Road 4 FAME

Deliverable 1.1

Report on Results and Concepts from Relevant Initiatives

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PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
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[1] **R**=Report, **P**=Prototype, **D**=Demonstrator, **O**=Other

[2] **PU**=Public, **PP**=Restricted to other programme participants (including the Commission Services), **RE**=Restricted to a group specified by the consortium (including the Commission Services), **CO**=Confidential, only for members of the consortium (including the Commission Services)

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1 Executive Summary

Context and content of this document

This *report on results and concepts from relevant initiatives* serves as main input for the roadmapping process of the Road4FAME project. Its core intention is to provide a sound overview of recent and ongoing research activities in the field of manufacturing IT based on an analysis of research topics, results and concepts from recent and ongoing research projects.

This document contains three main sections of content:

- An overview of recent and ongoing research activities (section 4)
- An analysis of these research activities (section 5)
- An analysis of these research activities and recommendations (section 6)

A summary of the content is provided on the following pages.

Together with data from other deliverables which contribute to push or pull perspective in Road4FAME, important analyses can be performed. Despite the fact that most analysis work results from analysis *across* several deliverables (see Deliverable 1.3 for these analyses), sections 5 and 6 present some assessments already based on the data contained in this document.

Relevance of this document

The overview of recent and ongoing research activities is an important building block for the push perspective in Road4FAME which describes the innovation generated by research activities.

The knowledge of what is already being researched is very relevant as a basis to identify research gaps or misalignment of research with the *needs* of manufacturing businesses in Europe, to which the Road4FAME roadmap must be aligned.

Approach

To establish this overview of recent and ongoing research activities, 138 national and European research projects have been selected and analysed. They have been clustered into a set of research themes and have been analysed.

Groups of research activities

Recent and ongoing research activities have been grouped as follows:

- **Factory-level results and concepts** like integration of CP(P)S, i.e. additional intelligence to production environments, implementation of the plug and produce paradigm, optimization of user interaction in manufacturing environments, exploitation of knowledge and decision-making, etc. Please see section 4.1 for more details.
- **Production network level results and concepts** such as cloud manufacturing, overall optimization of production networks, total customization for which challenges like

interoperability and security issues have to be overcome. Please see section 4.2 for more details.

- **Other results and concepts**, e.g. related to organizational and strategic aspects such as migration strategies towards next generation IT systems in manufacturing, and performance assessment for such systems. Please see section 4.3 for more details.

Overview of research topics

Research topic	Objectives / expected benefit	Status of technology / maturity	Challenges / research activities
Cyber-physical (production) systems / intelligent components	• Increase intelligence in production environments • Increase flexibility • Gather data for optimisation tasks	Intelligence is distributed hierarchically / centralised and restricted to purpose of production system	• Integration of sensors and actuators to CP(P)S • Easy integration of CP(P)S to production environments • Security & privacy for mobile CP(P)S
Plug & produce / self-describing & easy-to-configure equipment	Minimum effort for equipment integration during ramp-up or reconfiguration of production	Mainly proprietary interfaces or pre-defined descriptions structures. Existing standards are often XML-based if existing at all. Lots of customisation programming during equipment integration	• Equipment self-descriptions and their automated generation and update • Automated generation of machine programs based on product and process specifications • Stepwise increase of automation degree by manual workplaces which are extendable with automation equipment
Autonomous manufacturing system components	Increase flexibility and agility in manufacturing environments; Complexity reduction by self-organisation	Hierarchical control infrastructures, centralised decision-making (on ERP, MES, or PLC level), associated commands and control parameters are dispatched to concerned levels below.	Implementation of agent-based concepts in production systems e.g. • Context-awareness • Autonomous decision-making • Cooperation and self-organisation to avoid conflicts

Factory knowledge base	Collect and store data gathered throughout the manufacturing environment in order to make it available for further analysis and optimisation tasks	Restricted accessibility of data due to separated systems, lack of sensing, etc. If systems are integrated, this takes place via proprietary interfaces.	• Standardised access to relevant information • Information structures and data models to represent the manufacturing context of a certain production environment fitting into consistent, standardised models (e.g. by semantics)
Data analysis	Support monitoring of KPIs and resource consumption, performance assessment, maintenance prediction, etc.	Specific data analysis within restricted applications	• Real-time analysis capabilities • Interdependencies among processes and parameters in order to understand and manage yet unknown impacts
Decision making & Factory optimisation	Find best decisions / optimisation options throughout all involved components and processes	Decisions / optimisation mainly is restricted to certain responsibility areas / purposes.	• Interdependencies among available data • Knowledge-based, self-learning systems support optimisation • Safe decision-making / determination of impact
Usability	Enable intuitive usage, hide complexity from users	Intricate user interfaces which require special trainings; Simple usage most often goes in parallel with quite limited functionalities.	• Hide / restrict accessibility of functionalities from the user which are not relevant at the given moment or in the given context • Augmented reality for seamless workflow integration of user interfaces • Mobile applications
Man-Machine Interaction	Increase ergonomics for workers and process precision	First systems already applied, even if they are mainly specific developments	• Ensure safety of workers (redundant safety & security systems • Advanced movement control for human robot guiding • Virtual interaction in critical environments

Manufacturing-IT as a Service	Provide production IT via new business models and cloud-like infrastructures	Mainly few specific services available, no holistic platforms available	• Service-registries / simple search and categorisation • Service orchestration to achieve higher-level functionalities • Integration of manufacturing equipment / facilities • Cloud-based machine control
New manufacturing IT features	Depending on functionalities to be developed	Various functionalities are already implemented	• Advanced / self-organising production planning and execution services • Self-diagnosis systems for manufacturing equipment, e.g. to enable self-healing • Sustainability / energy monitoring and optimisation
Knowledge transfer between manufacturing and engineering	Enable short time-to-market, reduction of engineering and production costs	Manufacturing equipment is mainly designed and programmed for specific product characteristics (except standard machines for	• Product specifications already including information necessary for related production processes • Feedback of information from manufacturing • Cooperation mechanisms in all phases from product conception to production

Cloud manufacturing	Increase flexibility of manufacturing networks by resource virtualisation	Long-term supply chain cooperations for complex products; Communication via EDI-based standards	• Integration and description / virtualisation of manufacturing facilities on cloud manufacturing platforms • Alignment, capacity planning, joint execution of manufacturing processes when manufacturing cloud is not private • Exchange of production level information and related security aspects
Total customisation / ad-hoc production networks	Enable maximum individualisation of products while maintaining manufacturing efficiency	Customisation based on pre-defined patterns; For higher degrees of personalisation, costs increase considerably	• Product specification tools and analysis mechanisms (to map specifications to production needs /processes) • Platforms for provision of manufacturing capabilities and customisation options • Search and selection of appropriate production partners for certain product specifications

Optimisation of production networks	Faster, more flexible reaction to changing markets, reduction of search efforts, failure consequential costs, production downtimes, inventories, etc.	Various optimisation mechanisms already implemented, even if full potential is often not exploited due to lacks in information availability, communication speed, reaction times, security concerns, etc.	• Total product tracking • Life cycle assessment, life cycle costing • Large-scale data gathering throughout production sites • Assisting systems to compare planning and real data and to react to differences • Improved demand forecasting, performance assessment, etc. • Data mining and analysis to detect additional interdependencies and optimisation potentials throughout production networks • Decision making considering the needs of several production network participants
Migration strategies	Seamless integration of and migration to future manufacturing IT systems, considering existing legacy systems and data / information	No smooth, non-disruptive migration strategies, methods, and tools available; Migration success highly depends on responsible persons and related risk management	• Definition of appropriate rules for decision making processes in production IT projects • New networked and flexible organisation structures for future intelligent factories • Real-time visualisation and calculation of possible decision options to increase planning reliability • Project management support tools designed for the specific needs of manufacturing IT system projects

Performance assessment for future ICT applications	Ensure that new IT applications in manufacturing really fit the production environment to which they are integrated	Assessments are made, if at all, only after implementation of respective technologies in production environments. Even then, gathering all necessary information is challenging.	• Get fast and cheap statements about efficiency of certain technologies and production strategies specifically for the settings applicable for a certain company • Simulation-based approval of certain decisions / virtual try-out of specific IT components

Drivers for current research

The drivers for research topics listed in this deliverable are related to trends and drivers which apply to society, market, business, and manufacturing environments, as they are described in deliverable D2.3. In the following, an excerpt of the major trends and drivers identified there are:

Megatrends:

- Demographic change
- Globalisation
- Innovation and new technologies
- Knowledge as enabler
- Language barriers and cultural differences
- Rise of environmental consciousness

Manufacturing trends (related to market and business models):

- Demand for individualisation and high quality standards
- Optimisation and (semi-)automated decision making
- Shortage of skilled staff
- Increasing demand for products and services
- Increasing complexity of products, processes, supply networks
- Shorter product life cycles
- Maintain competitiveness of high-wage countries
- Distributed manufacturing: local adaption / manufacturing close to markets; companies increasingly focus on their core business
- Urban production
- Added value potential through new services / business models

Manufacturing trends (related to specific measures in manufacturing):

- Resource productivity and efficiency
- Increasing flexibility of manufacturing facilities
- Maximise efficiency and quality
- Increasing hybrid cross-over solutions / use of ICT technologies
- Flexibility in supply chain participation
- Evolution and emergent behaviour of production networks

2 Context and objectives

This section describes the role and relevance of this document and the underlying work in the overall roadmapping process in Road4FAME.

Role of this document in the overall roadmapping process

The roadmapping process in Road4FAME is depicted in figure 1 and comprises three main phases:

- Phase 1: Establishment of push perspective and pull perspective, as a preparation for the core roadmapping process
- Phase 2: Core roadmapping process to join push and pull perspective and iteratively develop the roadmap
- Phase 3: Finalization of roadmap and development of recommendations

The work documented in this deliverable is one important building block in phase 1, highlighted in figure 1. It contributes to establishing the *push perspective* which describes the innovation generated by research activities.

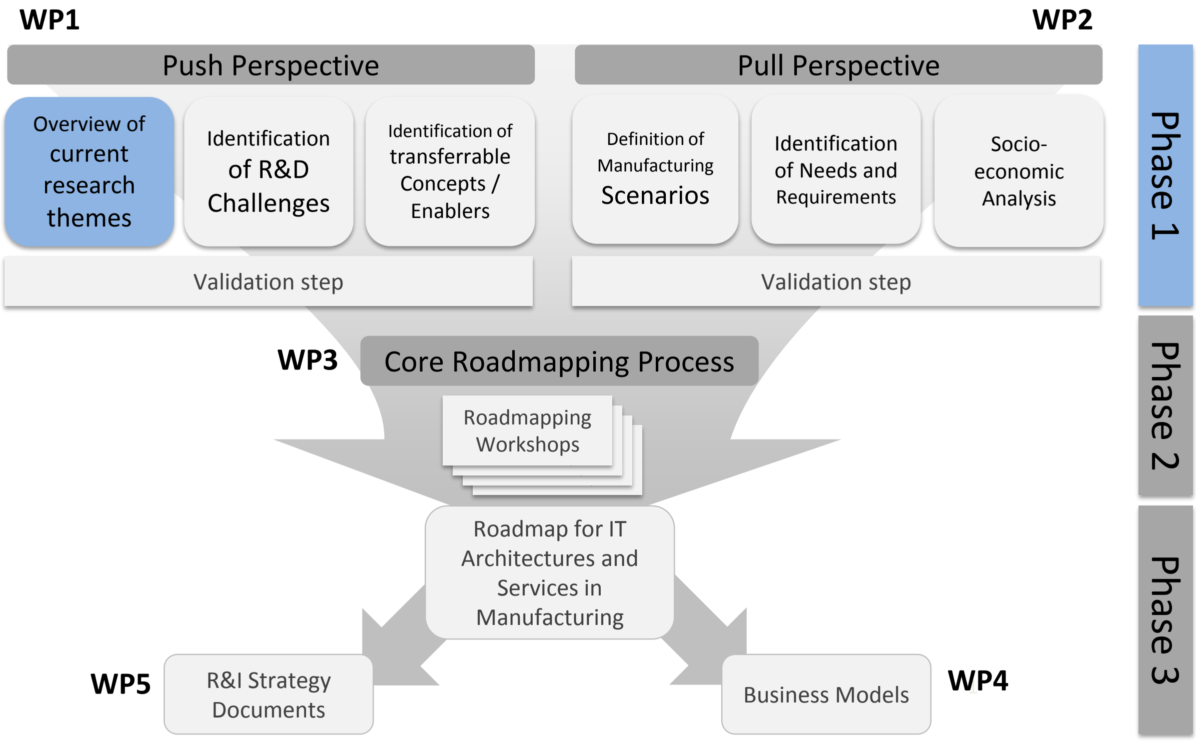

Figure 1: Road4FAME roadmapping process

Content of this document

This *report on results and concepts from relevant initiatives* serves as main input for the roadmapping process of the Road4FAME project. Its core intention is to provide a sound overview of recent and ongoing research activities in the field of manufacturing IT based on an analysis of research topics, results and concepts from recent and ongoing research projects. To establish this overview, a substantial amount of research projects at the national level (UK, Germany, Portugal, and Italy) and the European level (Factories of the Future PPP, Artemis JTI) have been analysed (see section 3 for approach).

Since Road4FAME develops a roadmap for IT architectures and services in manufacturing, the consortium analysed these research projects with regard to their relevance for IT architectures and services for manufacturing. The relevance of each project and covered research topics / concepts was assessed in order to be able to prioritise and appropriately consider the topics during the roadmapping process.

This document contains three main sections of content:

- An overview of recent and ongoing research activities (section 4)
- An analysis of these research activities (section 5)
- An analysis of these research activities and recommendations (section 6)

Relevance of this document

The overview of recent and ongoing research activities is an important building block for the push perspective in Road4FAME. This knowledge of what is already being researched is very relevant as a basis to identify gaps, e.g. by posing questions like *"Are current research activities addressing all industrial needs?"* or *"Are current research activities in line with the recommendations of today's strategy documents and roadmaps?"*. (Based on the content of this document, Deliverable 1.3 presents an analysis of such questions.)

Thus, this document provides a basis to identify misalignment of research with the *needs* of manufacturing businesses in Europe (see D2.2), to which the Road4FAME roadmap must be aligned.

3 Approach and scope

As has been described in the previous section, this *report on results and concepts from relevant initiatives* is to provide a sound overview of recent and ongoing research activities in the field of manufacturing IT.

To establish this overview, a substantial amount of research projects at the national level (UK, Germany, Portugal, and Italy) and the European level (Factories of the Future PPP, Artemis JTI) have been analysed (see section 3 for approach) for the research topics they cover, and the results and concepts produced.

