. Static data, dynamic data (e.g. for logistics) and field data (e.g. for tracking and tracing) need to be incorporated in this approach • Smart mobile components, networks integrating multiple wireless communication technologies (GSM, GPRS, WLAN, RFID, Bluetooth, Zigbee) and sensors for real-time network visibility are technical requirements for this topic • Training programs including all the actors of a supply chain are to be established. These programs provide support for the distribution and application of communication standards based on ICT technologies. • International standards for intra- and inter-enterprise integration and networks oriented to large/SME, multi-product enterprises and supply-chains need to be developed. • A guideline for adoption of new performance measurement methods for processes and logistic services needs to be established.
Suggested Scheme:	SSA, STREP
Main interested Regions:	**Region** / **Why / Reference** **EU**: • Systems to integrate supply chain for quick response to market changes • Models for the improvement of the

	Japan Korea US	supply chain performance • new organizational models for the management of the supply chain • sustainable supply chain Supply chain redesign: transportation optimization (consolidation / logistics center) • Stochastic models for design of sustainable supply chains • Standards Networks of supply chains Supply chain agility and devolved technical responsibility Interviews conducted in the US evidence also the need for advances in this topic, especially the area of ICT: Capturing and representing data - From data to knowledge
	Whole IMS	• Argentina: Models, tools and architectures to efficiently managing and integrating global supply chains • India: Modeling of Two-echelon supply chain which are applicable to real life scenario
Possible links to other initiatives:	PPP "Factory of the Future", FP7, MANUNET, ERANET	
Timeline:	Short and medium	
Dependencies:	RT3.18 - Knowledge Generation Systems	
Topic Relevance Indicator:		
Regional Interest for Collaboration:		

11.51 RT 3.14 - High Accuracy Modelling

ABSTRACT:	Companies face the problem that current production, planning and control (PPC) approaches aren't able to incorporate all relevant influence factors

	leading to inefficient and ineffective production in worldwide networks. Integrated multiple optimization of economic and sustainable production based on high accuracy modelling seems to be a reasonable solution. There is a need for development of methodologies and new ways of visualization based on ICT. This would improve PPC processes within complex company networks involving multiple stakeholders.
Technical Content and scope:	The research topic describes a new level of PPC based on high resolution models. The adaptability of planning and forecasting processes within the company, the supply chain and aligned with multiple stakeholders is a precondition to keep production in high-wage countries. These complex models allow a detailed visualization and description of relative changes. Based on high-end information and communication technologies, high resolution models give a deep insight in the highly complex inner- and inter-organizational interdependences and give detailed and realistic prognoses. In order to produce with a high orientation on ecological sustainability and economic success these models have to be able to support any kind of system like classic hierarchic systems or decentralized production control mechanisms.
Expected results and impact, with special focus on the industrial interest:	Development of methodologies and ICT that allow the high resolution planning and forecasting of PPC processes within complex networks of companies and multiple stakeholders. New ways of visualization have to be invented to make the results maximum applicable.
Specific Features:	• manufacturing companies in high wage countries; • communication within networks based on standardized inter-organizational ICT interfaces; • standards for the generation and visualization of high resolution models of worldwide operation production networks; • inter-organizational standardized processes and data between interacting companies.
Suggested Scheme:	
Maininterested Regions:	**Region** / **Why / Reference** **EU** **Japan** **Korea** **US** — Interviews conducted in the US evidence also the need for advances in this topic, especially the area of technology

		accuracy – maturity and algorithm optimization
	Whole IMS	
Possible links to other initiatives:		
Timeline:	From now on	
Dependencies:	RT3.22- Dealing with Unpredictability	
Topic Relevance Indicator:	● ● ●	
Regional Interest for Collaboration:		

11.52 RT3.15 - Semantic Business Processes

ABSTRACT:	The intensive global competition motivates an increasing number of companies to cooperate throughout the entire value chain. Models, tools and standards for inter- and intra-organizational business workflows and process execution have to be developed in order to guarantee high-quality integration of processes within cooperation. Using semantic descriptions for this purpose ensures flexibility and a common understanding of involved processes.
Technical Content and scope:	Efficient cooperation of organizations throughout the value chain continues to be a challenge on all levels of interaction in most industry sectors. Further potentials are expected to be found in particular with regards to business process engineering and workflow management. A typical example for an industry sector migrating to higher inter-organizational workflow management is the energy market. Liberalization forces regional as well as national energy providers to collaborate. Furthermore, highly integrated value chains as for example the automotive industry could gain further flexibility by semantic process models. Semantically defined objects, processes and interfaces support companies acting flexibly and competitively in corresponding markets. The usage of semantic process models would in particular simplify developing new markets, adapting to the changing environment or switching providers. In general, promising approaches are the enrichment of modelled processes and workflows with semantics in order to allow for • a responsive adaption to the dynamic business needs; • a higher degree of automated information flows; • an intensified integration of different IT-Systems; • well-defined interfaces for simplified collaboration. To define and agree upon common business models need cooperation and exchange of knowledge between different companies and stakeholders. To develop and implement new methodologies acting as “Communities of practice” to identify common models, processes and framework is necessary. Processes, workflows and interactions will in many cases be tacit knowledge which has to be identified and made explicit. Methodology and tools for bringing tacit knowledge to explicit knowledge need to be developed.
Expected results and impact, with special focus on the industrial interest:	Results are models, tools and standards for semantically supported inter- and intra-organizational workflows, objects and process execution. They will create a common understanding of processes, relevant information and involved objects and persons. One solution could be a definition of reference processes. They provide interfaces between reference process steps as well as interfaces to a company’s

<table>
<tr><td></td><td>process or value chain. A company has to implement all interfaces provided by the reference process. However, the company is free to implement and modify the internal process so that it matches internal structures and requirements. While reference process modelling is already under way in many industry sectors (e.g. SCOR, eTOM), a precision with semantic modelling language could further increase the benefits.

Expected impacts are:
frictionless integration of processes throughout several companies;
simplified horizontal and vertical interchangeability of involved companies throughout a value chain;
reduced time to establish collaborations. This could lead to just in time collaboration.
Simplified collaboration and interchangeability of companies could also increase competition and raise perceived customer service value.</td></tr>
<tr><td>Specific Features:</td><td>The standardization of adequate semantic models for process engineering and workflow management as well as recommendations for an efficient implementation of semantic technologies is fundamental and should be goal of this research topic. As mentioned, industries of main interest are for example the dynamic energy sector, especially in combination with the vision of an Internet of Energy. Also the health care sector and the automotive sector show potential for optimization through semantic processes.