Scope of analysis

In principle, two kinds of projects are considered to be relevant for analysis:

a) Projects focusing on ICT for manufacturing, developing e.g. specific services, architectures, and infrastructures to serve a certain purpose in manufacturing environments.

b) ICT projects without explicit manufacturing orientation which might provide concepts for future application in the manufacturing domain via spill-over / transfer / cross-fertilization for manufacturing IT.

Analyses showed that for a)-type projects, the search space consists of projects in the order of hundreds, with a high proportion of actually relevant projects. For b)-type projects, the search space consists of projects in the order of several thousands, with a much lower proportion of relevant projects. With the goal of a most resource efficient analysis, the target for analysis were a)-type projects with the following scope:

- All relevant projects funded under the Factories of the Future PPP
- All relevant projects funded under the Artemis JTI
- Relevant national projects funded in Germany under the Industrie 4.0 programme
- Relevant national projects funded in the UK
- Relevant national projects funded in Italy under the Industria 2015 programme
- Relevant national projects funded in Portugal
- Relevant international projects familiar to consortium members

The set of projects from the so-scoped search space provided a more than sufficient sample for extraction of state-of-the art research themes. From this search space, **138 projects** have been found to be relevant and were analysed in detail.

Data sources

There are several sources available to identify relevant research projects:

- For the identification of EU-level projects, online databases of EFFRA and of Artemis were used, supplemented by the Cordis search tool.
- National projects were identified by consortium members employing respective search tools and consultations at the national level.
- The Road4FAME Experts Group was involved in an online consultation to point to further relevant projects at national and EU level. 28 experts have provide input in the online consultation.

The in-depth analysis of projects was performed based on publicly available information from project databases or project websites. Where this information did not suffice to perform the analysis sufficiently, and if consortium members were not familiar with the respective project through own involvement, consortium members from the respective project were contacted and interviewed. This also served as a first validation step, since during the interviews executed for this purpose, the consortium members also got better insights to the research motivation, challenges, and innovative aspects of the respective project.

Project analysis

A defined approach to select relevant projects, extract relevant information from them, and to summarise and prioritise the research topics and results was followed.

Step 1: Pre-analysis to select relevant projects

In a first step, a list of national and EU projects has been compiled which seemed of relevance for in-depth analysis. This assessment has been performed on the following criteria:

- Research topics covered
- Up-to-date-ness, i.e. when the research has taken place
- Reputation of project partners and coordinator

138 projects were found to be relevant.

Step 2: In-depth analysis of relevant projects

In a second step, all projects lined up for in-depth analysis were analysed along the extensive information structure below:

- Project name
- Purpose of the developed system
- What is considered to be new, i.e. what is the research challenge dealt with and how is it addressed?
- Physical Distribution of System Components
- Diversity of System applicants and stakeholders (roles, number, etc.)

- Timing requirements, time criticalities (What are necessary reaction times?)
- Integration of further (sub-) systems / components / legacy systems necessary? If yes, please explain
- Amount and kind of data to be handled
- Are services/APIs etc. visible and usable from other (external) systems? If yes, are there any limitations to that other than security aspects?
- Which security aspects were considered (e.g. availability, connectivity, data and message level security, etc.) and how?
- Were there pre-defined design-patterns or architecture concepts applicable?
- Which underlying infrastructure has been used (e.g. cloud computing, mobile devices, cyber-physical systems, etc.)
- Which maturity level is achieved / intended to be achieved (research-result/concept, prototype, ready for commercialization)?
- In which industrial settings have the results been validated (and for which purpose)?

Since this detailed analysis work was divided up among consortium members, this common information structure ensured uniform analysis results.

Step 3: Clustering and prioritization of research topics

The findings were grouped according to their occurrence throughout typical production system hierarchies and similar topics were clustered appropriately.

As a validation step, a review of the results, their descriptions including innovative aspects and challenges, comments about the state-of-the-art, etc. was done by manufacturing experts in the consortium in order to have a sound basis for future involvement of project externals.

(The involvement of external experts will take place after the submission of this deliverable in the form of workshops where first roadmap drafts, including the results reported in this deliverable, are validated and extended. The results of these activities will be contained in future deliverables produced in WP3.)

4 Overview of recent and ongoing research activities

From the in-depth analyses of 138 projects, conducted along the information structure presented in the previous section, most relevant topics and strands were identified and merged appropriately. These are presented in this section.

4.1 Factory level results and concepts

4.1.1 Cyber-physical (production) systems / intelligent components

Objective / Purpose of development: Making manufacturing environments more intelligent and flexible, i.e. able to provide relevant data, e.g. to exploit analysis potentials, and to enable more sophisticated control mechanisms.

State-of-the-art: Products, carriers, and tools are in most cases not intelligent, i.e. not equipped with sensors and/or actuators and respective IT services. Intelligence of machines varies depending on industry branch, specific processes, etc. What most of them have in common is that not all information which is potentially available is gathered by the machines, but only the information which is directly necessary for production control. Other data which could be provided theoretically since e.g. sensors are integrated to the machines, and which would be useful for further purposes is often not made accessible, i.e. not collected and not shared, due to a lack of connection among the systems that manage these data.

Innovative aspect / research challenge: In order to realise the integration of intelligence to products, carriers, tools, fixtures, machines, transport systems, etc. in manufacturing environments research is executed on

- Sensor and actuator systems which are able to be integrated to these objects. In this regards, aspects like energy autarkic systems, miniaturisation, or integration of innovative measurement and actuating technologies in order to extend the range of potential applications, data to be gathered, etc. is of relevance.
- Easy integration of CP(P)S to production environments. In this regard, appropriate communication infrastructures, interfaces (protocols, syntax, and semantics) and services (CPS and service registries, analysis of data which is gathered, appropriate control mechanisms, etc.) have to be developed and standardised.
- Leverage the value of data collected through CP(P)S for different kinds of activities covering the whole process – not only the manufacturing execution. This is focused on the people that are parts of the process with innovative ideas about how such data could help to improve the time/costs/quality of their task and also the performance of the manufacturing process itself.
- Security / access rights when intelligent components move throughout the supply chain. An example is the access restriction of tracking data when products are delivered to customers and store respective data by themselves.

System characteristics: Depending on the application case, stakeholders are customers, manufacturers, equipment suppliers, and sensor / actuator providers. As soon as CPS are not only used to gather data, but also to act within processes, timing restrictions (up to real-time requirements) apply.

Industrial perspective: Current projects deal e.g. with integration of additional sensors, actuators, and intelligence to machining equipment and tools, complex system components such as electric drives, carriers, complex products such as cars, etc. The expected benefits range from additional information to be used for maintenance prediction or optimisation of product development to reduction of latency times, and increase of process quality or production flexibility.

Up to now, there are various research projects dealing with this topic. However, full industrial application of related systems is rarely implemented due to concerns about ROI.

4.1.2 Plug & Produce / self-describing and easily configurable equipment and components

Objective / Purpose of development: Minimum effort for equipment integration during ramp-up or reconfiguration of manufacturing environments. Besides easy integration of components, also their reconfigurability and reusability play an important role here in order to support fast reaction on market changes.

State-of-the-art: Depending on industry branch, proprietary interfaces or pre-defined description structures enabled by standards are state-of-the-art. In most cases, equipment interfaces and their commands, events, parameters, and sensor IOs are represented e.g. by means of an XML based structure, in case there exist interface / equipment descriptions. The configuration and integration of equipment to existing manufacturing environment usually takes place via “customisation programming” in case of proprietary interfaces, or manual configuration in case of standardised descriptions, according to product and process specifications

Innovative aspect / research challenge: The following topics are part of current research activities intending to enable plug & produce:

- Equipment self-descriptions or adapter components which are representing knowledge about the equipment / manufacturing facilities and their components. The descriptions or adapters should be able to be easily interpreted by higher-level IT systems in order to enable fast access to the manufacturing capabilities provided by the equipment in order to exchange data, i.e. commands and parameters as well as events and measurement results with them.
- Automated generation and update of equipment self-descriptions or configuration of adapter components and associated mapping mechanisms would increase the benefit of self-descriptions and adapter components considerably. First of all, it obviously decreases integration effort since the descriptions and mappings do not have to be created manually. But even more important is the up-to-date-ness which is ensured by this and would probably suffer during system changes otherwise.
- In order to further decrease integration efforts, this approach could go beyond description of protocols, input / output parameters etc., e.g. by representing further equipment characteristics, process knowledge, etc.

- Additionally, easy programming or configuration of machines plays a role here. This could e.g. take place via the automated generation of machine programs based on product and process specifications.
- Flexible concepts to stepwise increase the degree of automation in manufacturing are also to be mentioned. They could e.g. be based on manual workplaces which can easily be extended with automation equipment when throughput increases and vice versa.

System characteristics: Stakeholders for this topic are equipment providers and manufacturers. Equipment self-descriptions or adapter components have to be able to be easily integrated to various legacy systems, e.g. different MES (Manufacturing Execution Systems). Most approaches are based on XML-based descriptions and/or ontologies, but also artificial intelligence may play a role here.

Industrial perspective: Since there exist already well-established standards for equipment self-descriptions and integration in industries where standardised equipment are usual (e.g. semi-conductor industry), research is often focussed on special purpose machinery for which no mature developments exist which could easily be applied for a wide range of equipment and industry branches. This is also caused by the lack of standardisation in this field, which is only implemented for standard process equipment in certain industries yet.

4.1.3 Autonomous manufacturing system components

Objective / Purpose of development: The objective of implementing autonomous manufacturing system components such as products, carriers, machines, robots, or transport systems is mainly to increase flexibility and agility in manufacturing environments. The manufacturing system components are intended to self-organise and act autonomously, i.e. without being strictly controlled by higher-level systems.

State-of-the-art: Nowadays, manufacturing environments are usually controlled by hierarchical systems, e.g. with an ERP on the top level, and programmable logic controllers (PLCs), sensors, and actuators on the bottom level. Applying such an architecture, decisions are made on the appropriate level and then the associated commands and control parameters are dispatched to lower-level systems which have to react respectively.

Innovative aspect / research challenge: Current research on autonomous manufacturing system components comprises the following topics:

- Implementation of agent-based concepts in production systems. In detail, this means that system components, e.g. specific machines, carriers, or transport vehicles act on their own following a specific objective. For successful implementation of such concepts, it is necessary to also consider the following aspects:
  - In order to be able to act autonomously, the components have to be aware about their environment and current situations. Appropriate sensors and intelligence / interpretation mechanisms have to be integrated to components, together with the ability consider historical data.
  - Since concepts for autonomous systems do not foresee top-down/external commands to be received by the system components to be executed, the components have to make decisions on their own. To achieve this, on the one hand,

it is necessary for systems to be aware of the current digital and physical situation. On the other hand, well-defined local objectives have to be available which fit into the global objectives of the overall manufacturing environment.

- Cooperation and self-organization: To avoid conflicts among several autonomous components all dealing with the same or similar tasks, it can be useful to create component groups, i.e. groups of autonomous components which are able to talk to each other in order to align tasks with each other or even share them.

System characteristics: Stakeholders for this topic are mainly manufacturers and their equipment suppliers. Since there is no master system when following autonomous system concepts, the interaction of related components is not managed by a master system but has to be organised by the systems themselves. This causes a need for real-time reactions to changing digital and physical environments, where processes and security require this. Furthermore, system components have to be able to communicate with each other, for which appropriate communication standards are necessary. Security has to be ensured by each component on its own. However, there is also the challenge to ensure the safety and security of the overall system.

Industrial perspective: In industry, concepts for autonomous systems are rarely implemented yet. Deployment of such systems is mainly restricted to on-premises transport tasks since machines are usually stationary and for this reason not able to re-order and cooperate independently.

4.1.4 Factory knowledge base

Objective / Purpose of development: To collect and store data gathered throughout the manufacturing environment in order to make it available for further analysis and optimisation tasks.

State-of-the-art: Often, data are not accessible or only available within certain systems (e.g. MES, APC, ERP, etc.). However, they could bring additional benefit when provided to certain analysis mechanisms, especially if data from other systems is correlated. When data are integrated across system boundaries, this takes place mainly via proprietary systems.

Innovative aspect / research challenge: In order to make data available for further analysis and optimisation, the following aspects are considered by current research activities:

- Appropriate information structures and data models have to be developed which represent the manufacturing context of a certain factory / production environment appropriately. In order to enable easy access to the information stored within such structures, the respective services have to provide standardised interfaces to request specific data sets. Besides this, the information structures and data models representing factory knowledge have to be extendable in order to ensure that they are applicable not only for specific cases and can be adapted to changing manufacturing environments (e.g. when machines are reconfigured, product changes are made, etc.)

- Furthermore, it may be useful to map the factory-specific data gathered to consistent, standardised models, e.g. by means of semantic mapping mechanisms, in order to make them usable also for applications or services which are not implemented or customised for the specific production environment.

System characteristics: Stakeholders for this topic are manufacturers and manufacturing IT providers. Timing requirements only apply when the data gathered is re-used in control mechanisms. A major topic is the integration of legacy systems which will frequently have to be included to gather respective data. This includes IT systems as well as CP(P)S. Depending on the application case, handling the amounts of data in combination with timing requirements and data structures can be a challenge related to "Big Data". The data stored has to be made available for further systems which e.g. execute certain analyses or optimisation algorithms. Various basic technologies can be used to store the data. Depending on their structure, it is e.g. possible to use relational or NoSQL databases, ontologies, etc. For large amounts of data, it may also be advantageous to outsource storage to cloud infrastructures. Since the data stored are considered confidential in most cases, appropriate security mechanisms have to be implemented.

Industrial perspective: This topic is relevant throughout various industry branches and application cases. Especially in large companies, there already exist implementations which can be regarded as factory knowledge bases. However, they are often restricted to a set of application cases and not fully adaptable for other purposes (e.g. by easy integration of further data sources and analysis applications).

Together with the following two topics, factory knowledge bases contribute to the implementation of Big Data in production.

4.1.5 Data analysis

Objective / Purpose of development: There is a wide range of objectives which require analysis of available production data. Examples are performance assessment, energy monitoring, maintenance prediction, etc. All of them have in common that additional information needs to be extracted from data gathered from manufacturing environments in order to become aware of certain conditions, initialise events e.g. based on exceeded thresholds, etc.

State-of-the-art: Nowadays, specific data analyses are executed mainly within restricted applications such as SPC (Statistical Process Control) in highly sophisticated industries. However, the full potential of data (digitally and potentially for acquisition through additional sensors) is by far not exploited.

Innovative aspect / research challenge: Research focussing on data analysis in production environments usually considers the following aspects:

- Manufacturing systems and manufacturing engineering data have a potential to be included in different kinds of big data solutions. However, one of the main prerequisite is the implementation of an easy way to gather data across the factory. This includes structured and unstructured data, and real-time data, when appropriate. Currently, typical shop floor IT systems are mainly focused on a restricted amount of data sources and subsystems.
- Data gathering by means of additionally available/integrated systems and appropriate data monitoring tools for various application cases.
- Beyond transferring Business Intelligence concepts to the production level, a major challenge dealing with data analysis in production is the analysis of data in "real-time", i.e. fast enough to have results available within seconds or minutes and herewith having a sufficiently up-to-date digital representation of the physical factory (e.g. for monitoring energy consumption

or creating commands for certain actions). In Business Intelligence applications time constraints are set much wider and timing requirements are significantly less strict

- For data analysis in production, data mining and herewith finding new interdependencies in processes etc. plays a major role, too. In this regards, methods like pattern recognition, adapted to manufacturing-specific information structures, and interpretation mechanisms e.g. based on semantic technologies, are highly relevant. Also, efficient ways to analyse Big Data are required.

System characteristics: Stakeholders to be involved depend on the data analysed and could range from customers to manufacturers, equipment suppliers, and manufacturing IT providers. Depending on the application case, timing requirements apply, especially when analysis results are reused for further actions. Data amounts are high which, in combination with tight time constraints, causes a need for application of high-performance infrastructures, e.g. in the form of appropriate cloud computing infrastructures. In case that analysis results should be reusable by further systems, e.g. in-factory user interfaces or control systems, appropriate interfaces have to be provided therefore. Security also plays a role, e.g. to make sure that only data from the party executing a certain analysis are used when those analyses are provided via a cloud platform.

Industrial perspective: In industry, this topic is highly relevant throughout industry branches and applications. However, currently implementations are mainly restricted to pre-defined application cases, i.e. analyses. For this reason, systems are often not flexible enough to enable additional analyses or recognition of certain behaviour or patterns in order to generate additional knowledge e.g. for future developments.

4.1.6 Decision making / Factory optimisation / Emergent behaviour

Many approaches for factory optimisation are based on simulation. Since this is in the scope of the Pathfinder project[3], they are not considered here.

Objective / Purpose of development: Optimise manufacturing environments, i.e. finding an optimum throughout all involved components (products, equipment, etc.) and processes (engineering, production, sales, etc.) by means of intelligent decision making. Decisions have to be made according to strategic factory objectives and current situations which means that appropriate actions also have to be taken in case of unexpected events.

State-of-the-art: Today, decisions are mainly made within certain responsibility areas. Respective IT systems are usually restricted to certain purposes (e.g. production process parameter optimisation). Furthermore, industrial stakeholders, i.e. managers etc., are used to “have control”, which is why many decision-making systems are mainly implemented, if at all, as suggestion-making systems.

Innovative aspect / research challenge: Current research regarding intelligent decision-making in order to optimise factory environments focusses on

- Interdependencies among available data: Knowledge about how available information has to be analysed to extract specific KPIs, and how those KPIs (which have to be aligned with

[3] http://www.pathfinderproject.eu/

strategic objectives of a factory) can be influenced by the production system. This goes in close cooperation with appropriate data analyses and their implementation.

- Knowledge-based systems which could be self-learning from existing manufacturing settings and configurations, and feedback e.g. from customers, in order to suggest and establish new settings as fast as possible.
- Safe decision-making: Since decisions cause actions within the manufacturing environment, systems have to ensure that these actions do not cause a decrease in efficiency or other strategic KPIs of a factory, or even cause damages to the overall system or humans. To do so, the impact of decisions has to be known to the system.

System characteristics: Stakeholders to be involved depend on the data analysed and could range from customers to manufacturers, equipment suppliers, and manufacturing IT providers. Time constraints depend on the purpose of the decisions made. If a decision influences further processing of products, response times in the order of seconds are required. For strategic decisions, e.g. to integrate additional equipment, no such time constraints exist. The amount of data involved for decision-making might be quite high. As systems become more interconnected and the number of deployed sensors experiences strong growth rates, decision will increasingly be made based on Big Data. In combination with tight time constraints and high velocity of data generation, this causes a need for application of high-performance infrastructures, e.g. in the form of appropriate cloud computing infrastructures, and novel approaches to handling large data quantities. Since the decisions made have to be forwarded to the executing systems in most cases, appropriate interfaces have to be provided.

Industrial perspective: For some applications like optimisation of process parameters (e.g. Advanced Process Control – APC), there are already well-established solutions. However, for many other application cases, industry hesitates to apply such technologies due to concerns about robustness, safety, security, and trust on human experts. This is why in research projects mainly "suggestion-making systems" are implemented instead. They are based on the same technologies, but leave any decision exclusively to human production experts.

4.1.7 User Interfaces / Improved Usability

Objective / Purpose of development: To hide the complexity of manufacturing IT systems from users, i.e. production engineers and workers. Additionally, intuitive usage of the systems should be enabled.

State-of-the-art: Nowadays, sophisticated manufacturing IT systems in most cases have very complex user interfaces for which special trainings are necessary to be attended in order to enable production engineers and workers to deal with them. Exceptions are applications which provide limited functionalities (e.g. tracking of products) which can be run e.g. on mobile devices and which are, due to their limited functionality, easy to use.

Innovative aspect / research challenge: The following topics are part of current research activities intending to increase usability of manufacturing IT systems:

- In order to hide complexity from users, a major aspect is to restrict visibility and accessibility of functionalities and information/data which are not relevant for the user at the given moment or in the given context. To do so, it is essential to implement appropriate modular architectures which enable user-specific, situation-specific, and context-specific feature / service provision. Furthermore, user interfaces have to be migrated from "IT expert views" to "user views", since many user interfaces show information and feature structures etc. in the form they are represented in the IT system and not in the way the user would expect.

- Augmented reality also can contribute to usability since it is able to integrate user interfaces seamlessly to workflows and extends the visualisation options in production environments.
- The introduction of mobile applications to manufacturing environments is an approach to make user interfaces available where they are needed, providing ways to interact with stationary equipment in a mobile way. Especially in existing manufacturing environments they also can help to replace intelligent equipment and components since they enable ad-hoc user actions to gather data and execute commands.

System characteristics: Stakeholders for this topic are mainly workers, production engineers, and manufacturing IT providers. Time constraints are related with providing sufficient responsiveness for optimal user experience. Data amounts and interfaces depend on specific applications as well as underlying infrastructures (e.g. wireless communication, mobile devices, etc.) to be chosen and security concepts (according to user roles, system boundaries, etc.) to be implemented.

Industrial perspective: This topic is relevant for manufacturing companies in order to optimise their process and IT systems interactions. However, it is more important for manufacturing IT providers in order to strengthen their market positions. Current implementations are restricted to quite simple mobile applications like product tracking or management-level monitoring. Augmented reality and user-specific configuration of features is limited to research projects at the moment.

4.1.8 Man-Machine Interaction

Objective / Purpose of development: In order to increase ergonomics for workers, man-machine interaction intends to take loads or environmental risks from workers during the execution of tasks for which other human skills are needed, e.g. due to positioning precision required, process knowledge, etc.

State-of-the-art: First systems are already applied in industry, even if they are mainly specific developments.

Innovative aspect / research challenge: While executing research on man-machine interactions, the following topics are considered:

- The most critical aspect of this research topic is the safety of workers which as to guaranteed at any time when workers are closely cooperating with robots. For this reason, the safety and security mechanisms of the systems have to be implemented in a redundant way and able to react in real time, since robots applied in industrial contexts usually have much power which could cause considerable damages to the humans in case of system failures.
- In case the robots only take over the load from the humans, and are guided by the human who moves the product the robot holds, the implementation of associated movement control algorithms is a challenge, since forces caused by the heavy products themselves are much higher than the forces caused by the operator movements.

- In addition to direct interaction, robots can also be used for virtual interaction in critical environments. This means that the operators are guiding a virtual representative of the robot while the real one is executing tasks in a critical or non-ergonomic environment.

System characteristics: Stakeholders for this topic are mainly manufacturers and robot suppliers. Real time requirements apply since the robots have to react immediately. When research on this project is regarded on its own, interface and infrastructure aspects do not really apply. They become relevant, when the robot is e.g. also acting as some kind of an autonomous system.

Industrial perspective: The maturity of related systems is quite advanced. Industrial applications are e.g. implemented in automotive industry for specific use cases such as assembly of car doors.

4.1.9 Manufacturing-IT as a Service

Objective / Purpose of development: Since manufacturing IT systems are usually quite expensive and require administration efforts which especially SMEs cannot afford, Manufacturing-IT as a Service concepts focus on providing respective systems via new business models and cloud-like infrastructures. Especially the initial costs for the application of manufacturing IT systems are eliminated, e.g. by the provision of pay per use (e.g. tracked products) or time period (monthly) billing options.

State-of-the-art: Currently, only few singular services or specific functionalities are provided via infrastructures as described above. Most IT systems in manufacturing are used in the form of on-site installations. Integration of IT services provided via cloud platforms etc. is rarely implemented yet.

Innovative aspect / research challenge: In order to make manufacturing IT services available for on-demand usage, the following aspects are considered by current research activities:

- In order to provide services via marketplace-like platforms, the services have to be made available via appropriate service registries. There, they should be categorised in order to simplify service search for potential applicants, etc.
- Since services provided via such platforms are usually focussing on specific functionalities such as tracking, certain analyses, workflow execution, etc. it should be able to orchestrate them in order to create higher level functionalities or services which are e.g. providing holistic MES features to a user.
- In case the IT services used on-demand and running on cloud infrastructures do not only provide features covered by encapsulated software, but also functionalities which require integration of / communication with equipment, appropriate interfaces have to be provided, too, together with well-defined access control and other security mechanisms.
- In an extreme case, the outsourcing of manufacturing IT to the cloud means cloud-based control of machines / equipment. However, since control of machines / equipment and their components requires real time capabilities, the technological basis for such services does not exist yet.

System characteristics: Stakeholders for this topic are mainly manufacturers and manufacturing IT providers, as well as platform hosts implementing new business models. Timing requirements apply mainly when related IT services provide control functionalities. Data amounts handled depend on service features and manufacturing environment using them. Security issues play a major role (on message, data, and infrastructure level). Implementations are based on cloud computing concepts in most cases. IT services shall be able to be easily integrated with each other in order to enable higher-level, user-specific applications. When factory equipment is integrated to a service provision platform, appropriate infrastructures and architectures have to be provided, e.g. the adoption of ESB (Enterprise Service Bus) concepts to establish a MSB (Manufacturing Service Bus).

Industrial perspective: Existing platforms which are aiming at the provision of manufacturing IT as a service are currently only providing singular services without the opportunity to combine them to higher level features. Furthermore, equipment integration or even control is not available. The main concerns which are announced by industrial manufacturers, i.e. potential customers for those systems, are related to security and robustness.

4.1.10 New manufacturing IT features

Objective / Purpose of development: The purpose depends on the respective feature developed. Examples are environmental foot print calculation for production environments, or automatically finding optimum production settings during reconfigurations based on historical data – either on factory or on production network level. Manufacturing IT providers intend to strengthen their market position or to extend their product portfolio by means of such developments.

State-of-the-art: Various factory level manufacturing IT features are already existing and well-established. Examples are process execution, product and process tracking, production scheduling and dispatching, process optimisation, calculation of KPIs, etc. However, there is always space for improvements or new features which might generate additional benefit for manufacturers, and herewith to their IT suppliers.

Innovative aspect / research challenge: New factory level manufacturing IT features which are developed in current research activities include for example

- Development of flexible, intelligent, and self-organising production planning and execution services. The challenge here is to deal with ad-hoc requirements, e.g. resulting from product changes or specific orders, in order to initiate production system reconfigurations and appropriate production process execution.
- Self-diagnosis systems for manufacturing equipment in order to make components self-aware and support self-healing production environments.
- Development of sustainability or energy efficiency monitoring and optimisation methodologies. An objective could for example be to calculate environmental footprints for products during their manufacturing. Therefore, not only resource usage of machines has to be considered, but also the consumption caused by the whole production environment such as buildings and transport units.

System characteristics: The stakeholders involved strongly depend on the specific use cases covered by the additional IT features developed. However, manufacturing IT providers and representatives of the manufacturers are usually concerned. Since manufacturing IT services are becoming increasingly complex and computing resource consuming, outsourcing to cloud infrastructures is often intended. To simplify integration of new services with existing infrastructures, appropriate legacy interfaces etc. would be useful, even this is often not considered since additional IT services are mainly developed to enhance own higher-level software products provided by the developing manufacturing IT provider.

Industrial perspective: Since the introduction of additional functionalities to existing IT systems is continuously undertaken, the maturity level of those developments is quite high. Acceptance and deployment in industry is given as soon as the ROI (Return On Investment) can be proved by manufacturing IT providers who intend to strengthen their market position or to extend their product portfolio by means of such developments.

4.1.11 Knowledge transfer between manufacturing and engineering

Objective / Purpose of development: In order to enable short time to market, it is necessary to transfer product designs seamlessly to production environments with a minimum effort for specific adaption of manufacturing equipment, e.g. in terms of configuration and programming.

Besides this, product design would in most cases benefit from manufacturing knowledge in order to address overall company objectives.

State-of-the-art: In most cases, manufacturing equipment are specifically configured and programmed manually according to current product specifications. However, there is process equipment which is able to directly generate process control programmes based on provided CAD files.

Manufacturing and product usage data are collected not consistently to be provided to the design phase. However, there are approaches to integrate product life cycle knowledge; to which also manufacturing information belong, by means of appropriate knowledge-based systems.

Innovative aspect / research challenge: To achieve automated transfer of knowledge from product design to manufacturing and vice versa, research is executed on

- Product specifications already including all information necessary to adapt related production processes, since nowadays much of this knowledge is brought into the process by production engineers.
- Information has to be gathered during manufacturing and usage of products. Therefore, appropriate integration of (additional) data sources is necessary. The data gathered have to be mapped to respective product design related aspects.
- Cooperation mechanisms, to reinforce the exchange of information and the sharing of knowledge among the actors involved in all the phases of the product conception and realisation.

4.2 Production network related results and concepts

4.2.1 Cloud manufacturing

Two definitions exists around Cloud manufacturing: a) Using cloud computing for manufacturing, and b) the transfer of cloud computing concepts (Anything-as-a-Service – XaaS) to the manufacturing domain and implementation of the Manufacturing-as-a-Service (MaaS) paradigm. Here, we are focussing on the second aspect, since the first is already covered to a large extent by section 4.1.9.

Objective / Purpose of development: To make production networks more flexible, i.e. implement appropriate IT platforms to realise Virtual Enterprise concepts. To do so, manufacturing facilities have to be integrated on demand, which also requires ad-hoc integration of the participants' manufacturing IT infrastructures in order to be able to easily communicate factory capacities and capabilities, orders, production status etc.