Companies and users need to be informed and trained in how to use Business Process modelling as a tool to manage and make own businesses more innovative and competitive.</td></tr>
<tr><td>Suggested Scheme:</td><td></td></tr>
<tr><td>Main interested Regions:</td><td><table><tr><th>Region</th><th>Why / Reference</th></tr><tr><td>EU</td><td>X</td></tr><tr><td>Japan</td><td></td></tr><tr><td>Korea</td><td></td></tr><tr><td>US</td><td>Interviews conducted in the US evidence also the need for advances in this topic, especially the area of dynamic planning / Supply Chain modelling, automation: operational efficiency - modelling for flow</td></tr><tr><td>Whole IMS</td><td></td></tr></table></td></tr>
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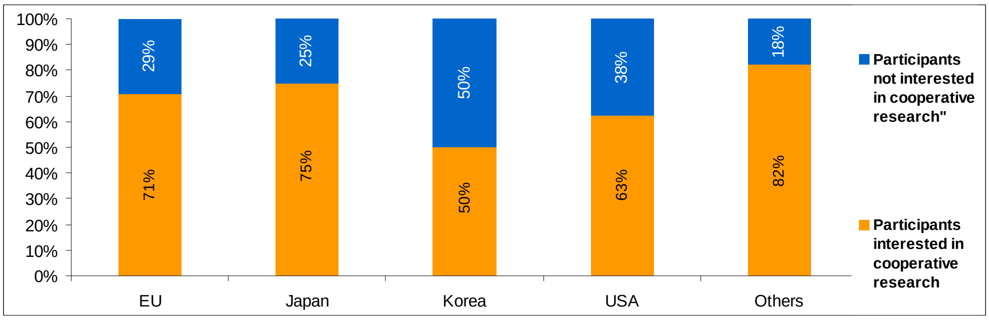
Regional Interest for Collaboration:	

11.53 RT3.16 - Professional Virtual Collaboration Platforms for Regional Clusters Optimization

ABSTRACT:	For the manufacturing industry it is imperative to continue to exploit innovative business strategies long time in advanced. One essential strategy of the future is to participate in dynamic business networks. Two major objectives of this strategy are to bring the core capabilities into a flexible network and to govern through stakeholders. The result should be dynamic and flexible representation of business processes and technology for virtual collaboration among regional clusters. Therefore, the research focus should be on extracting higher potential from regional cluster based on professional virtual collaboration platforms (collective governance and expert contribution). The concept is based on three interrelated aspects: Professional web, Dedicated micro-portals and Knowledge management.
Technical Content and scope:	Problem identification High performance manufacturing as an industrial sub-sector that is geared towards an integrated approach to optimize the organization of design, manufacturing productivity and quality processes. In the modern business environment, the survival of western manufacturing SMEs depends on their capacities to create and offer more innovative and competitive solutions to their customers. Therefore, to create more value and to reach higher customer satisfaction levels are two of the key issues requiring constant attention. Collaboration, co-creation, specialization and outsourcing are nowadays core of proposing array of solutions to these problems. The contemporary ICT technologies allow finding new innovative business models, which can overcome these problems. Research, development and acquisition of new technologies are much more cost effective and affordable in this way. The informal social web based structures have shown promises but lack greatly in supporting conventional industries. This potential needs to be extended to develop the professional web mechanisms. Aim The trends suggest the importance of innovative and dynamic mechanisms to set-up competences-based multilayer collaboration networks (e.g. communities of practice) focusing on high performance manufacturing (industry customised) problems. Further, such mechanisms are required to research and implement ICT collaboration and support platforms, systems of governance.

	Core focus The preceding could be achieved through exploiting technological achievements in the social online platforms and services; the need to manage knowledge by supporting the knowledge worker within and among enterprises is recognized as a key success factor. For the manufacturing industry it is imperative to continue to exploit innovative business strategies long time in advanced. One essential strategy of the future is to participate in dynamic business networks. Two major objectives of this strategy are to bring the core capabilities into a flexible network and to govern through stakeholders. Explanation of the modular structure Professional cluster based collaboration: focuses on the formation of regional clusters - based on their realization to collaborate in a more dynamic environment, i.e. an internet platform representing the collective needs and goals of the regional associates/stakeholders. • Professional communities: communities focus on the information and resource sharing. • Expert groups: experts form groups based on sub-domain expertise and provide services to the lower layers, such as consultancies for problem identification and solution. • Research and development: The optimal point of a professional virtual platform is to be able to conduct research on new product and service innovation based on knowledge resource sharing. The type of data that should be made available through the platforms depends on the platform configuration and is generated based on the cluster needs; e.g. for market trends analyses tools of collected wisdom could be used and for quality assurance quality guidelines could be extracted leading to quality standards.
Expected results and impact, with special focus on the industrial interest:	Research and development The optimal point of a professional virtual platform is to be able to conduct research on new product and service innovation based on knowledge resource sharing. We suggest for the research layer to be functional it is imperative that exploitation layers - cluster, communities, expert groups - should be integrated in the virtual collaborative governance and maintenance
Specific Features: e.g. Needed standardization	• process and service standards; • integrative training and governance.

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<tr><td>actions, education/training needs, involved industries, …</td><td></td></tr>
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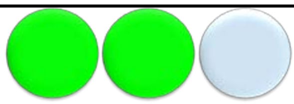
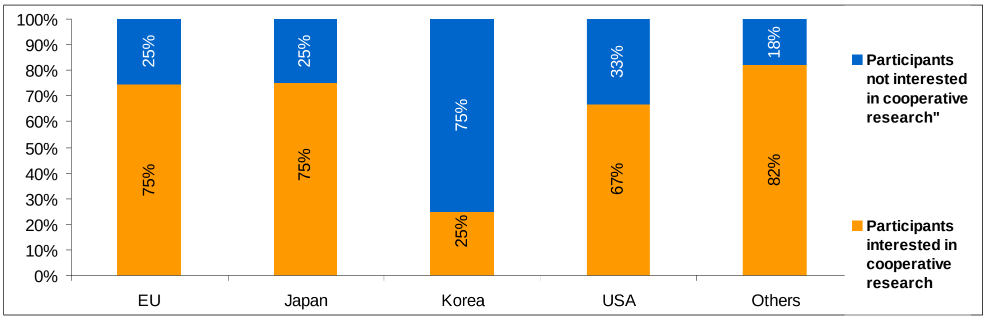
<tr><td>Topic Relevance Indicator:</td><td></td></tr>
<tr><td>Regional Interest for Collaboration:</td><td>
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11.54 RT3.17 - Ontology Based Engineering Asset Management

ABSTRACT:	Optimisation of assets and more particularly of engineering assets is a key and challenging issue for modern industrial societies. Engineering Asset Management (EAM) is an emerging inter-disciplinary field that combines technical issues of asset reliability, safety and performance with financial and managerial requirements. The emphasis of EAM is clearly on sustainable business outcomes, risk management and value. EAM is concerned with assets throughout the lifecycle. Efficient Engineering Asset Management is realised with the efficient development of closed loop Product Lifecycle Management (PLM) technologies allowing for the efficient management of all the business processes distributed along the product's lifecycle phases. Middle of Life and particularly maintenance is of particular interest and importance for Engineering Asset Management. Along that line predictive maintenance and maintenance for sustainability approaches, models, methods and tools need to be developed.
Technical Content and scope:	Organisations worldwide are looking for opportunities to reduce the cost of maintaining their assets, improve the performance of those assets through effective decision making, and gain competitive advantage. In many industries regulatory requirements as well as safety criticality of these assets add to the complexity. In this environment, it is essential for organizations to accurately track the current configuration and trace historical configuration changes throughout the asset lifecycle. However, traditional configuration management systems have often proved inefficient for managing Maintenance, Repair and Overhaul (MRO) data because they represent only the last asset configuration and fail to provide the ability to consistently trace the current and historical changes to the asset configurations. Hence organizations often experience a lack of information between the initial acquisition of the asset and the following service operations. For instance, the acquisition information regarding the asset is often obsolete due to changes in the asset setup since installation, and considerable amounts of time are wasted on inefficient updates. In this context, ontology - an emerging research field seem appropriate to support the development of conceptual models to trace the asset configuration history. A generic engineering asset management and configuration framework based on will improves visibility and control of asset configuration changes throughout its lifecycle. As a result, support for service and maintenance could be provided. Usage information originating from sensors, maintenance activities etc. will be structured automatically according to the ontology tree of classes and will be used to create knowledge. This, knowledge will be used to predict components' status and maintenance operations (manage maintenance resources), avoid break downs (increase costumers' satisfaction and sense of security) and eventually send feedback to BOL for repeated failures of components or software. The ontology based "reasoner" would categorize components, events, products according to

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<tr><td></td><td>predefined criteria, and so support decision making.