State-of-the-art: Nowadays, long-term supply chain cooperation is usually implemented by production networks which are manufacturing complex products. Communication takes place via EDI (Electronic Data Interchange) based data exchange on business and logistics level. On production level, however, no information is exchange in most industries. The integration of IT systems (mainly ERP) causes high efforts for the production network partners.

Current cloud manufacturing implementations are mainly restricted to research projects and prototype implementations, as well as defined industrial consortia without ad-hoc integration of additional partners.

Innovative aspect / research challenge: Research focussing on cloud manufacturing usually considers the following aspects:

- In order to be able to manage distributed manufacturing facilities according to the needs of a virtual enterprise, these facilities have to be integrated and described on the respective cloud manufacturing platform. Therefore, usually concepts to virtualise manufacturing resources are used which intend to generally describe the resources, their capabilities and capacities, and which give information about how to access / communicate with them in order to enable on-demand order execution.
- Especially when manufacturing clouds are not restricted to well-defined associations of manufacturers, alignment and joint execution of manufacturing processes and the related capacity planning might become a challenge since priorities of the involved partners likely will differ. The challenge is to dispatch and execute incoming manufacturing orders in a way that end-user requirements are fulfilled as well as prioritisation of individual production partners are considered.
- Furthermore, exchange of production level information throughout the virtual enterprise requires well-defined handling of the related data in order to make sure that no unauthorised party is able to access respective information. An example therefore could be that within a value chain, one manufacturer delivers detailed measurement data to the following process executor while all other participants are only allowed to know that the sub-product delivered has sufficient quality.

System characteristics: Stakeholders involved are manufacturers, i.e. suppliers as well as companies selling end-products on demand. In most cases, time constraints are not very strict, since it is usually sufficient that the information flow velocity is more or less aligned with the material flow throughout the network. Legacy integration plays a major role, since manufacturing facilities have to be represented and controlled by the cloud manufacturing platform. Security is also important, since various partners cooperating in such platforms expect that their data are protected against unauthorised access. Most of the platforms researched today are based on cloud computing paradigms and infrastructures. Integration of resources often takes place via manufacturing service descriptions which are e.g. based on standardised XML descriptions, ontologies, or even STEP. They are usually managed by means of appropriate service registries (e.g. based on UDDI).

Industrial perspective: In industry, cloud manufacturing platforms are rarely applied today because of considerable concerns about security and ROI (due to considerable efforts to implement interoperability). Furthermore, the maturity of the platforms is limited to a prototype status nowadays. However, there are some industry settings, from which interest in such a concept is stated such as associations of SMEs who intend to jointly provide customisable products, or industry clusters who would like to make their members' abilities easily available (searchable and usable) for other members.

4.2.2 Total Customisation / Ad-hoc establishment of production settings

Objective / Purpose of development: Individualisation is one of the major socio-economic trends identified within D2.1. In order to address it and enable total customisation of products, appropriate IT infrastructures and tools have to be implemented which are able to manage and analyse product specifications, select manufacturing facilities accordingly, and dispatch and track respective orders.

State-of-the-art: Nowadays, customisation is usually provided via standardised patterns for products and their sub-products which can be selected by the customers (e.g. car colours). When customers wish to influence the design and functionality of a product beyond that, products and their specifications are usually processed according to engineering-to-order principles, which involves considerable interaction among manufacturer and customers and a high degree of costly, non-standard process steps.

Innovative aspect / research challenge: The following topics are part of research projects intending to establish total customisation capabilities in manufacturing environments:

- Appropriate creation tools and analysis mechanisms (for the mapping from specification to production needs) of customer-specific product specifications is the basis for product design executable by customers and automated transfer of so created specifications to the production environment. To achieve this, mainly solutions which are combining CAD and knowledge-based system capabilities are considered to be relevant. However, this topic is not considered in Road4FAME since this is a topic related to PLM and herewith in the focus of the Pathfinder project.
- Manufacturers have to provide their capabilities and possible customisation options to associated platforms, e.g. by means of appropriate digital resource / capability descriptions. The information provided has to be extracted from real equipment capabilities, i.e. not specified as pre-defined options in order to enable full customisation.
- When a product specification is analysed, appropriate production partners have to be searched and selected. This applies for suppliers of sub-products as well as assembly tasks etc. To do so, e.g. semantic technologies can be used, together with rule engines etc. to find partners who can execute the needed processes in combination with the required process parameters. Also costs and available capacities for specific manufacturers should be considered during set up of the ad-hoc supply chains.

System characteristics: The stakeholders involved to this topic are usually customers and manufacturers which are providing process execution services, customisable sub-products, or execution of assembly processes, etc. Related IT platforms have to include strong knowledge-based systems in order to execute product specification analysis and partner selection without failures or uncertainties. Since some system requirements and use cases overlap, cloud manufacturing platforms might be appropriate underlying infrastructures.

Industrial perspective: Current systems addressing this topic are mainly restricted to research yet. In case there are industrial applications, they are restricted to products which require no supply chain integration and for which well-defined specification standards exist. Overall maturity of related systems is limited to prototype level, there are no comprehensive systems which are really providing the above-mentioned features as a whole yet. Potential applications of such systems focus on high-value products for which added value by means of individualisation is provided, e.g. high-value design consumer products.

4.2.3 Optimisation and integration of production environments / networks

Objective / Purpose of development: The objective of activities focusing on this topic are mainly faster and more flexible reaction to changing markets, reduction of search efforts, failure consequential costs, production downtimes, inventories, high-effort tracking in case of quality issues as well as lead times, and the improvement of product quality, throughput, etc. While addressing these objectives, it has to be considered that none of the stakeholders is fleeced by achieving global optima.

State-of-the-art: There are already various optimisation mechanisms in place in industrial production networks. However, the full potential is often not exploited due to a lack in information availability, communication speed, reaction times (this also includes e.g. integration efforts for new network participants), security concerns, etc.

Innovative aspect / research challenge: Current research on optimisation of production environments considers the following topics:

- Total product tracking
- Gathering higher amounts of data which can be used for optimisation tasks, e.g. from production, business, or logistic processes. This can e.g. take place by means of CP(P)S, but also be enhancing existing IT systems with additional intelligence. The exchange of process relevant data has to take place in a standardised way to ensure fast integration and a common understanding between various manufacturing facilities. Furthermore, respective information has to be available in time (i.e. minimum in parallel to the material flow) to control and optimise value chains in a decentralised network.
- Assisting systems which are able to compare planning and real data with each other and suggest actions in case of differences.
- Improved demand forecasting, performance assessment, and other planning and data analysis tools. Therefore both aspects have to be considered: the algorithms which are used to execute analysis and planning, and the amount and quality of data integrated to those systems.

- Data mining and analysis systems which are able to detect additional interdependencies and optimisation potentials throughout production networks.
- Decision making technologies considering the needs of several network participants while aiming at global optima. The latter have to be specified e.g. by aligning strategic objectives of core production network partners.

System characteristics: Stakeholders involved to this topic are manufacturers participating in (complex) production networks. Data amounts might be very high. Security and integration of production network participant's IT systems, i.e. legacy integration, play a major role.

Industrial perspective: The maturity of associated developments strongly depends on industry branch, complexity of related processes and products, etc. Especially for consumer products, there are for example advanced forecasting methodologies available. However, there is huge optimisation potential remaining, for long-term production networks which are based on strategic cooperations which intend to jointly improve their processes, as well as for companies which frequently change suppliers in order to react to changing market demands, etc.

4.3 Other results and concepts

4.3.1 Migration strategies towards next generation factories

Objective / Purpose of development: In existing factories, usually various legacy systems are in place in which relevant historical data is stored, etc. Furthermore, the slogan "never change a running system" is widely applied in industrial production environments, that is in order to not jeopardise robustness of production systems by integrating new features which might not necessarily be needed. To overcome these issues while introducing new IT concepts to factories, appropriate migration strategies are necessary.

State-of-the-art: Nowadays, there exist no smooth, non-disruptive migration strategies towards new ICT concepts in production. When new systems are introduced to manufacturing environments, project success usually depends on the abilities of the responsible persons and related risk management.

Innovative aspect / research challenge: While developing appropriate migration strategies towards next generation ICT systems in manufacturing, the following topics are to be considered:

- Definition of appropriate rules for decision making processes in production IT projects (e.g. for alignment of stakeholders with differing planning horizons and objectives), i.e. in networked systems with decentralised intelligence.
- New networked and flexible organisation structures for future intelligent factories.
- Real-time visualisation and calculation of possible decision options to increase planning reliability
- Development of specific project management support tools designed for the specific needs of manufacturing IT system projects.

System characteristics: Mainly organisational aspects have to be considered here, technological challenges are secondary. Stakeholders range from operators to production engineers, manufacturing IT providers, and companies' management and IT staff.

Industrial perspective: The maturity level of appropriate migration strategies is quite low. However, successful implementations would be highly relevant for industry.

4.3.2 Performance assessment for future ICT applications in manufacturing

Objective / Purpose of development: In order to make sure that new ICT applications in manufacturing really fit the production environment to which they should be integrated, it is necessary to assess their performance as soon as possible, ideally before integration decisions are made.

State-of-the-art: Nowadays, respective assessments are made, if at all, only after implementing respective technologies within production environments. Even then, gathering all necessary information about the current and previous situation is a challenge in most cases.

Innovative aspect / research challenge: To assess the performance of future ICT applications in manufacturing without having them in place in a certain setting, it is necessary to

- Get fast and cheap statements about efficiency of certain technologies and production strategies specifically for the settings applicable for a certain company. Knowledge-based systems using information from previous analyses can contribute to this.
- Simulation-based approval of certain decisions / virtual try-out of specific IT components. To do so, the production environment and IT system behavior have to be modeled appropriately.

System characteristics: Stakeholders are manufacturers, i.e. their decision makers with regard to IT systems, manufacturing IT providers, etc. Basically, this topic is related to organisational aspects. However, data gathering and simulation take place IT based by means of integration of existing systems and technologies related to the digital factory.

Industrial perspective: Maturity of related solutions is low. However, appropriate applications would be highly relevant for industry since it makes companies able to judge on ICT applications within their production environments without expert knowledge.

5 Analysis of recent and ongoing research activities

The following table provides an overview of how frequently the several research topics are addressed by research projects:

Topic	Section	Appearence in Projects	
		#	percentage
Plug & produce / self-describing & easy-to-configure equipment	4.1.2	15	11%
New manufacturing IT features	4.1.10	14	10%
Total customisation / ad-hoc production networks	4.2.2	14	10%
Optimisation of production networks	4.2.3	14	10%
Autonomous manufacturing system components	4.1.3	13	9%
Cyber-physical (production) systems / intelligent components	4.1.1	10	7%
Data analysis	4.1.5	9	7%
Knowledge transfer between manufacturing and engineering	4.1.11	9	7%
Factory knowledge base	4.1.4	8	6%
Decision making & Factory optimisation	4.1.6	8	6%
Manufacturing-IT as a Service	4.1.9	7	5%
Man-Machine Interaction	4.1.8	6	4%
Usability	4.1.7	4	3%
Cloud manufacturing	4.2.1	3	2%
Migration strategies	4.3.1	2	1%
Performance assessment for future ICT applications	4.3.2	2	1%

Table 1: Frequency of appearance of research topics in projects

By contrast, the prioritisation of research themes resulting from the first Road4FAME Expert Workshop (March 6, Brussels) is presented in the table below.

Research Themes	**Number of votes**
Reconfigurable systems	8
Integration of business models (manufacturing + engineering)	6
Standardisation	5
Security	5
User interfaces	5
Business models	4
Total customisation	4
IT infrastructure	3
Data analysis + optimisation	3
Intelligent components	1
Decision-making	1
Resource efficiency features	0

Table 2: Prioritisation of research themes at Brussels workshop

Observations and assessment

For some topics, there is sufficient **alignment** between the coverage of recent and ongoing research activities and the priority votes received from the workshop:

- In the case of *reconfigurable systems* (Table 2), current research activities (*Plug & produce / self-describing & easy-to-configure equipment,* Table 1) are in line with the high priority voting from the workshop.
- Standardisation (table 2) is sufficiently covered by reconfigurability and SC integration (table 1) and they are both similarly ranked.
- *Integration of business models* (Table 2) sufficiently covered by *Knowledge transfer between manufacturing and engineering* (Table 1) and they are both similarly ranked.

There are **deviations** for most other research topics:

- Slight deviations for Big-data related topics
- In the case of *Security* (table 2), there are no projects among the ones analyzed which have a first priority on this topic which is why it does not appear in the table 1. This points to a research gap, because security issues in manufacturing IT are certainly relevant. In fact, security concerns have been identified in interviews with industry (D2.2) as one of the major show stoppers for IT innovation in manufacturing companies today.
- Considerable deviation for user interfaces / usability, Intelligent components / CPS, Resource efficiency features (covered by new manufacturing IT features)

Conclusions:

- *Security* and *User interfaces* would have to be addressed stronger by future research, especially since interview with industry (D2.2) have identified strong needs in relation with them.

6 Analysis of research activities and recommendations

Overview of recommendations for manufacturing IT research

Research topic	Recommended activities	Timescale
Cyber-physical (production) systems / intelligent components	• Integration of (wireless) sensors, actuators, and intelligence to production environments • Distributed M2M / IoT connectivity for various classes of devices across the shop floor • Low-power embedded distributed control system architectures	Long-term
Plug & produce / self-describing & easy-to-configure equipment	• Open IT platforms for integration and networking of control systems • Universal adapters to interface devices which enable (semi-) automated integration with underlying legacy systems • On-demand modular and replicable models for faster factory initialisation	Mid-term
Autonomous manufacturing system components	• Local intelligence and signal-processing solutions for self-adjustment and correction • Cooperation and self-organisation	n.a.
Factory knowledge base	• Distributed perception architectures to handle large amounts of data from sensors, filtering at different levels • Real-time event repository to be resolved against particular exception conditions • Real-time synchronisation of factory models • Distributed data consistency	Mid-term
Data analysis	• Consideration of provenance and context of data to assess quality and reliability of data • Exploit complex event processing technologies in production • Modelling for complexity management (usage of models to represent and analyse interdependencies and behaviour of systems not only during engineering phases, but also during operating stages)	Mid-term
Decision making & Factory optimisation	• Self-learning & Self-healing systems • Safe decision making • Condition prediction reference models	Mid-term
Usability	• Standardised user-interface libraries easy to incorporate in production systems • Decoupling user interfaces from main systems logic; incorporate modular approaches • Feedback mechanisms to capture user interactions as basis for improvement of future system versions • Enhanced visualisation of complex manufacturing and production data; Modelling and representation of human	Mid-term

	knowledge and behaviour to enable fast reorganisation, adaption and optimisation of workflows, task distribution, etc. • Adaptive learning mechanisms to fit as much as possible with the daily practice of workers	
Man-Machine Interaction	• Advanced perception and situation analysis capabilities to plan automatically or interactively in the context of incomplete information about tasks and scene • Semantics, reasoning, self-learning and decision-making capabilities for smart and autonomous robots interacting with other robots, machinery, and human workers • Multimodal interfaces among machines, robots and human workers to improve overall interaction	Long-term
Manufacturing-IT as a Service	• Control of machines / equipment from cloud environments (real-time communication as precondition) • High-performance computing leveraging the cloud to deal with the execution of additional analyses based on large amounts of data, and related real-time reactivity • One-stop manufacturing IT app store	Long-term
New manufacturing IT features	• Dynamic manufacturing execution environments for smarter integration of new evolving features, and smarter integration into dynamic and agile factories • Exploitation of event driven services and mechanisms for generating real-time production performance indicators • Condition-based optimisation of production schedules in real-time, based on self-learning approaches • Services for continuous evaluation and mitigation of manufacturing risks	Mid-term
Knowledge transfer between manufacturing and engineering	• Manufacturing intelligence for informed product and process design • Life cycle assessment and life cycle costing based on tools integrated throughout the whole product and production life cycle • Conception stage integration of multi-disciplinary synergetic technologies such as new machine architectures, active machine elements, etc.	Mid-term
Cloud manufacturing	• Unified resource naming schemes which can be extended to abstract physical entities within the supply network • Service delivery framework for easy deployment and consumption of manufacturing services • End-of-life applications in a network of remanufacturing stakeholders	Short-term
Integration of manufacturing, product, and service business	• Holistic product-service, process and value chain design and operation • Transfer of paradigms such as lean management from production to service domain and vice versa	n.a.
Total customisation / ad-hoc production networks	• Establishment of B2C communities to integrate customers to the development / design process	Mid-term

	• Collaborative design environments for SME involvement • ICT- and market based costing and manufacturability assessment	
Optimisation and integration of production networks	• Collaborative and cross-layer adaptive modelling and planning, traceability, and execution • Data collection and anonymity during product use • System-oriented quality control strategies in multi-stage manufacturing environments • Scalable real-time architectures to master complexity and data security in supply networks and underlying logistics	Mid- to long-term
Migration strategies	• Scalable (CPS) architectures for adaptive and smart manufacturing systems to dynamically enable continuous design, configuration, monitoring and maintenance of operational capability, quality, and efficiency • Modernising legacy systems by upgrading critical subsystems and integrating them seamlessly into existing infrastructures • Industrialisation (modularisation) of software development to enable rapid configuration, adaption, and assembly of manufacturing IT systems	Mid-term
Performance assessment for future ICT applications	• Set up controlling and measurement standards for ICT performance assessment • Integration of IT activities to strategic company objectives	n.a.
Standardisation and reference architectures	• Standardisation of collaboration and exchangeable information among systems • Harmonisation / extension / simplification of existing standards for information exchange in production • Definition of a reference architecture, i.e. a technological description and implementation of standard definitions, relaged logical and infrastructural layers, etc. • Open standards, operational systems, engineering tools, (communication) infrastructures, which prevent access restrictions to future production IT systems	Mid-term
Security, privacy & legal aspects	• Establishment of security by design principles for manufacturing IT systems • IT security concepts, architectures, and standards which are able to establish trust, integrity and availability in open, heterogeneous system networks • Unique and secure identities and related validation mechanisms for products, processes, facilities, etc. • User-friendly and cost-efficient security solutions • Guidelines and frameworks for IPA, confidential data, liabilities within collaboration networks • Establishment of certifications for parties participating in future manufacturing IT systems	Mid-term

Business models and demonstrations	• Business models exploiting new manufacturing IT architectures and services (based on superior value to existing business models or provision of additional services) • Establishment of demonstrator systems which not only show technological developments but especially the business models behind (and their benefit)	Mid- to long-term
Stakeholder education	• Communication of future manufacturing IT concepts with special focus on critical aspects like security and privacy, robustness, etc. • Teaching factories, i.e. real production facilities developed for education and training purposes • Cross-sectorial education • Innovation agents and benchmarking for keeping stakeholders up-to-date • Serious games to support rapid competence development, knowledge externisation and transfer • Personalised ubiquitous learning (efficient and targeted training of individuals) • Accelerated learning by means of problem based learning throughout several cooperating organisations	Short-term

Analysis of recommendations for generic IT research

In addition to that, the following generic ICT-related research topics were identified:

Research topic	Recommended activities	Rating of how relevant the ICT topic could be for manufact-uring IT	Implementation & awareness	
			Research	Practice
Infrastructure				
Communication channel Speed and connectivity	Smart antennas; real-time, low-latency communication, energy efficient communication; ad-hoc connections, security, robustness, etc.	1	1	1
Real-time capabilities	Integration methods and validation approaches for correct and efficient integration of mixed real-time systems	2	2	2
Smart Components	Miniaturisation of devices; Embedding smart functionality; energy efficiency; Awareness and cooperation; appropriate engineering methods	2	2	1
Network technologies	Reliable, intelligent, auto-configured / self-managed, context-aware and adaptable network technology, network discovery, and network management; Network virtualisation techniques contributing to evolutionary deployment of IoT applications; Infrastructure for "network of networks" supporting dynamically small area and scale free connections and characteristics	1	1	0
Computing technologies	High performance heterogeneous cloud infrastructures; federated cloud networking; dynamic configuration, automated provisioning and orchestration of cloud resources; mechanisms to increase trust, security, transparency for cloud computing; Low power computing	1	2	0
Interoperability among heterogeneous systems	Technical / syntactic and semantic integration, including component, service, and capability descriptions in a formalised way; Certification of systems which can be composed and support dynamic reconfiguration; Merging IoT, IoP, IoE, IoM, IoS (Internet of things, people, energy, media, services) to a common global IT platform of seamless networks and networked smart objects Intelligent inter-machine communication and configurable / low-effort integration of legacy systems and communications	2	1	0
Software Services and algorithms	Service management including identity, relationship and reputation management, especially for distributed architectures and related mobile, adaptive, etc. components, service and device discovery, and semantic interoperability; Specific services such as virtualisation software, bio-inspired algorithms, solutions based on game theory, algorithms for optimal assignment of resources in pervasive and dynamic environments	2	1	0

Big Data				
Smart sensors and sensor data fusion	Perception techniques for measurement, object and event recognition to increase context-awareness and intelligence; Sensors which monitor data quality (accurateness, robustness, durability, etc.) and perform advanced analysis to only transfer information which is really needed; sensor data fusion, i.e. treating, correlating, and reducing data from sensors (including gaining additional information by combining several sensor inputs)	2	2	1
Knowledge generation / data analysis	Appropriate database technologies, analysis and correlation of distributed large data sets, information integration, data reduction mechanisms, novel data structures and data structure alignment, consideration of historical aspects of data, self-learning for analysis mechanisms, etc.	2	2	1
Decision making	Visual representation of large amounts of complex data for decision support; Methods for uncertainty quantification, dealing with varying data quality; Continuous optimisation models reflecting current situations; Autonomous & safe decision making; Collaborative decision making considering global objectives / negotiations among sub-systems	2	2	0
Forecasting	Planning and forecasting of (semi-)autonomous actions using multi-criteria situation evaluation (real-time analysis and evaluation of situations) and artificial intelligence	2	2	1
Complexity management	System architectures supported by intelligent services for managing modularity, flexibility, service composition, etc. by exploiting Big Data and CEP techniques	2	1	0
System engineering / design				
User-centred design	Usage simulation, quality of experience, quality in use, experience labs, usability engineering, integrated human- and system architecture models	1	1	0
Multi-level modelling	Advanced requirements engineering considering all relevant aspects (model-based, iterative, etc.); Multi-domain modelling techniques and integrated tool chains, also for open systems / platforms, large, complex and data-intensive, autonomous and/or evolutionary systems and their management, which also consider dynamic behaviour; Gathering experience from system implementation and usage and use it for design rules / future system modelling	2	2	0
Definition & Evolution of System Architectures	Design patterns and network typologies for low effort integration, abstract data models and interfaces and their binding to neutral technologies to ensure wide ranged applicability; Generic platforms and suites containing abstract components for easy roll-out of developments throughout various application domains;	2	1	0

Prototyping	Prototyping within operating Systems / SoS rather than test beds; Creation, reconfiguration, extension of experimental infrastructures and exploitation of data gathered there; Experimentation-as-a-Service, virtual experimentation	2	1	1
System behaviour				
Situation awareness	Gathering appropriate sensor data, set it in respective contexts, analyse it in real-time (potentially throughout distributed sensor networks)	2	2	1
Measurement and metrics	Measuring System performance requires identification of appropriate KPIs and related data to be gathered, ensure comparability of data, effectiveness; Predictive measures, real-time measurement, traceability of measurements	2	2	1
Resilience, adaptability, flexibility, and evolution of systems	Engineering and design approaches to deliver modularity, flexibility, adaptability, and resilience at run-time, under conditions not necessarily foreseen during the initial design phase; Interoperability, self-configuration, self-organisation, and self-healing mechanisms; Performance assessment for evaluation of system configurations and possible alternatives	2	2	0
Distributed control	Avoidance of negative dynamic side effects caused by non-cooperating control units (e.g. via physical couplings) Dynamic ad-hoc control loops in cooperative networks; cooperative functionality monitoring to support dynamic re-routing and migration of control functionality in case of singular system failures System architectures to support distributed control and integration of control systems	1	1	0
Autonomous systems	Situation awareness / interaction with the environment via sensors and actuators; distributed control & decision making (including related negotiations etc.); Finding the right balance (depending on the application case) for the distribution of functionality/intelligence between smart things and the supporting infrastructure	1	1	0
Emergent behaviour	Understanding possibilities and limits of emergent behaviour and its prediction; Predictive techniques, modelling and simulation, tools for early warning, devise strategies to make emergent behaviour less unexpected and avoid undesirable, and allow for desirable emergent behaviour	1	0	0
User interfaces / Human aspects				
Multimodal interfaces	Intuitive and transparent usage of systems; Joint control (by humans and machines) of open complex socio-technical systems; Multilingual speech processing, including semantics; Coping with spontaneous spoken language and gestural interaction; Augmented reality applications	2	1	0

Situational awareness and user-specific adaption	Enable awareness of psychology, culture, organisational aspects, preferences, intentions, application context, etc. by sensors and intelligent mechanisms, and appropriate adaption of visualisation / user interaction; Modularity of user interaction components for individual interface composition.	1	1	0
Technologies for creative industries, social media and convergence	Improve collaboration and user-community interaction by understanding the dynamics of co-creative processes.	0	1	0
Human-centric digital age	Understanding how new technologies change societies; Exploration of fundamental notions such as identity, privacy, relationships, culture, reputation, motivations, responsibility, attention, safety, fairness, etc.	0	1	0
Human learning and teaching	Smart learning environments providing students with adaptive and personalised learning assessment, including multi-modal / multi-sensory interaction technologies and advanced interfaces.	1	1	1
Wearable technologies	Sensors, actuators, and visualisation technologies which can be integrated to clothing (miniaturisation, materials, supporting software solutions)	1	1	0
Security-related topics				
Operational safety and reliability	Secure runtime environments; Consideration of physical, ethical, and cyber aspects of safety and security (including cross-reference to safe/secure decision making); Mixed criticality systems (compositions of applications with different safety requirements) and their integration, qualification, and incremental certification	2	2	2
Privacy and know-how protection	Security-capable hardware; Efficient, light-weight cryptographic techniques and protocols; Scalable security concepts (closed and open, modular / reconfigurable systems); Security by design, across all hardware and software layers of an ICT system; Authentication and authorisation for huge amounts of heterogeneous devices, across different administrative domains; Cross-referencing multiple identities of an object throughout domains; new effective addressing policies for reliable and consistent encoding and decoding of identifiers; decentralised authentication, access and use rights management; Integration of additional systems/components into privacy-preserving frameworks, evaluation of privacy-preserving effectiveness	2	2	1

Establishment of trust	Enable technical transparency of systems (in usage and essential functionality); Transparent and effective management of privacy policies; Clearness about data ownership, legal and liability issues; Development standards and security regulations and related certifications	2	1	1
Consensus				
Governance modes / structures	Criteria, recommendations, structures and measures for centralised or decentralised control and decision making, considering fairness towards all applicants and avoidance of negative side-effects when every system optimises for its own purpose.	2	2	0
Standardisation	Standards should be open and covering various aspects (legal, organisational, semantic, technical) Standards for interoperability of systems including domain models (formalised application knowledge, e.g. by means of ontologies and domain-specific description languages), requirements, functional models, reference architectures, interfaces, protocols, etc; Continuous learning / adapting mechanisms for optimisation of related context models; Transformation of models throughout domains. Harmonisation and efficient application of existing standards;	2	1	1
Regulatory measures	Warranties; Responsibilities for data protection; Common validation, verification and certification guidelines; Establishing risk analysis and evaluation for complex systems and providing it as regulative measures; International / cultural harmonisation of regulations to cover common ethical, quality, security etc. aspects	2	1	1
Industrial application				
Education of stakeholders	Education programmes to address the respective stakeholder groups appropriately	1	1	1
Business models	Determination and optimisation of risk-benefit ratio, i.e. potentially large investments which are necessary to establish new technologies / systems. In the future less investment may be necessary due to new business models; Governance of systems which consist of several independent components and where all stakeholders participate interactively; Development of new products / services / product-services, appropriate consideration of interactive cooperation, customer-orientation & individualisation of products / services, etc.	2	1	1

Demonstrations / Living labs	Implementation of small-scale demonstrators constituting working examples and showing the related benefits of the new systems; Experimentation, i.e. implementation of systems and collection of data for evaluation, and evaluation of various (all relevant) aspects such as environmental, economic, social etc. impact; Bring together technology push and application pull, engage stakeholders.	2	1	1
Web entrepreneurship and collaborative ideas management	Online platforms with new services, e.g. connecting existing local web entrepreneurship ecosystems and hubs, and build upon these in order to provide new services; Platforms going beyond technologies and applications to include necessary conditions for collaborative innovation.	0	1	0
Other				
Thin, Organic and Large Area Electronics	Improve materials, functionality, manufacturability, etc.	0	0	0
Optimisation of electronic sustainability	Increase recyclability of electronic components	0	0	0
Cracking the language barrier	Improve quality and coverage (in terms of languages and text types) of machine translation	0	0	0
Digital gaming / gamification technologies	Digital gaming technologies and components (including game engines, emergent narrative, 3D, textures, models for simulations, game design, learner profiles, emotional models, etc.) applicable into a wider scenario of use in non-leisure contexts	1	1	0

<u>Observations and assessment</u>

- <u>Many generic IT research topics are well taken up in manufacturing IT research and practise</u>: As it can be seen from Table 2, many generic ICT research topics are also relevant for manufacturing IT applications. For some ICT topics, their adoption and awareness about them is very well corresponding to their relevance for manufacturing IT – in practice as well as in research. This is especially the case for essential IT features like real-time capabilities (for critical applications), communication channel speed and connectivity, and operational safety and reliability. In such cases, manufacturing IT applications are often already fulfilling requirements which are stated for research activities in generic ICT roadmaps. But also for minor topics which do not have appreciable impact on manufacturing, correspondence of relevance and implementation activities converge.