Engineering asset management creates a need for cross sectorial education related to understanding of societal and cultural trends, identification of consumers and market opportunities, exploitation of new global business paradigms as well as of innovative materials, ICT and manufacturing technologies. Safety and well being of future workers also demand new cross sectorial education actions, as well as the manufacturing of a new generation of healthy and green products for final consumers. There is a serious need for research to understand how enterprises can create and increase awareness of these topics and how they could be addressed along the manufacturing value chain in multiple sectors.</td></tr>
<tr><td>Expected results and impact, with special focus on the industrial interest:</td><td>Help industries maximize value generation from their assets through effective management of asset configuration and decision-making. This will benefit industry practitioners, especially those who manage complex industrial engineering assets such as aircraft, locomotives, vehicles, etc. by effectively maintaining regulatory compliance while increasing engineering asset reliability and availability, resulting in an effective value proposition.</td></tr>
<tr><td>Specific Features: e.g. Needed standardization actions, education/training needs, involved industries, …</td><td>Application of new technologies. Need for new education programs.</td></tr>
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<tr><td>Korea</td><td>X</td></tr>
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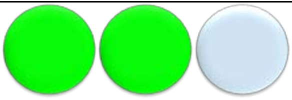
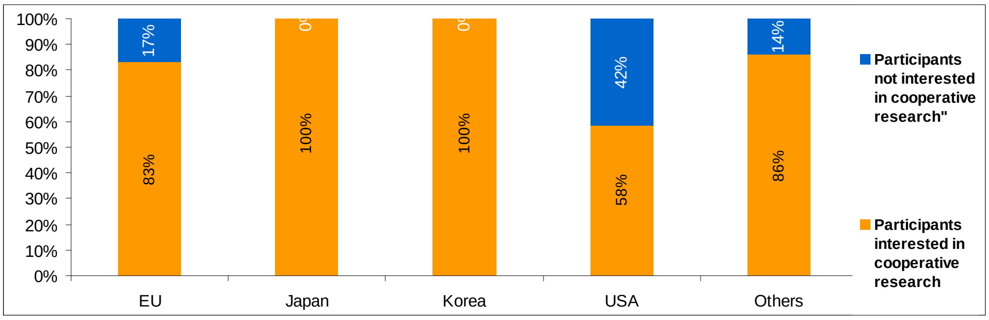
<tr><td>Topic Relevance Indicator:</td><td></td></tr>
<tr><td>Regional Interest for Collaboration:</td><td>
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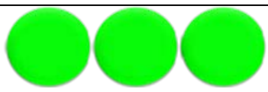
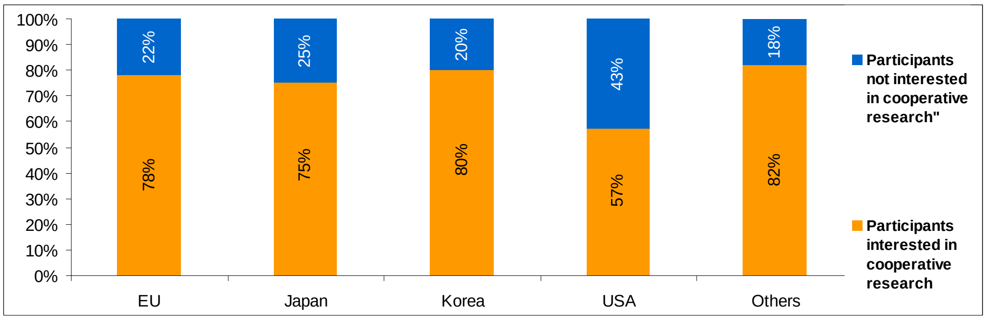
11.55 RT3.18 - Semantic Based Engineering

ABSTRACT:	Nowadays interoperation and collaboration is an essential requirement for an increasing number of enterprises. Through this process they face the problem of poor data management for improving future activities and actions. Although a lot of data is being collected by various systems, there is no efficient and productive method to map, to process and to make the data useful. The development of Systems capable of understanding the data and generating knowledge is required. Semantics through ontologies ensure flexibility and a common understanding of terms for both human beings and computer systems. New systems developed following semantic based engineering approaches will be semantic-concept-based and will combine concepts with data to generate new knowledge. Semantic based engineering may become a key enabler of sustainable engineering in general since it provides a seamless interoperability environment which through experience so far appears to be a key issue in complex systems optimisation.
Technical Content and scope:	Collaborative engineering even within the same enterprise has many barriers to overcome. The theory which is the basis of the today's data and information systems should change and it should move from the traditional process of "software design and implementation" to "concept composition and knowledge generation". The initial concepts are always simple (i.e. humans are mammals, mammals are animals, etc.). The composition of many simple concepts leads to complex concepts. This will be the basis for developing new systems for Semantic based engineering. The Semantic systems will be concept-based and will combine existing simple and complex concepts with data, in order to generate "new" concepts and therefore new knowledge. All concepts of the system will be semantically defined. Each Data loaded into the system has a meaning and hence, belongs to a concept. The importance and the usefulness of the "new" concepts would be evaluated according to the Data loaded into the system. Moreover, the data will be used to validate the "new" concepts against any logical inconsistencies. Thus, the data will be fully exploited and new concepts would be validated. The validated "new" concepts are the new knowledge generated. Semantic based engineering Systems will be developed using ontologies and other semantic web tools. Their scope is to generate new knowledge in order to reduce costs, support enterprise flexibility and make enterprise's managing system adaptive and generative. To define and agree upon common engineering concepts, there is the need for cooperation and exchange of knowledge between different companies and stakeholders. To develop and implement new methodologies acting as "Communities of practice" to identify common models, processes and framework might be valuable. Processes, workflows and interactions will in many cases be tacit knowledge which has to be identified and made explicit.

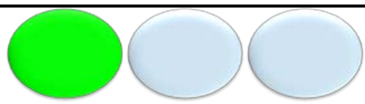
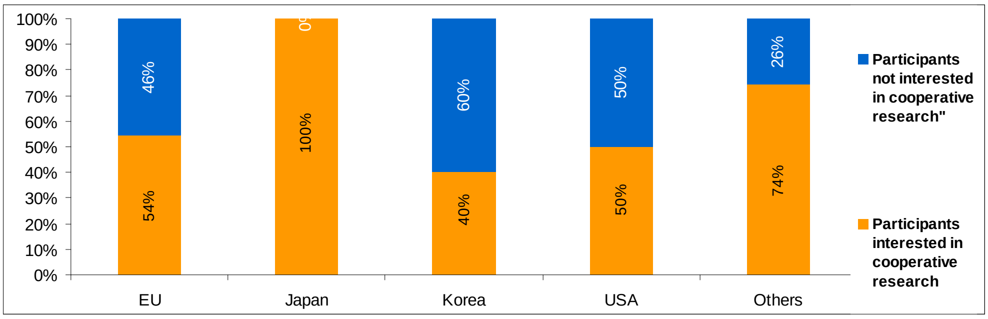
	Methodology and tools for bringing tacit knowledge to explicit knowledge need to be developed.
Expected results and impact, with special focus on the industrial interest:	Increased Efficiency in data mapping, use data, for knowledge this can be translated for: • Decrease of collaborative barriers and costs • Market leadership • Decrease of environmental footprint of the enterprise (Solutions found and understood faster by both humans and engineering systems). • Standardisation of concepts (similar to medical or biology terms i.e. what is a mammal or what is the illness of measles) • Education on conceptual meaning of ontologies in depth. Education on the use of new technology. Tacit Knowledge management to increase the awareness of deeper meanings of semantics.
Specific Features:	
Suggested Scheme:	• Define the concepts of the domain; • Develop conceptual Models describing the domain; • Define the semantics of each concept; • Infer new knowledge.
Main interested Regions:	**Region** — **Why / Reference** **EU** **Japan** **Korea** **US** — Interviews conducted in the US evidence also the need for advances in this topic, especially the area of ICT: Capturing and representing data - From data to knowledge; and its effective application for improvements in data availability and reliability **Whole IMS**
Possible links to other initiatives:	• Concept standardisation • Education on use of new technology. Tacit Knowledge management to increase the awareness of deeper meanings of semantics.
Timeline:	From now on
Dependencies:	Depends on education for improving the level of understanding on new technology.
Topic Relevance Indicator:	