  For most of the generic ICT research challenges such as big data technologies, smart components, situation awareness, resilience, privacy and know-how protection, governance modes and structures, and network technologies, it can be said that their potential for manufacturing IT is quite well represented in current research activities, although state-of-the-art applications in productive factories are some steps behind. Research in these fields should be continued to really implement these topics in practice.

- Underestimated potential of some generic IT research topics for manufacturing: However, there are also some generic ICT research recommendations which are not considered appropriately in manufacturing IT research. This may be an indicator for underestimation of the potential of these topics.

  The most significant deviations between ICT research and adoption of technologies in manufacturing apply for:

  - Interoperability (beyond plug & produce manufacturing IT projects), change from system integration to information integration
  - Complexity management
  - Definition and evolution of system architectures
  - Emergent behaviour
  - Prototyping
  - Non-technical aspects: Establishment of trust, standardisation, regulatory measures, business models, demonstrations / living labs (refer to section 3.1: these topics are recommended for manufacturing IT, but underrepresented in research activities)

  The relevance of these topics for manufacturing IT has been rated higher than their current appearance and holistically consideration in research projects and state-of-the-art applications. For this reason, special attention may be laid on these topics in future manufacturing IT research.

7 Conclusion

This *report on results and concepts from relevant initiatives* was created with the objective to provide a sound overview of recent and ongoing research activities in the field of manufacturing IT. To establish this overview, a substantial amount of research projects at the national level (UK, Germany, Portugal, and Italy) and the European level (Factories of the Future PPP, Artemis JTI) have been analysed for the research topics they cover, and the results and concepts produced.

The analysis of 138 projects provided a sufficient sample for establishing such an overview, indicated by the fact that research topics quickly converged into the groups presented in section 4.

This overview of recent and ongoing research activities is an important building block for the push perspective in Road4FAME. Together with data from other deliverables which contribute to push or pull perspective in Road4FAME important analyses can be performed. Despite the fact that most analysis work results from analysis *across* several deliverables (see Deliverable 1.3 for these analyses), sections 5 and 6 present assessments already based on the data contained in this document.

The resulting observations are important to take into account in the further roadmapping process. In this further roadmapping process, the knowledge contributed by this document will be reflected against other perspectives and will be adequately represented in the roadmapping activities. (Note that there will be no retroactive adjustment of the content of this document since it must be understood to contain standalone observations. Any opinions received by experts and any perspectives contributed by other documents will influence roadmap and recommendations, just as this document does but it must not alter the data presented in this document.)

Annex I: Identified research initiatives and projects

This section gives an overview on the most relevant initiatives and related projects on national, European, and international level. Each project is shortly described. The results from analysis of these projects are described in section 4.

I.1 National projects

I.1.1 Projects from the German "Industrie 4.0" initiative

The German "Industrie 4.0" initiative is a programme set up by the German Ministry for Education and Research in order to strengthen the industry on a long-term perspective. The following projects are funded in the context of the "cyber-physical systems" and "autonomics" calls:

Projects from the Industrie 4.0 / CPS initiative:

1. BaZMod
   Full title: product-adapted machine configuration in manufacturing by means of cyber-physical extension modules.
   Short description: This project develops an integrated approach for the communication among machine, control devices, and production environment. Self-configuration of systems, i.e. „plug and produce", will be enabled by means of cyber-physical extension modules. To do so, the establishment of an international standard for relevant interfaces in the area of machining tools is intended. These interfaces shall be independent from certain provider's interests and easy to integrate to the machines. Due to these extension modules, machining tools can integrate additional process steps which extend their application options, improve their process quality and efficiency, i.e. lead times and costs.
   Duration: 11/2013 – 10/2016
   Coordinator: Ewald Hasselkuss, KOMET GROUP GmbH, ewald.hasselkuss@kometgroup.com

2. CSC
   Full title: CyberSystemConnector – intelligent generation and usage of equipment documentation.
   Short description: The objective of this project is to ensure an up-to-date technical documentation of equipment by means of their virtual representation throughout the whole product and production lifecycle. To do so, the CSC component acts as interface for each system component of a tool or equipment. For each reconfiguration of tools or equipment which requires also an update of the documentation, the virtual representation is re-loaded, so that the equivalent virtual representation fits the real manufacturing environment at any time.
   Duration: 11/2013 – 10/2016
   Coordinator: Stefan Magerstedt, KHS GmbH, stefan.magerstedt@khs.com

3. CyProS
   Full title: Cyber-Physical Production Systems – Increasing productivity and flexibility through integration of intelligent systems in factories.
   Short description: High wages and challenging environment standards prevent that manufacturing companies in Germany can compete only via product prices. For this reason, they advertise globally referring to high quality and innovative products. However, competitors are catching up. Consumer goods as well as industrial goods are going to be increaslingly differentiated and demand for them varies unexpectedly. For this reason, production and logistic processes have to be able to react holistically and dynamically. CyPros develops methods and tools to develop and operate cyber-physical production systems to address this challenges and evaluates their application in this context in several production and logistic scenarios.
   Duration: 09/12 – 09/15
   Coordinator: Heiko Frank, Wittenstein AG, heiko.frank@wittenstein.de
   Website: http://www.projekt-cypros.de/

4. eApps4Production
   Full title: Flexible Integration and application of intelligent engineering apps (eApps) to easily monitor and maximise equipment performance
   Short description: The objective of this project is to make information and knowledge about production, i.e. from real status and process information which are e.g. gathered by means of cyber-physical systems, available at any time, location, and user device. Using this data and information takes place via application-specific engineering apps (eApps), i.e. small applications with a specific functionality which support engineering activities with a certain focus. Examples for this are applications for monitoring of efficiency or equipment, process control, or quality management. They should be able to be configured by the engineers they need to use them by themselves in order to achieve maximum usability.
   Duration: 11/13 – 10/16
   Coordinator: Peter Lindlau, pol Solutions GmbH, peter.lindlau@pol-it.de
   Website: http://www.eApps4Production.de/

5. ERANET-MANUNET-ARSGuide
   Full title: Augmented Reality System for Guidance
   Short description: ARSGuide aims at providing humans during development of services for complex production systems. By means of fading in relevant information to the representation of equipment and components, an augmented reality should be established which simplifies engineering work and decreases maintenance times.
   Duration: 04/13 – 03/15
   Coordinator: Willy Chen, Softplant GmbH, willy.chen@softplant.de

6. ERANET-MANUNET-DeLas
   Full title: Development and Ramp up of automated Laser Assembly
   Short description: The objective of this project is to develop an innovative, software-based engineering environment for workflows in flexible automated precision assembly, specifically for optical components and lasers. To do so, existing software tools for product development and optics simulation are extended and combined with an engineering environment for

assembly processes. The developed software simplifies integrated process development for assembly. Engineering efforts and costs decries while production volume flexibility increases.
Duration: 04/13 – 03/15
Coordinator: Sebastian Haag, Fraunhofer-Institut für Produktionstechnologie IPT, sebastian.haag@ipt.fraunhofer.de

7. ERANET-MANUNET- MANUbuilding
   Full title: Energy efficient building for industrial environment
   Short description: MANUbuilding aims at enabling considerable energy savings by means of intelligent combination of individualized and flexible manufacturing process and appropriate building automation. To achieve this, relevant sensor data such as temperature, illumination, humidity, etc. are identified from production and building operations, analysed, and integrated to a holistic production and building automation software. The results of this project provide the opportunity to use new generation control systems for building and production planning in order to realize energy savings in manufacturing companies.
   Duration: 06/13 – 05/16
   Coordinator: Jochen Masuch, UPAS GmbH, jochen.masuch@upas.de

8. ERANET-MANUNET- Sim4SurfT
   Full title: Integrated Simulation System for Laser Surface Treatment of Complex Parts
   Short description: The objective of Sim4SurfT is the development of an innovative, software-based technology for laser hardening, which enables an intelligent integration of programming and manufacturing workflows for geometrically complex moulding tools. This should also be cost-efficiently applicable for small series and lot size one production as it is necessary for mould construction.
   Duration: 04/13 – 03/15
   Coordinator: Maximilian Wegener, Fraunhofer-Institut für Produktionstechnologie – IPT, maximilian.wegener@ipt.fraunhofer.de

9. IWEPRO
   Full title: Intelligent self-organising workshop production
   Short description: In workshop production, flexible structures and autonomous acting components have considerable advantages in comparison to inflexible, centralized control mechanisms and structures. Such a smart workshop production consists of decentralized structures with small control loops and is based on an efficient, result-oriented communication and well-integrated cooperation of all production process participants, i.e. workers and other necessary resources. In the future, the workers will be in the position to make decisions situation-dependent, based on intelligent networked products, equipment, etc. which exchange order and process information with each other.
   Duration: 11/13 – 10/16
   Coordinator: Benjamin Kuhrke, Adam Opel AG, benjamin.kuhrke@de.opel.com

10. KapaflexCy
    Full title: Self-organising capacity flexibility in Human-Cyber-Physical-Systems
    Short description: Production of customer-specific products requires continuously increasing dynamics, transformation ability, and customer orientation. This requires high flexibility of technical equipment as well as staff. KapaflexCy develops a self-organised capacity control system, which allows companies to control their manufacturing capacities highly flexible, on short notice, and throughout production networks, while directly involving the executing workers. Current vertical command hierarchies (top down) are replaced by horizontal decisions within and across working groups.
    Duration: 09/12 – 09/15
    Coordinator: Moritz Hämmerle, Institut für Arbeitswissenschaft und Technologiemanagement, moritz.haemmerle@iao.fraunhofer.de
    Website: http://www.kapaflexcy.de/

11. KARISPRO
    Full title: Small-scale autonomous, redundant intra-logistic system for production
    Short description: Karis Pro develops and validates an intra-logistic system, which combines the advantages of cost efficiency and mutability. The basic principle to realise this is the application of redundant, identically constructed components which navigate by themselves and transport carriers. Furthermore, the system should recognize the need for adaption to changes in the production system by itself, simulate alternatives, and reconfigure itself appropriately.
    Duration: 10/13 – 12/16
    Coordinator: Andreas Trenkle, Karlsruher Institut für Technologie (KIT), andreas.trenkle@kit.edu

12. mecPro2
    Full title: Model-based engineering process for cybertronic products and production systems
    Short description: Complex industries demand software tools, which enable to deal with modern, integrated systems. Current embedded systems which are part of technical products integrate increasingly with each other via the virtual world of the internet. These systems, which exchange information and influence each other's behaviour, are called cyber-physical systems (CPS). This project focuses on the integration of information from all contributing disciplines and the description of the CPS to be developed by means of model based systems engineering, as well as the administration and forwarding of this system descriptions supported by product life cycle management.
    Duration: 11/13 – 10/16
    Coordinator: Dirk Spindler, Schaeffler Technologies AG & Co. KG, dirk.spindler@schaeffler.com
    Website: http://www.mecpro.de/

13. MetamoFAB
    Full title: Metamorphose towards the intelligent and integrated factory
    Short description: The objective of this project is to enable and support the transformation towards intelligent and integrated factories for existing enterprises and the production sites they operate. According to the vision of "Industry 4.0", this can increase productivity and

flexibility considerably. In order to ensure the transfer to industry, the approach, models, methods, and tools as well as necessary qualification process for planning and execution of the transformation to future CPS factories are developed application and branch independent. The findings are evaluated by means of virtual and real laboratory demonstrators, and afterwards implemented in three real manufacturing environments of industrial partners.
Duration: 11/13 – 10/16
Coordinator: Dr. Nils Weinert, Siemens AG, nils.weinert@siemens.com

14. netkoPs
Full title: Integrated, cognitive production systems
Short description: netkoPs develops a new, decentralised controlled material flow system for production. This enables that process equipment, handling, and transport systems interact in an intelligent way and are geared to human cognitive capabilities.
Duration: 11/13 – 10/16
Coordinator: Dr. Heiko Stichweh, Lenze SE, stichweh@lenze.de

15. pICASSO
Full title: Industrial cloud-based control platform for a production with cyber-physical systems
Short description: pICASSO aims at the development of a scalable control platform for cyber-physical systems in industrial manufacturing environments. Such a platform should provide scalable computing power which is provided automatically depending on the complexity of algorithms. The monolithic control technology will be overcome and dispatched to the cloud. To do so, strict requirements from the production domain such as real time capabilities, availability, and security have to be fulfilled.
Duration: 10/13 – 09/16
Coordinator: Florian Holz, SOTEC Software Entwicklungs GmbH + Co KG, f.holz@sotec.eu
Website: http://www.projekt-picasso.de/

16. ProSense
Full title: High-definition production control based on cybernetic support systems and intelligent sensor systems
Short description: The objective of ProSense is to develop a production control system based on self-controlling supporting systems and intelligent sensor systems. The control system should support human decisions for production planning and control by means of detailed, online gathered data from production combined with an intelligent visualisation. The decisions suggested will go in parallel with the objectives of enterprises such as meeting delivery deadlines or increasing throughput.
Duration: 09/12 – 09/15
Coordinator: Till Potente, RWTH Aachen – WZL, t.potente@wzl.rwth-aachen.de
Website: http://www.prosense.info/

17. RobIN4.0

    Full title: Robustness through integration, interaction, interpretation, and intelligence

    Short description: The objective of RobIN 4.0 is to enable the parallelisation of information flows and material flows in mechanical deformation processes. This will cause an increase in process robustness, reliability of production processes, and productivity throughout processes.

    Duration: 10/13 – 09/16

    Coordinator: Prof. Dr. Peter Groche, Technische Universität Darmstadt, groche@ptu.tu-darmstadt.de

18. SecurePLUGandWORK

    Full title: Intelligent commissioning of machines and interlinked equipment

    Short description: SecurePLUGandWORK focuses on self-configuration mechanisms in production-related software components throughout all layers of the production IT hierarchy. To do so, open standards should be used which are already applied in industry today. Project results are shown by means of several specific demonstrators; the efforts for ramp-up of production should be reduced for about 20%, efforts for integration of equipment and control systems to higher level systems for about 70%.