Regional Interest for Collaboration:	

11.56

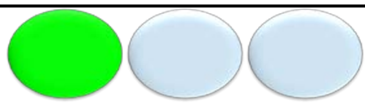
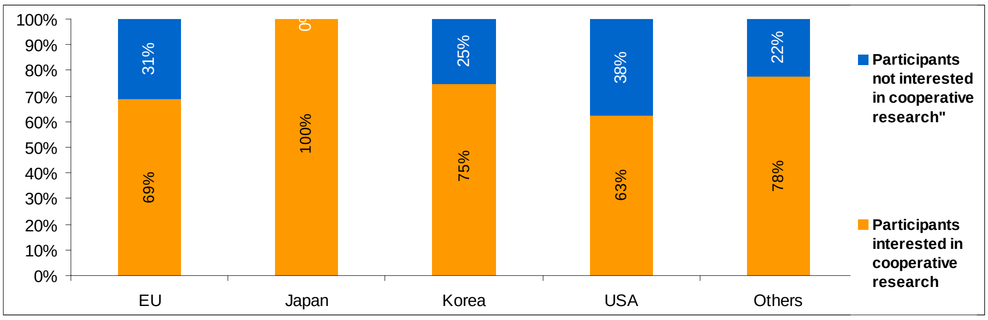
RT3.19 - Forthcoming "Brown Fields" Re-engineering

ABSTRACT:	The scope of this research is the development of a new business model to increase the effectiveness of brown field production. Therefore it is essential to develop supporting tools and methodologies such as, for example, “plug and interoperate” devices, interfaces for interoperability, fast simulations and re-programming tools, methods to improve the plant control, assembly and disassembly aspects.
Technical Content and scope:	Research on how to reuse a brown field has been ongoing for years. Little has been developed on how to prevent an old manufacturing site to become a rusting corpse. Actually many industries have old or “ageing” production plans; often small and disorganized actions are carried out to partially modernize them, trying to fill an evident and momentary lacking, without a well structured plan on what to do and when. The scope of this research is the development of: • new business models of plans usage and re-modernization • production plan design methodology to increase the effectiveness of “brown field” re-engineering and re-use. Therefore it is essential to develop supporting tools and methodologies such as, for example, “plug and interoperate” devices, interfaces for interoperability, fast simulations and re-programming tools, methods to improve the plant control, assembly and disassembly aspects.
Expected results and impact, with special focus on the industrial interest:	Expected results are: • Development and application of plug and interoperate devices • Development of interfaces for fast interoperability • Fast simulation methodologies and tools • Tools to re-program the various machines present in the plan • Methods to control the plan while under improvement / taking into account different machines ages • Fast plant assembly / disassembly strategies and methodologies. • Management of hazardous wastes • Reduction of soil contamination The potential impact of the research is to reduce of 25% the average cost of plant reengineering with a final target of 7% of production cost reduction.
Specific Features:	

Suggested Scheme:	
Main interested Regions:	**Region** / **Why / Reference** **EU** **Japan** **Korea** **US** — Interviews conducted in the US evidence also the need for advances in this topic, especially the area of smart Sensoring – product quality and workforce safety **Whole IMS**
Possible links to other initiatives:	
Timeline:	
Dependencies:	
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

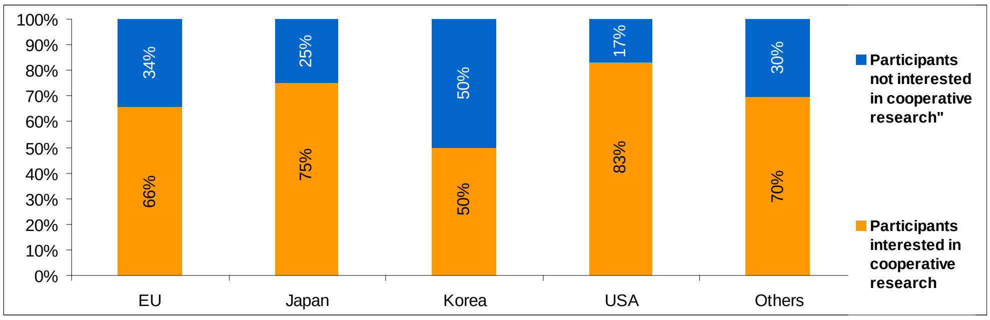
11.57 RT3.20 - Advanced Automation for Demanding Process Conditions

ABSTRACT:	Advanced automation and control systems for processes with fluctuating input streams (such as raw materials, fuels, etc.) need to be developed in order to enhance process stability and thus product quality. Beside a constant product quality, energy consumption and production costs can be decreased by achieving higher throughputs and increased energy efficiency of the process.
Technical Content and scope:	The objective of a production process is to achieve the required product quality and quantity in an (energy) efficient way. For this, process stability is the key parameter. In the process industries fluctuations in input materials and fuels especially challenge this stability. With inconsistent input conditions (chemical and physical properties, quality and quantity of raw materials or fuels) potential process fluctuation and instabilities will increase. Therefore, new intelligent automation and control systems are required in order to ensure process stability and thus energy efficiency. Research should address the development of automation concepts and advanced process control systems able to cope with anticipated increased process instabilities and at the same time ensuring product quality and eventually enhance efficiency. New developments are expected in intelligent control systems able to connect different independent subsystems. Such expert systems will be used for the cost effective operation of complex production processes and deliver timely information and recommend control actions that keep processes operating at conditions close to optimum.
Expected results and impact, with special focus on the industrial interest:	Advanced process control and automation systems will enhance process stability and lead to a constant product quality. Therefore, the energy efficiency of a process can be increased while reducing production costs and saving natural resources. Constant product quality and decreased energy const will contribute to strengthen the competitiveness of manufacturing companies.
Specific Features:	Research efforts in this area would highly benefit from a cross-sector collaboration comprising comprehensive knowledge transfer from different types of automation and control concepts.
Suggested Scheme:	
Main interested Regions:	**Region** / **Why / Reference** **EU** **Japan** **Korea** **US** — Interviews conducted in the US evidence also the need for

		advances in this topic, especially the area of machine auto-diagnosis, as well as automation: operational efficiency - modelling for flow
	Whole IMS	
Possible links to other initiatives:		
Timeline:	Immediately	
Dependencies:	RT3.17 - Engineering Asset Management	
Topic Relevance Indicator:		
Regional Interest for Collaboration:		

11.58 RT3.21 - Business Concept B2C-Communities

ABSTRACT:	The increasing competitive pressure on global markets constrains companies to reduce their costs and to encourage customer retention. By integrating customers into the development process of new products and services, companies are able to save money and to meet end customers' requirements. Therefore methods, tools and standards are needed that help companies to build up their individual B2C-communities.
Technical Content and scope:	Today many departments are faced with an increasing competitive pressure caused by globalization. For the modern industrial nations, which nowadays are based on skill-intensive manufacturing processes, it is impossible to undercut the prices of low-wage countries like China or country-region India. Creating innovative products and services is the only chance for the high-wage nations to compete with the low-wage nations. For an innovative development process, it is mandatory to know the needs of the end customers. By integrating the customers into the development process of new products and services, companies are able to save money and to meet end customers' requirements. Since the consolidation of the European Single Market leads to a cross-border trade of products and services the constitution of B2C-Communities is an important topic for companies that are located in the European Union. These companies have to meet end customers' requirements even if they do not know the cultural and regional distinctions. Against this background method, tools and standards are needed that help companies to build up their individual B2C-communities. In this context methods have to be designed that lead to customers' participation in such communities. Motivating factors are not only monetary aspects. Soft factors such as increasing reputation and the possibility to extend respectively to recess the own network are quite important as well. Since the realisation of B2C-communities requires the accomplishment of many different processes tools have to be developed for a successful supervision of the initiation and operation phase of communities. Due to the fact that B2C-communities are a promising concept standardization activities have to be adopted to guarantee the transferability of the B2C-community building processes.
Expected results and impact, with special focus on the industrial interest:	The final result of work in this field of research will be a guideline including different methods and tools. By using this guideline the transferability of the B2C-community building concept shall be guaranteed. Furthermore it has to be possible for different companies from variable branches by using this guideline to meet the end customers´ requirements and to build-up their individual B2C-community.
Specific Features:	Standardization bodies have to work on a document that describes all sub-processes of the B2C-community concept. This document has to assign the

e.g. Needed standardization actions, education/training needs, involved industries, …	methods and tools to the different scenarios of the building process. Against this background institutionalized standardization by DIN, CEN and ISO should also be involved. All the persons involved in the building process have to be trained in the different methods and in the use of the relevant tools.
Suggested Scheme:	
Main interested Regions:	**Region** / **Why / Reference** **EU** **Japan** **Korea** **US** – Interviews conducted in the US evidence also the need for advances in this topic, especially the area of standardization on the documentation of sustainable business practices **Whole IMS**
Possible links to other initiatives:	
Timeline:	From now on
Dependencies:	
Topic Relevance Indicator:	
Regional Interest for Collaboration:	

11.59 RT3.22 - Knowledge Embedded Products

ABSTRACT:	More intelligent products with embedded knowledge, use of smart materials, sensors, RFID etc will generate new business opportunities and competitiveness for the manufacturing industry and more value for the customers. Through case studies of best practice and state- of-the art within knowledge embedded products, the manufacturing industry will obtain new innovative ideas on how to provide more value for their customers. For the manufacturing industry this will not only represent new markets but also more value and sales to existing customers.
Technical Content and scope:	In a global market, the manufacturing industry is facing global competitors with consistently improving value, productivity, better performance and lower prices. This global competitiveness is reflected by customers with increased demands in many directions. In the new economy, the winners will be technology product manufacturers who have the best products which *includes a* total solution for the customers, for example sales, distribution, service etc in the product. To generate growth, manufacturers should focus on "solution" thinking and deliver solutions rather than products to their customers. Intelligent products could possess information on how it should be used and should "educate" the user to obtain the best possible value of the product to a greater extent than the customers themselves. Through understanding how intelligent products would be appreciated by consumers and other market participants such as retailers and the sales force, manufacturing companies would be educated into new market thoughts that would generate revenue for the companies. In the research project we would search into the following: • What is knowledge embedded products and product intelligence? • What kind of service, information and knowledge could be embedded in the new products/ customer solutions in the manufacturing industry? • How is product intelligence related to new product advantage and market potential? • How can manufacturing companies develop intelligent products with high product advantage in a market-oriented manner? • How should companies communicate knowledge embedded products and new intelligent functionalities to the market place so that potential consumers easily understand the benefits? Research on these questions will give the manufacturing companies knowledge that will represent a huge competitive advantage in a global market.

<table>
<tr><td>Expected results and impact, with special focus on the industrial interest:</td><td>Creating a new market for a totally new type of product characteristics and properties, more value to existing customers and knowledge on how to communicate the new product to the new and existing markets.</td></tr>
<tr><td>Specific Features: e.g. Needed standardization actions, education/training needs, involved industries, …</td><td>Should be linked to specific cases of product and industries (ex new innovative sustainable products).</td></tr>
<tr><td>Suggested Scheme:</td><td></td></tr>
<tr><td>Main interested Regions:</td><td>
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<tr><th>Region</th><th>Why / Reference</th></tr>
<tr><td>EU</td><td></td></tr>
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<tr><td>US</td><td>Interviews conducted in the US evidence also the need for advances in this topic, especially the area of Wireless technology</td></tr>
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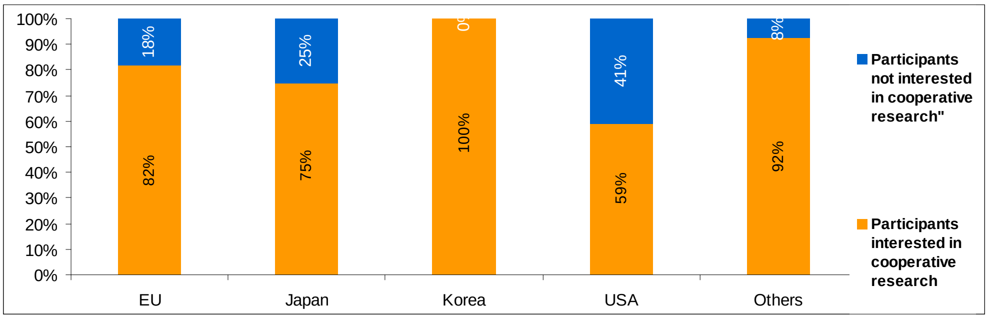
Regional Interest for Collaboration:	

11.60 RT3.23 - Dealing with Unpredictability

ABSTRACT:	Innovation processes are crucial in developing products and processes in manufacturing companies. Traditional methods are insufficient to cope with the risk embedded in such projects and radically new methods are needed taking both contextual and strategic risk into account. The impact of this topic will be better predictability of innovation projects. It will develop a new attitude towards dealing with risk in manufacturing projects.
Technical Content and scope:	Innovation processes are crucial for building competence to manage the future manufacturing technologies. Most innovation is during projects. All projects carry risk. Innovation projects have a high risk and opportunity potential. The industry is well aware of this and conducts extensive risk analysis in all such projects. Still there are many unexpected outcomes. Innovation project are to a large extent characterised by unpredictability. Traditional risk management techniques have proven insufficient for innovation projects. One explanation is that they focus on operational risk and overlook contextual and strategic risks. The unpredictability is probably due to that contextual and strategic risks are ignored and therefore yielding a residual risk. Better predictability in the innovation processes will make development of new products, services or manufacturing processes much more efficient. A fundamental new way of managing risk in complex projects must be developed and tested. It should be based on application of advanced ICT to support the innovative approach. Feasible solutions will probably be based on an engine providing risk scenarios from simulating behaviour patterns in a technical, business and social context. The scenarios would be developed using semantic web technology combined with serious games. Projects should explore the nature of contextual and strategic risk and develop methods to assess these risks and improve predictability. A successful project will go beyond the traditional technical and business risk and take an integrated approach including social behaviour and thus addressing “wicked” problems. This will include formal qualities such as structure of the project organisation and informal qualities such as interaction, culture, diversity and relations. Such processes need to be modelled in order to be applied in a scenario engine.
Expected results and impact, with special focus on the industrial interest:	The expected impact of this research topic will be reduced unpredictability in innovation processes. Development tasks can be executed faster and with less resource spent on coping with unexpected events or stakeholders. A 25 % reduction in risk could easily reduce cost overruns and schedule delays with 20 %. Improved success rate of innovation projects would also build better competence to deal with uncertainty and enable better quality of products.