    Duration: 11/13 – 10/16

    Coordinator: Dr. Olaf Sauer, Fraunhofer-Institut für Optronik, Systemtechnik und Bildauswertung – IOSB, olaf.sauer@iosb.fraunhofer.de

19. SmartTool

    Full title: Intelligent tools for the integrated production of tomorrow

    Short description: The increasing number of product variants and frequency of product changes result in the need for more frequent tool changes and an increasing number of different tools in machining, e.g. for production of components for plant construction. Due to the various steps in the tool life cycle like purchasing, assembly, and usage, and their need for information, which are necessary for the allocation of the tools, the related effort has increased considerable in the past, so that the related costs represent almost 25% of the manufacturing costs. One major issue to be overcome in order to exploit existing optimisation potentials is the lack of information transparency in tool life cycles due to closed, heterogeneous IT systems which host tool-related data, and the lack of information availability, e.g. about current place of action and related process details.

    Duration: 10/13 – 09/16

    Coordinator: Matthias Wieschollek, Heidelberger Druckmaschinen AG, matthias.wieschollek@heidelberg.com

20. ToolCloud

    Full title: Cloud life cycle management for tools throughout production sites by means of unique identification

    Short description: In order to apply tools, e.g. to chip plastics, wood, or metal in automated production environments appropriately, the tool provider has to provide real geometries and applicable operating parameters like cutting speed to the machine setters. These information are noted on so called tool escort cards which always stay close to the tool. By re-sharpening the tools, the real geometries are changed and are updated during the whole life cycle of the

tool. For each usage of a tool on a machine, the current correction and operational parameters have to be entered at the machine. This is fault-prone and costly. Though there are singular solutions to transfer tool data factory-internal to certain machines, there are no systems which provide standardised solutions for certain industry branches or application throughout company boundaries. The medium brake between tool manufacturing, usage, sharpening, and measuring is not overcome up to now.
Duration: 10/13 – 09/16
Coordinator: Ulrich Doll, HOMAG Holzbearbeitungssysteme AG, ulrich.doll@homag.de

Projects from the Autonomics Initiative:

21. AGILITA
Full title: Agile production logistics and transport facilities
Short description: AGILITA is focussing on the integration of control systems in production with RFID technologies in order to enable autonomous control and consistent tracking of components to be manufactured. Furthermore, the development and implementation of a concept for automated, individually configurable transport units will be executed, which ensures to fulfil the specific requirements of high-value components and high transport reliability. This flexible and re-configurable units, also called carriers, will be used for transport tasks within and throughout factories.
Duration: n.a.
Coordinator: Dr. Hilmar Apmann, Premium AEROTEC GmbH, hilmar.apmann@premium-aerotec.com
Website: http://www.agilita-projekt.de/

22. AutASS
Full title: Autonomous drive technologies by means of sensor fusion for intelligent, simulation-based monitoring and control of production facilities
Short description: This project aims at the development of a permanent "health check" for production facilities. The objective is the integration of sensor functionalities to electric drive systems such as engines. Thereby, intelligent and autonomous diagnosis abilities (self-diagnosis) for separate components of the drive system and processes are established, and herewith a mechatronic control loop is implemented which enables early and reliable detection of the "health" of electric drives (overload, abrasion, life time forecast etc.). Also following processes can be evaluated by means of validation of measurement signals and flexible and modular integration of sensor functionalities. All sensor units are connected wireless to "intelligent electronics". The algorithms for signal processing and analysis which are available there ensure their autonomous working mode. Furthermore, the "intelligent electronics" are connected to a central diagnosis system which serves the execution of further analyses (trends, thresholds, failure forecasts, etc.), monitoring, control, and visualization.
Duration: n.a.
Coordinator: Dr. Harald Buchalla, Hanning Elektro-Werke GmbH & Co. KG, Harald.Buchalla@hanning-hew.com
Website: http://www.intracomgroup.de/AUTASS/

23. AutoBauLog

Full title: Autonomous control in construction logistics
Short description: The objective of this project is to intelligently integrate all construction machines in large construction sites, so that they are aware of their situation and tasks, and can analyse and optimize them. To do so, they are implemented as mainly independent and result oriented controlled units. The approach involves 3 innovations: a) equip construction machines with software-based intelligence and sensors, b) cooperation of construction machines and establishing machine teams c) integration of machine-based construction processes in a virtual-reality and simulation supported control system.
Duration: 10/09 – 05/13
Coordinator: Hans Schulz, RIB Information Technologies AG, hans.schulz@rib-software.com
Website: http://www.intracomgroup.de/AUTASS/

24. AutoPnP
    Full title: Plug&Play for robotics
    Short description: Within this project, a software architecture for syntactic and semantic integration of hardware and software components is drafted in order to develop and adapt complex systems easier, faster, and more cost efficient. The automated integration and configuration of new components to an automation system will be enabled without additional efforts for application-specific adaption. Based on this, concepts and algorithms of artificial intelligence are used. In addition to architectures, methods, tools, and application scenarios are implemented which support development and engineering, and approve applicability of the selected approach.
    Duration: 2011 – 2013
    Coordinator: Prof. Dr. Sahin Albayrak, Technical University of Berlin – DAI laboratory, sahin.albayrak@dai-labor.de
    Website: http://www.autopnp.com/

25. CyCoNet
    Full title: Development of energy-autarkic, intelligent networks of carriers in air freight industry
    Short description: DyCoNet is going to establish an alternative solution to RFID infrastructures for communication throughout logistics objects by means of an example in air freight industry. To do so, unlimited integration of objects by means of everywhere available technologies like GSM/UMTS and GPS is intended. Additionally, the system should work energy autarkic, so that no change to existing processes and establishment of new infrastructure is necessary for its application. The air freight containers should be able to communicate throughout enterprise networks and without additional infrastructures. Environment information will be gathered by means of sensors and transferred to appropriate actions like request of transport vehicles or triggering alarms.
    Duration: n.a.
    Coordinator: Lufthansa Cargo AG, Project Contact: alexander.hille@iml.fraunhofer.de
    Website: http://www.dyconet.de/

26. LUPO
    Full title: Performance assessment for independent production objects

Short description: The objective of this project is the analysis and evaluation of the benefit of application modern, intelligent and self-communicating hardware and software components in production. To do so, a hybrid laboratory is established which combines the advantages of model factories (e.g. the visualization of different processes for improved acceptance) and computer simulation (e.g. highly flexible representation of various processes). As a result, various scenairos and processes can be configured, simulated, and analysed easily. The integration of real hardware components and the analysis of their application and behaviour is enabled, too.
Duration: n.a.
Coordinator: Prof. Dr. Norbert Gronau, University of Potsdam, norbert.gronau@wi.uni-potsdam.de
Website: http://lupo-projekt.de/

27. marion
Full title: Mobile autonomous, cooperative robots in complex value chains
Short description: The objective of this project is the robotisation of processes by means of autonomous vehicles while considering cooperation with executing machines. Core of the concept is the movement planning of mobile machines and machine groups, which is the basis for autonomous machine operation. The implementation takes place by means of intelligent assistance systems, which execute processes autonomously and support involved staff. The prototypical implementation is done within intra-logistic and agricultural applications.
Duration: 08/10 – 11/13
Coordinator: Dr. Max Reinecke, CLAAS GmbH, max.reinecke@claas.com
Website: http://www.projekt-marion.de/drupal/

28. RAN
Full title: RFID-based Automotive Network
Short description:. This project aims at efficient information exchange in automotive supply chains by means of standardised process and application of RFID technologies, contributing to a info broker concept for the overall automotive industry. The info broker enables the standardized exchange of process relevant real time data to control and optimize value chains in a decentralized network. Assisting systems compare planning and real data with each other and suggest actions in case of differences. This should also contribute to faster and more flexible reaction to changing markets, since standardized auto-ID-equipment and process modules reduce search efforts, failure consequential costs, production downtimes, inventories, and high-effort tracking in case of quality issues as well as lead times.
Duration: n.a.
Coordinator: Oliver Czech, DAIMLER AG, oliver.czech@daimler.com

29. rorarob
Full title: Welding task assistance for pipe and framework constructions by means of a robot system
Short description: The objective of this project is the development of a prototype of a hardware and software assistance system (multi-robot-system) for executing welding tasks in

pipe and framework construction. The main approach followed is man-machine collaboration in robotics while considering safety aspects.
Duration: 2009 – 2012
Coordinator: Prof. Dr. Gerd Grube, carat robotic innovation GmbH, gerd.grube@carat-robotic.de

30. SaLsA
    Full title: Secure autonomous logistic and transport vehicles
    Short description: In order to achieve seamless integration of the overall material flow and a high degree of automation, this project aims at the development of autonomous transport vehicles which move fast and safe also beyond production and warehouse buildings in environments, where also common human-controlled vehicles and pedestrian are moving.
    Duration: 2010 – 2013
    Coordinator: Dr. Sebastian Behling, Götting KG, info@salsa-autonomik.de
    Website: http://www.salsa-autonomik.de/

31. smartOR
    Full title: Innovative Communication and network architectures for the modular, adaptable, and integrable future operating room
    Short description: The objective of this project is to develop innovative network concepts for a modular, flexible integration of systems in operating rooms. Based on open standards and man-machine interaction, and considering effective risk management, the ability to implement integrated medical systems throughout different system providers shall be demonstrated. This especially concerns the modular integration of imaging, computer-based navigation, mechatronic instruments, and monitoring. Furthermore, the increase of usability and acceptance for modular systems is also a focus of this project.
    Duration: 2010 – 2013
    Coordinator: Prof. Dr. Klaus Radermacher, RWTH Aachen, radermacher@hia.rwth-aachen.de
    Website: http://www.smartor.de/

32. viEMA
    Full title: Integrated, information-based teaching and execution strategies for autonomous assembly processes
    Short description: The viEMA project develops a scalable, roboter and sensor based assembly concept: When starting ramp-up of production, assembly takes place at manual work places. When throughput is increasing, a flexible assembly cell is integrated there. To do so, only minor changes are necessary at the manual workplace, so that for decreasing throughputs, production can easily switched back to manual mode.
    Simple and appropriate programming of such flexible assembly cells is enabled by beans of teaching and execution strategies to be developed during the project. To do so, several issues have to be resolved: the robotic systems must be able to recongnise the products by themselves, grip them, and put them to another carrier or defined position. To do so, an object and skill database is implemented. It integrates object and scenario detection and modeling and abstraction of actions with modern methods for user interaction to enable ergonomic robot teach-in. Easy programming of assembly processes, also for untrained users, is an important result of this.

Duration: n.a.
Coordinator: Zhixing Xue**,** FZI Forschungszentrum Informatik, xue@fzi.de
Website: http://www.viema.org/index.php?content=intro

Further projects will be funded related to the call topics “virtual techniques” and “big data”. However, since the evaluation of these proposals is not finished yet, there is no reference available to respective projects.

I.1.2 UK research projects

The following projects have been identified to be funded on national level in the UK by the EPSRC (Engineering and Physical Sciences Research Council):

1. **Full title:** Simulation Tools for Automated and Robust Manufacturing
   Short description: The aim of this project is to use statistical methods to develop "green button" manufacturing processes: processes that can be run without a human operator, and can respond to unpredictable variations in the properties of the materials that are being machined. We will be focussing on "high value, low volume" manufacturing: manufacturing relatively small numbers of very expensive components, where it is costly to have to scrap a component because of a fault in the machining process. We will work on a case study: machining the landing gear of an aircraft, which we will use to develop methods that can be applied more generally. The first step will be to build a computer model of the machining process. Given the computer model, we can experiment with different parameters of the machining process such as the speed at which the metal is cut, and the path that the cutting tool takes through the metal. In theory, we could then search for the best choice of parameters, such that the component is machined in the shortest time and is least likely to be defective. However, the properties of the metal to be cut will vary from item to item, so what is best for one item may not be best for another. We can't measure all the relevant properties, so we need to first assess how much variability we are likely to see, and then find parameter settings that best able to handle this variability without producing faulty items. We can then use the simulation model to explore different strategies for modifying the process mid-production, in response to the cheaper sensor data, to avoid faults (eg "reduce the cutting speed by 10%" if a sensor reports vibration 5% above average"). It will be cheaper and faster to design the automated process using the simulation model, rather than conducting more expensive cutting tests. The end product will be a manufacturing process that can run efficiently without a human operator, making adjustments as the sensor data are observed, and will be configured in such a way so that it can deal with variability in the properties of the items to be machined. Our aim is to produce statistical methodology for configuring such a process, that can be applied in many different settings.
   Duration: 05/2013 – 04/2013.
   Coordinator: Dr. J. Oakley**,** University of Sheffield

2. KDCM
   Full title: Knowledge Driven Configurable Manufacturing
   Short description: The proposed research programme will attempt to create self-reconfiguring manufacturing systems that are based on intelligent and highly accurate models of manufacturing processes and the products being manufactured. The goal of the

research is to enable a radical change in manufacturing effectiveness and sustainability. The target type of manufacturing is component-based modular reconfigurable systems, i.e. systems that are built up of various elements and assembled together, in a similar fashion to building with 'lego'. This is a class of manufacturing system that is typically used in assembly and handling applications, where you tend to find families of modular machine components that can be reused and reconfigured as the product, and hence production processes change. Major applications for this are in the automotive and aerospace sectors. One example is in powertrain assembly, as seen in the UK at Ford. If the re-configurability of such production systems can be enhanced, Ford estimate that potential savings of over 30% in costs are achievable with a target of a 50% reduction in the time to build and commission such a system that typically costs �30 million per engine line. The realisation of this research has the potential to help enable the retention of high value engineering activity in the UK by improving the competiveness in the engineering of reconfigurable manufacturing systems. The capability to achieve this aim is to be built on the foundation of current, internationally leading research at Loughborough University, which has created a method for building reconfigurable systems from reusable components that is currently being adopted in automotive supply chains.

The concepts of flexible and reconfigurable manufacturing systems are well established; however problems still exist in the effective, efficient, rapid, configuration of such flexible systems, particularly as lifecycle product changes occur, whether such changes are minor or more fundamental. Many flexible and reconfigurable system examples exist. However, most are designed intuitively and a systematic methodology is still lacking. Additionally, engineering this integration of product and processes is essential in a lifecycle context across the supply-chain, yet this remains largely unaddressed.

Virtual engineering also has a major role to play in that we can simulate production systems and products. However the effectiveness of such simulation design tools for reconfigurable systems remains poor. Such tools need to be able to encompass the full system lifetime and be able to replicate the functions of the production system exactly in the models. These models are key enablers for understanding what might happen throughout a production system's lifecycle and can drive better configuration of the modular manufacturing systems we aspire to create.