<table>
<tr><td>Specific Features:</td><td>This topic is suited for enterprises that are frequently involved in complex development projects connected to new products, services or manufacturing processes.</td></tr>
<tr><td>Suggested Scheme:</td><td></td></tr>
<tr><td>Main interested Regions:</td><td><table><tr><th>Region</th><th>Why / Reference</th></tr><tr><td>EU</td><td></td></tr><tr><td>Japan</td><td></td></tr><tr><td>Korea</td><td></td></tr><tr><td>US</td><td>Interviews conducted in the US evidence also the need for advances in this topic, especially the area of predictive Math algorithms and their application on testing prototypes (e.g. eliminate animal testing for medical devices industry)</td></tr><tr><td>Whole IMS</td><td></td></tr></table></td></tr>
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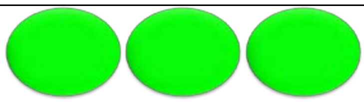
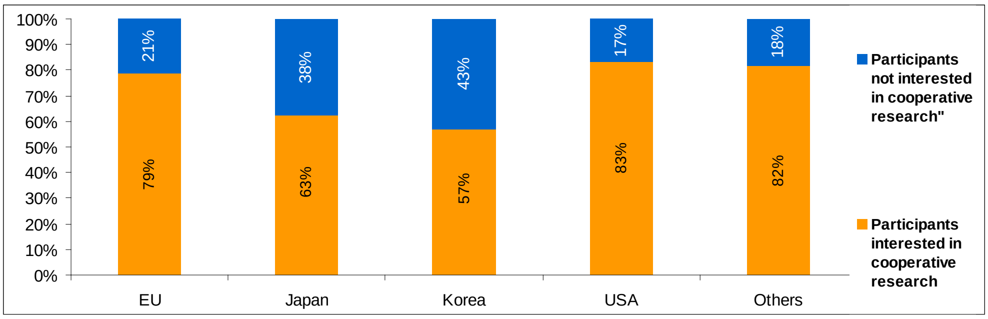
<tr><td>Topic Relevance Indicator:</td><td></td></tr>
<tr><td>Regional Interest for Collaboration:</td><td>
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12. Annex 3: Innovation, Competences Development and Education Research Topics

Innovation, competence development and education contains research topics to support the development of learning organizations through building learning communities, establishing teaching factories, creating innovation agents, etc. Competence is a key factor in the knowledge economy and a prerequisite for a future competitive manufacturing industry. The final version of the roadmap follows a preliminary version of Research Topics, since these are referenced in section 8 - Relations with Innovation, Competences Development and Education (page 47) as tools to be used within previous Research Topics.

12.1

RT5.01 - Teaching Factories

ABSTRACT:	Teaching factories are real production facilities developed for education and training purposes for students and workers, which will significantly reduce the gap between academia preparation and industrial needs, and improve the lifelong learning effectiveness of skilled workers.
Technical Content and scope:	Research and development to develop and validate teaching factories, i.e. infrastructures in the form of producing factories that also can be used for education, training and lifelong learning. Students and workers will come to the factory and learn theory and practice in a real manufacturing environment, where new products are continuously conceived, designed, manufactured and delivered. Therefore it must include all actors from design, development to manufacturing and shipment. Furthermore, teaching factories are supposed to be part of a real industrial value chain, involving suppliers of technologies, components and materials, as well as retailers and vendors. Such a real world value chain will be involved in the teaching factory innovation processes, assessing new solutions and contributing to the technology transfer action of such infrastructures. Teaching factories may be also innovative experimental set ups for product innovation, supporting the continuous product innovation by means of exploitation of new concepts, design, components, materials and manufacturing technologies for the development of prototypes and samples, as well as small series. There should be agreements with schools/universities as well as companies to use this infrastructure for educational and training purposes. Related research topics will be: new conception and design technologies, new cad-cam instruments, new manufacturing technologies, new ERP, MES and PDM tools, new supply chain schemas, new vending concepts and tools.
Expected results and impact, with special focus on the industrial interest:	Competence development and training in an industrial environment which is closely adapted to the industrial needs. This can support introduction of new technology in SME and provide opportunities for learning between enterprises, with reference to CAD-CAM, ICT and data management, as well as automation and manufacturing technologies. Particularly, teaching factories will significantly reduce the gap between academia preparation and industrial needs, reducing the insertion time of new workers in manufacturing industries to zero, and improving the lifelong learning effectiveness of skilled workers.

12.2 RT5.02 - Cross Sectorial Education

ABSTRACT:	Exploitation of new challenges on the global scale as well as of new enabling technologies for manufacturing and ICT solutions requires education efforts which are not sector specific. Such cross sectorial education action will improve manufacturing industry added value in different sectors. Education and exploitation of business opportunities related to new technologies will be of great benefit for SMEs.
Technical Content and scope:	In manufacturing industry there are many cross sectorial education needs, related to understanding of societal and cultural trends, identification of consumers and market opportunities, exploitation of new global business paradigms as well as of innovative materials, ICT and manufacturing technologies. Particularly, bio and sustainability issues as for processes and products require a new culture and manufacturing approach to be disseminated. Safety and well being of future workers demand also for new cross sectorial education actions, as well as the manufacturing of a new generation of healthy and green products for final consumers. The mentioned education actions are expected to be devoted to different professionals in manufacturing industry: from designers, to engineers, to manufacturers, to suppliers, to retailers and vendors. There is a serious need for research to understand how enterprises can create and increase awareness of these topics and how they could be addressed along the manufacturing value chain in multiple sectors. Specific related research topics will be: new society needs, new business paradigms, new materials, ICT and manufacturing technologies, sustainable processes and products, safety of workers, well being of consumers.
Expected results and impact, with special focus on the industrial interest:	Improved ethical standard of manufacturing enterprises and stronger focus on perspectives of social nature, considering sustainability as well as well being of workers and consumers. Serious reduction of emissions and resources consumption, improvement of workers safety and consumers well being.

12.3

RT5.04 - Communities of Practice

ABSTRACT:	Enterprises, and especially SMEs, in the manufacturing industry have a need to learn from each other and best practice. This could be obtained by establishing communities of practice. This research will give the manufacturing industry a **new learning method**: how to learn from the best (best practice), learn faster, solve problems and be more innovative through the use of communities in practice.
Technical Content and scope:	Learning is becoming an urgent topic and even more important is how to learn in innovative ways. Knowledge is a key source of competitive advantage in the business world, but we still have little understanding of how to create and leverage it in practice. Knowing is an enacted, communicated process that is difficult to observe, let alone manage, in organizations. Traditional knowledge management approaches attempt to capture existing knowledge within formal systems, such as databases. But innovative and dynamic knowledge that makes a difference in practice requires the participation of people who are fully engaged in communicating and using knowledge. We frequently say that people are an organization's most important resource. Yet we seldom understand this truism in terms of the communities through which individuals develop and share the capacity to create and use knowledge. This research project would focus on: 1. What is communities in practice 2. How to build such communities 3. The importance of communities in practice; 4. How to make communities in practice grow and sustain. Through case studies of best-practice in the manufacturing industry and other industries, as well as state-of-the art within literature, researchers and the industry would together - through communities in practice - develop a future understanding of communities in practice. This would give the manufacturing industry a new learning method for the future. **1) Defining Communities of Practice** Members of a community are informally bound by what they do together—from engaging in lunchtime discussions to solving difficult problems—and by

what they have learned through their mutual engagement in these activities. Communities of practice develop around things that matter to people. As a result, their practices reflect the members' own understanding of what is important.

2) How to build communities of practice in organization

Communities of practice exist in any organization:

Within businesses: Communities of practice arise as people address problems together;

Across business units: Important knowledge is often distributed in different business units;

Across company boundaries: In some cases, communities of practice become useful by crossing organizational boundaries. For instance in fast-moving industries, employees form a community of practice to keep up with constant technological changes.

Through this research we would find knowledge about how to build communities in practice in and between organizations.

3) The importance of communities to organization

Communities of practice are important to the functioning of any organization, but they become crucial to those that recognize knowledge as a key asset:

- Communities in practice are nodes for the exchange and interpretation of information;
- Communities of practice preserve the tacit aspects of knowledge that formal systems cannot capture;
- Communities of practice can keep the organization at the cutting edge;
- Communities of practice are organized around what matters to their members, and are therefore a very important source of learning.

To be able to understand why the manufacturing industry should pay attention the communities in practice, we would have to find out more about the importance of communities to organizations.

4) How to make communities in practice grow and sustain

Technology and the internet can facilitate the development of communities in practice, and can help apply knowledge to practice situations. Virtual communities and the internet allow employees in the manufacturing industry to engage in mutual learning not constrained by time and place. There are also many other tools and methods to make communities in practice grow and sustain, which would be important to search into. (Source: Etienne Wenger)

Expected results and impact, with special focus on the industrial interest:	This research will give the manufacturing industry a **new learning method**: how to *learn from the best (best practice)*, *learn faster*, *solve problems and be more innovative* through the use of communities in practice.

12.4

RT5.05 - From Tacit to Explicit Knowledge

ABSTRACT:	Eliciting and externalizing tacit knowledge is particularly important in SMEs to reduce the vulnerability to loss of core competence, and to allow SMEs to make full use of employees' competence in improvement and innovation projects. Traditional knowledge management systems are often not suitable for sharing tacit knowledge in SMEs. Emerging technologies (unstructured tagging, weblogs, wikis etc) show strong promises in overcoming this obstacle. Research into how these technologies can be used in conjunction with social processes for externalizing and socializing tacit knowledge in manufacturing SMEs may help to overcome the competence vulnerability.
Technical Content and scope:	When Polyani presented his theory of personal knowledge in 1958, he introduced the distinction between tacit and explicit knowledge. He described the nature of tacit knowledge as personal and context-bound and linked to action – hard to articulate and communicate, whereas the explicit knowledge is easier to articulate and communicate. Since then, and particularly over the past decade, the interest in attempting to capture, document and share tacit knowledge as part of the businesses' knowledge management, has flourished. Tacit knowledge has been recognized as being essential for any business in creating business value and sustaining competitive advantage. However, the many failures experienced by companies attempting this may partly be due to the diversity of concepts and tools, partly a lack of understanding of the sometimes complex socio-technical factors which influence the externalization of tacit knowledge (e.g., when using Groupware), and partly due to the often easy and simplistic receipts offered by consultants. The research field is characterized by fuzzy terms, used inconsistently by the many communities that engage in it, partly caused by the various disciplines engaged in it, and the lack of integrative theories for socializing and externalizing tacit knowledge. SMEs are particularly vulnerable to loss of tacit knowledge, as the knowledge is spread across fewer individuals than in a larger enterprise. SMEs often also suffer from not being able to formally document explicit knowledge, such that even the potentially external knowledge remains with the individual employee. Current knowledge management systems often require implementation and maintenance resources that SMEs cannot sustain. The consequence is that SMEs in this situation are unable to make the full use of their people in innovation and improvement projects, impairing not only the company itself, but also its ability to communicate with actors both upstream and downstream in the value chain. Research aiming to mend the problems particular to SMEs is scarce, and even more so when concerning manufacturing SMEs, which is often characterized by highly computerized and automated production systems, in turn

	representing special challenges in the externalization of tacit knowledge (e.g., "hard" operator skills). Research is required to identify acceptable ways to both socialize and externalize SME competence promoting more effective and efficient organizational learning. Research into hybrid socio-technical systems for knowledge socialization and externalization in SMEs is particularly interesting, as features of new emerging technologies – unstructured tagging, weblogs, wikis and such – show strong promise in overcoming some of the obstacles of documenting knowledge as they exploit digital representation of less formal language than traditional knowledge management systems. However, the technology alone is insufficient. In close conjunction with the technology development, there is a need for **development of conceptual frameworks adapted to manufacturing SMEs**: • social interaction and engagement mechanisms for knowledge socialization and externalization; • analyzing, assessing and improving quality of the knowledge socialization and externalization process; • procedures for continuously eliciting both personal and organizational tacit knowledge into the common organizational memory, by continuously updating the quality of the explicit knowledge from the tacit knowledge pool; • incentive mechanisms for knowledge sharing.
Expected results and impact, with special focus on the industrial interest:	Externalization of tacit knowledge in SMEs to reduce the vulnerability to loss of core competence, and to make the full use of employees' knowledge in innovation and improvement projects.

12.5 RT5.06 - Innovation Agents

ABSTRACT:	To make sure the that innovation and research in the manufacturing industry represents the latest and most innovative areas and that the innovation changes necessary reaches most people in the manufacturing industry, global innovation agents would be - not only necessary but - crucial. A global innovation agent would represent action in finding and developing innovation and ideas globally, implementing the new ideas to the manufacturing industry Empirical evidence, state-of-the art and best practice within the field would represent the research on global innovation agents.
Technical Content and scope:	The term **innovation** means a new way of doing something and refers to changes in thinking, products, processes, or organizations. In many fields, something new must be substantially different to be innovative. In economics the change must increase value, customer value, or producer value. The goal of innovation is positive change, to make someone or something better. Innovation leading to increased productivity is the fundamental source of increasing wealth in an economy. An **agent** is an entity that is capable of action, working on behalf of someone else. A global innovation agent would represent action in finding and developing innovation and ideas globally, implementing the new ideas to the manufacturing industry. Research on the topic global innovation agents and engagement in a development and employment of innovation agents in practice represent a revolution to the manufacturing industry. The global innovation agents role would be to - Accompany enterprises and organizations in the implementation of innovative ideas and models in the manufacturing industry. - To promote constant innovation in enterprises in the industry The research would be focused on the following areas: 1) Look at innovation agents as a method and concept of learning. 2) Search into what has been done regarding innovation agents earlier. 3) Find the latest and most innovative research and development. 4) Implement innovation agents and innovative research in the manufacturing industry.
Expected results and impact, with	To establish a network of global innovation agents in the manufacturing industry. The expected results would be new ideas, innovative products and new revolutionary ways of producing in the industry. The industrial interest in

special focus on the industrial interest:	such consequences would be growth in income due to customer satisfaction and new sales, and reduced costs due to far more effective ways of producing in the manufacturing industry.

12.6

RT5.07 - Benchmarking

ABSTRACT:	Benchmarking as a tool is well established, but still lacks refinement to present a powerful mechanism for learning. The proposed research will investigate how benchmarking can be converted into a systematic approach for learning and undertake pilot implementations to evaluate the effects.
Technical Content and scope:	Benchmarking is a well-documented and tested method to improve performance of companies. It is used to define areas for improvement and gaps in technology and developments of the enterprise. The approaches for conducting benchmarking have evolved; from a strictly quantitative comparison of performance levels to more qualitative comparison of business process and practices. However, even though two authors in the mid-1990s suggested redefining the term benchmarking to *benchlearning*, less focus has been put on the use of benchmarking as a learning and competence development tool. Benchmarking studies primarily emerge as a response to specific improvement needs of an enterprise, often designed as one-way learning efforts where only the initiating organization harvests the benefits, and very rarely look beyond this immediate comparison exercise. Benchmarking has a clear potential as a more systematic learning methodology where a community of enterprises can benefit from practices and solutions to problems created and tested by others. This requires a systematic approach that at the same time both creates the best possible access to best practice learning while protecting the interests and possible intellectual property rights of the inventors of best practices. Attempts have been made at creating "benchmarking clubs" and on-line benchmarking services, but none of these have yet proven highly successful, perhaps because they have been characterized more by commercial interests than the intentions of creating genuine learning systems.
Expected results and impact, with special focus on the industrial interest:	Research in this area should aim to develop a new type of benchmarking approach and infrastructure to support the use of benchmarking as a tool for learning and knowledge sharing among organizations; an improved learning processes based on benchmarking. Research has shown that inside one enterprise or in one sector or region, if those companies performing below average improved their performance to average levels, there would be large gains in effectiveness, efficiency, less environmental impact, etc.

12.7 RT5.08 - Serious Games

ABSTRACT:	In the knowledge society, human capital has become of strategic importance for enterprises and there is a need for more effective technologies and methodologies to support rapid competence development, knowledge externization and knowledge transfer. The use of serious games empowers enterprises with greater agility in responding to market pressures and needs.
Technical Content and scope:	The existing manufacturing industry is at a crossroads, being threatened by global market pressures and the industry from emerging economies such as Brazil, China and India. Therefore the implementation of paradigms, such as sustainable manufacturing that supports highly personalized products that are customer-oriented whilst remaining environment friendly products, are necessary to keep global competitiveness. However, these new paradigms require the development of human capital, which are afflicted by difficult challenges to overcome such as the ever increasing growth of knowledge; the continuous shortening of acquisition time for new knowledge; the knowledge gap that continues to widens as tacit knowledge is lost with the departure of key individuals; the increased need of working in multi-disciplinary teams in varied geo-political landscape; the need for greater leadership, entrepreneurship and innovation; the understanding of emerging paradigms such as product disassembly, the customer involvement in co-creation of products and services, and energy efficiency manufacturing processes. The research should focus on the creation of innovative competence development platforms (e.g. using serious games) that reinforce the synergy of the individual and organization for learning and creativity. The platforms are to be integrated into existing enterprises, namely their organizational processes, workflows, competency management and knowledge management. A successful project must address clear needs within industrial environment that otherwise cannot be resolved with traditional approaches to knowledge management and competence development.
Expected results and impact, with special focus on the industrial interest:	The expected impact of this topic will significantly contribute to the global competitiveness of European enterprises in a global market place. The results will increase the employability of individuals and empower enterprises with greater agility that enables them to be more effective in their response to market pressures and needs. The use of serious games will also contribute to the gap reduction between large enterprises and SMEs in knowledge management, thus instigating an increase in competitiveness.

12.8 RT5.09 - Personalized and Ubiquitous Learning

ABSTRACT:	There is a need for more efficient and targeted training of individuals. Personalized and flexible learning allow employees to continuously upgrade necessary competence with flexibility as to when and where to learn. There is a need to establish digitalized course module repositories for manufacturing, supported by a tutoring system for establishing an individualized learning path. Modules must be adapted to the learning strategies of flexible learning and mobile technology.
Technical Content and scope:	To stay competent and updated in a world where technology rapidly changes, employees need to continuously upgrade their specific knowledge and expertise. Large corporations often demand that their employees regularly attend courses. Many large corporations have even developed tailor made courses and lecturers themselves. SMEs are rarely in this situation. Their employees are often faced with a high workload dictated by tight schedules. For this category of people, the traditional fixed curriculum is unsuitable, as it is not tailored to the SME's or the individuals' particular needs. Traditional courses are normally comprehensive and may go far beyond the need of the learner, and may also contain a lot of material that the learner is already familiar with. Flexibility in terms of adapting curricula to individual needs, as well as the opportunity to choose when and where to learn, are highly preferable learning characteristics in this context. The idea behind the popular terms eLearning, Technology Enhanced Learning (TEL) and ubiquitous enriched learning is to provide opportunities that may meet the flexibility demand. A framework for creating pedagogically sound mobile services suitable to support ubiquitous enriched learning experiences is under constant development (e.g., in the EU projects - MOBIlearn, WearIT@Work and Natacha). However, the mobile technology's aim is only to support flexible learning. Thus, course contents must be adapted to the new learning situation and the mobile technology. Manufacturing course modules need to be created, digitalized and standardized, e.g., according to the SCORM standard. The courses need to be modularized into so-called learning objects, including learning object metadata for indexing and searching. The metadata need to describe, e.g., difficulty levels of learning objects, preferable learning order of objects, prior knowledge required for the learning object, and learning outcome. Learning objects may in turn be assembled into a learning object repository for manufacturing that provides extended sharing and searching features. The learning object repository must also provide a tutoring system. This should allow individuals to identify gaps in current competence, rank the

	degree of relevance of learning objects to their intension and preference, and establish, from the provided metadata, an individualized learning path.
Expected results and impact, with special focus on the industrial interest:	Making training on the job more efficient and targeted to the needs of the individual.

12.9 RT5.10 - Accelerated Learning

ABSTRACT:	Many enterprises are undertaking development projects. Such projects can be used for defining problem based learning. These learning processes can be applied to improve the learning by cooperation amongst several enterprises. The impact of this topic will be faster and better take up of new technology and a faster development of new products and services.
Technical Content and scope:	In many European industrial enterprises quality and speedy deliveries have increased markedly in the past decade. However, systematic learning from experiences and from exploring new ideas has not been developed despite its great potential for enabling enterprises to cope with dynamic and complex environment. A key element in this effort is the empowerment of employees to become more self-driven to the extent that they can take initiative to solve complex problems, alone and in cooperation with peers and technical staff. This will require the development of supportive organizational processes aimed at stimulating collaborative learning including explicit as well as tacit knowledge. A successful research project should explore means for carrying out two parallel streams of activities: • a number of development projects to be carried out in industrial enterprises Each project is based on the Problem Based Learning framework and may address issues in a workshop or a whole plant dealing with quality, delivery, productivity issues, among others. A Problem Based Learning approach will provide specific issues to train employees, to exchange experiences, and to stimulate cooperation between universities and enterprises. • inter-company exchange programs During the company development projects an exchange of ideas, methods and results will be organized between projects. This will serve as a stimulus for collaborative learning. Some of the means of such exchange programs are visits to participating companies to audit and benchmark the ongoing development projects, and e-learning systems to support distributed exchange.
Expected results and	The expected impact is to enable enterprises to learn from its learning processes by developing self-driven operators through accelerated learning.

impact, with special focus on the industrial interest:	This will increase the speed of adapting to new technology by at least 20%. At the same time it will decrease the experimental effort to obtain a solution can operate with the stability required for maintaining a competitive position. It will also help launching new products or features or services rapidly into emerging markets.

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