Duration: 04/2013 – 03/2018

Coordinator: Prof. R. Harrison**,** University of Warwick

3. **Full title:** Transforming the adoption of Product Service Systems through innovations in applied gaming technology

   Short description: Servitization is the process of transforming manufacturers to compete through Product-Service Systems (PSS) rather than products alone. The commercial and environmental benefits of PSSs are compelling and well documented (Rolls-Royce earning over 50% of their revenue from services is cited to exhaustion). The opportunities are immense (three quarters of wealth world-wide is now created through performing services) and so politically PSSs are seen as key to industrial success in the 21st Century. Adoption of PSS is frustratingly slow in mainstream manufacturing. Superficially the concepts find appeal but fail to gain traction as the potential implications to a business are complex. In the meantime, China is catching up (Chinese manufacturing companies offering services have grown from 2 - 20% since 2006). In the UK, we need to get better at informing, educating and training, our senior manufacturing managers about PSS and servitization, giving them the means to visualize the potential impact upon their business.

Gamification offers a radical solution. Gamification bridges video-gaming technologies and computer simulations to offer three-dimensional virtual worlds, dynamic and content-rich, which can be used to entertain, educate and inform. This is especially innovative for user engagement, supporting behavior and attitudinal change, and the design of advanced human and computer interfaces for representing and handling complex data systems. This programme will therefore develop applied game technologies, design principles and protocols, to transform the adoption of PSSs within mainstream manufacturing companies and so accelerate the foothold of gamifiaction in strategic business analysis.

Duration: 02/2013 – 01/2018

Coordinator: Prof. K. Ridgway**,** University of Sheffield; Prof. T. Baines, Ashton University; Prof. S. de Freitas, Coventry University

4. AI2M

Full title: Integrated, information-based teaching and execution strategies for autonomous assembly processes

Short description: The AI2M research cluster will bring together leading researchers and practitioners in high value manufacturing, information science, ICT, mathematical sciences and manufacturing services to address the needs for future globally competitive ICT-supported manufacturing practices and infrastructures. The cluster also leverages two distinct supply chains, automotive and aerospace and defence with associated ICT and manufacturing service providers. UK manufacturing has to migrate towards supplying innovative, high quality, variable volume solutions to a global market. Low wage competition and reduced profit margins increase the difficulty of recovering the costs of early lifecycle phases (specification, design, analysis and setup) especially for lower volume products. "Right first time" production is a necessity to survive. In the automotive domain the relatively high volume market is crippled by increased complexity, quality and customer demands for variety. The high added-value, low volume defence and aerospace domains are also under pressure from: the spectrum of product and process complexity; the harsh manufacturing and operational environments and severe safety and legislative requirements. The future of UK manufacturing depends on supply chains being able to: remove defects generated throughout manufacturing; formalise and share product and process knowledge; optimise strategy based on resource utilisation, traceability and lifecycle performance monitoring and understand the implications of design features on manufacturing and operational performance as well as the impact of new materials, components and legislation (e.g. End of Life Vehicle) and the impact of the adoption of new technologies and business models. To pay dividends both in supply chain efficiencies, compliance and new business models, companies must capture and analyse a larger range of data, faster, at lower cost and manage it better than ever before.

The challenge of this project is therefore to develop an on-demand intelligent product lifecycle service system for increased yield for products and processes that can bridge the information gaps associated with inefficient supply chain integration and a lack of knowledge on product usage throughout lifecycles. Current commercial solutions are limited to "on-site" silos of information that are restricting UK manufacturing in terms of its ability to: optimise efficiency in materials, resource, energy utilisation; speed up innovation; improve the generation and exploitation of manufacturing intelligence; support supply chain collaboration throughout the product and process lifecycles, and enable new business models and technologies to be readily adopted (e.g. product service systems (PSS) supporting either product operation, usage or results oriented business models).

The key research challenges to be addressed by this cluster include: Service Foundations (dynamically reconfigurable architectures, data and process integration and sematic enhanced service discovery); Service Composition (composability analyses, dynamic and adaptive processes, quality of service compositions, business driven compositions); Service Management and Monitoring (self: -configuring, -adapting, -healing, -optimising and -protecting and Service Design and Development engineering of business services, versioning and adaptivity, governance across supply chains).

Duration: 02/2013 – 01/2018

Coordinator: Prof. A.A. West**,** Loughborough University

5. **Full title:** Cloud Manufacturing – towards resilient and scalable high value manufacturing

   Short description: UK economic prosperity will increasingly depend on maintaining and further expanding a resilient and sustainable manufacturing sector based on sophisticated technologies, relevant knowledge and skill bases, and manufacturing infrastructure that has the ability to produce a high variety of complex products faster, better and cheaper. In high labour cost economies, manufacturing competitiveness will depend on maximising the utilisation of all available resources, empowering human intelligence and creativity, and capturing and capitalising on available information and knowledge for the total product lifecycle from design, through production, use and maintenance to recycling. It will also require an infrastructure that can quickly respond to consumer and producer requirements and minimise energy, transport, materials and resource usage while maximising environmental sustainability, safety and economic competitiveness. Building on the latest developments in Informatics, Computer Science, Operations Research, and Manufacturing Systems Science, we will address these needs with a research programme centred on the concept of 'Cloud Manufacturing', which has been defined as ''a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable manufacturing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction''. The research will adopt the methods of cloud computing and crowdsourcing. The 'cloud' allows a range of data sources within design and manufacturing processes to be shared and mined to enable process optimisation and increase responsiveness; the crowds encompass manufacturing partners, designers, logistics partners, and consumers who are sources of potentially valuable data, information and product and process knowledge that can be elicited for optimising complex manufacturing environments. The approach admits new models for open innovation within the manufacturing space, enabling new enterprises to arise without a need for a large capital investment. The research programme is a radical departure from the current philosophy of manufacturing ICT - it will create a framework for participatory contribution of information from the actual manufacturing entities and support services to the consumers and users of

products. This transformational approach presents theoretical, technical, practical, ethical and social challenges that we will meet through new fundamental multidisciplinary research.
Whilst there have been some tentative steps taken to harness cloud concepts in manufacturing the theoretical methods, infrastructure and scientific knowledge needed to deliver the full potential of future cloud manufacturing have yet to be established. We aim to develop a holistic framework and understand its role within global manufacturing networks through: seeking the appropriate products, sectors, scales and volumes; identifying the impacted lifecycle stages from design to manufacture, maintenance and re-cycling; understanding how new product design and manufacturing will be influenced by lifecycle data; and finally analysing how future products will be influenced by cloud manufacturing enabling local on-demand supply of components and services. Cloud Manufacturing provides far reaching opportunities but has major research challenges including: understanding the diverse resource base, both in design collateral and production facilities; incorporating and integrating customer/user intelligence; and the representation and processing of information within a secure open service-oriented platform.
Duration: 02/2013 – 01/2018
Coordinator: Prof. S.M. Ratchev**,** University of Nottingham

6. **Full title:** Intelligent Decision Support and Control Technologies for Continuous Manufacturing of Pharmaceuticals and Fine Chemicals
Short description: Although continuous crystallisation provides significant benefits to innovative manufacture, the key challenge of real time, robust monitoring of quantitative attributes (form, shape, size) of particulate products still remains a massive challenge. While particle attributes are crucial for downstream processing of products, no current solution allows the processing of data from in-line sensors to reliably extract these attributes in real time across multiple manufacturing steps and the subsequent use of this knowledge for IDS and control of processes. The development of solutions for the sector requires expertise across many technologies driven by end user requirements. Industrial co-creators will provide the requirements, the range of expertise within the applicants ensuring that the goals of the programme are met. The grant will enable the establishment of a process test-bed which as the project matures, will be made available to a range of national and international user and application communities. This activity will support the creation of a requirement and technology roadmap, in so doing informing both the research and commercial communities on future opportunities. The project will also yield the following added value to the community:
- the cross-disciplinary nature of the project and participating teams will stimulate new solutions and promote creativity through sharing best practice in executing research from different perspectives
- the PDRAs will be applying their know-how to joint development tasks, allowing them to gain comprehensive knowledge and expertise across a range of field and in so doing provide trained, talented engineers that will fuel the deployment of these innovative solutions
- the project addresses the integration of a number of distinct architectural layers to transform a physical infrastructure into a flexible platform which supports a range of applications whilst accessible to users.
Duration: 02/2013 – 01/2018

Coordinator: Prof. I. Andonovic**,** University of Strathclyde

7. **Full title:** EPSRC Centre for Innovative Manufacturing in Intelligent Automation
   Short description: Manufacturing automation is an expanding field concerned with the delivery of high-value engineering technologies and services globally. The highest value areas of automation relate to the more difficult to automation applications, for example many occurring in aerospace and precision automotive applications. Industry sources estimate that in a typical aerospace manufacturing plant the costs associated with manual operations and the inspect-adjust-rework activity could cost millions of pounds across the UK. Automation in various forms has the potential to reduce this inefficiency but also has the potential to do great damage to quality if applied incorrectly. Whilst automation has been applied across many sectors of industry, the spectrum of applications has rarely pushed the boundaries of research. Safe and limited solutions are often the norm. The high value manufacturing industries have applied limited automation because of the highly skilled nature of the finishing, inspection and assembly work inherent in the manufacturing processes. These processes are difficult to automate because of minor variation in components that influence interaction between processing equipment and component being processed. In addition, parts are often made from expensive materials, with many parts requiring careful handling in a high added value state (e.g. fan blades). Whilst humans can accommodate variation at certain levels they often introduce variation by virtue of being human (e.g. through lack of concentration). These high value industries need an advanced kind of automation that delivers the precision of computer controlled machinery with the adaptability of a human operator, but with 24/7 capability and 100% quality performance and at reasonable cost and operational speed. When the variation in the product caused by variation in human performance has been removed by deployment of intelligent automated systems, it will be possible to gather better data about design for manufacture and feed this back into product development in a systematic manner. Intelligent Automation is a convergence of human-machine modelling, digital manufacturing, knowledge generation and learning with intelligent devices. The aim is to develop a generic process and product modelling and deployment capability that can radically impact on current limitations experienced within industries that rely on substantial input from human skill, expertise and adaptability. This EPSRC Centre for Innovative Manufacturing in Intelligent Automation will have a platform activity and two closely related and integrated research themes. The platform activity will emphasise 'Fast Track' projects for Early Win outcomes closely linked to the Tier 1 industrial partner expectations. Adventure projects will also be undertaken, aimed at more speculative high risk research. A small amount of Policy and Standards influencing work will be carried out. The first flagship research theme is: Modelling and Deployment for Right First Time Manufacturing, where extensive computer based modelling of intelligent automation systems will be undertaken to establish greater confidence during the design phase through to digital deployment and on to real deployment and operation. The second flagship theme is: Humans and Intelligent Automation Systems, where human skill is examined and how this influences difficult to automate industrial processes/tasks. The area of humans and robots sharing the same work space will also be investigated.
   Duration: 07/2011 – 06/2016
   Coordinator: Prof. M. Jackson**,** Loughborough University

8. **Full title:** Enhancing the Use of Radio-Frequency Identification Technology (RFID) to Optimise Operational Costs and System Efficiency in Outbound Logistics
Short description: In the literature, there are two groups of research contributing to the adoption of RFID. One is related to the technical aspects, such as enhanced security tags, increased tracking range, and authentication protocols. The other is associated with the applications, which provide greater contribution to potential adoption. This area of research explores RFID applications in manufacturing, inbound/outbound logistics, warehousing, and many more. However, a crucial aspect of research which is not currently being investigated is the exploration of extensive use of real-time RFID data to improve and add substantial values to the business operations, e.g. optimising distribution routes/network responding to dynamic changing environment. This area of research is vital as it will result in greater operational costs to be reduced and system efficiency to be enhanced, and leads to a more promising investment to achieving higher returns. This area of investigation forms the key aim of this proposal and contributes to the justification required for decisions for RFID adoption. The findings of the proposed research will also highlight to the RFID implementers that the technology is not merely for track and trace purposes, but is used as a way to achieve improved economic competitiveness. This research proposal is to investigate how distribution network in outbound logistics can be efficiently modelled, reconfigured, integrated, and optimised dynamically in response to changes in the market, the production and at any stage in the supply chain. To facilitate this research work, it is proposed to adopt the concept of multi-agent systems and intelligently integrate with RFID technology. The central part of this research is to develop a dynamic integrated agent-based control system to enable distribution routes to be dynamically modelled. In response to changes, alternative route configurations can be generated and evaluated by the optimisation strategy/methodology developed (i.e. operational level optimisation). In addition, a global level optimisation across the supply chain sectors will also take place simultaneously to ensure a smooth, efficient flow of operations in the supply chain. This will enhance the responsiveness of the supply chain operations coping with dynamic changes efficiently and cost-effectively. With the optimised distribution network it will help to reduce CO_2 emissions and as a result, promoting greener supply chain to support the UK government's Carbon Reduction Strategy for Transport (introduced in July 2009). Two industrial partners (Carton Edge and ATMS), the Centre of RF Applications and Testing at University of Hong Kong Science and Technology, and the RFID vendor IdentifyRFID, each with its expertise and interests in RFID, will support this research. These partners will play a significant role in this project, contributing to the project trials and output dissemination. They are able to provide resources to support the development and validate the methodology proposed. The end product of this research will then be used to assess the company's operations and they will receive a thorough assessment of the operational performance, as well as an evaluation of ways to maximise flexibility, agility, and efficiency of the operations to achieve economic competitiveness. The research will also identify how RFID-enabled operations can help them to add value to their customer services. ATMS, which develops RFID-enabled logistics software, has shown interests in exploiting the potential take-up of the end product of this research to a commercial exposure.
Duration: 11/2010 – 11/2012

Coordinator: Dr. M. Lim**,** University of Derby

9. **Full title:** Using the Grouping and Shrinkage Approaches to Forecasting Subaggregate Level Seasonal Demand

   Short description: Forecasts are needed at different levels. At the SKU level, short-term demand forecasts for each item are needed as a part of production and inventory systems. In most situations, demand is stochastic and that is when accurate demand forecasting is crucial. Forecasts and forecasting errors are used as inputs to various inventory control systems to either attain a target service-level at minimum cost or to minimise overall costs including components such as stock holding costs, stock out costs and transportation costs. These forecasts can also provide useful information for aggregate-level forecasting and planning, and impact marketing and financial plans of the organisations. Seasonality is a pertinent issue at the SKU level. Traditionally, seasonality is estimated from an item's own data history. This approach is not always satisfactory if the data is noisy and the length of data history is short. Two alternatives have been proposed in the literature: grouping and shrinkage. Previous research indicated that the grouping and shrinkage approaches are promising in terms of improving forecasting accuracy. In research conducted with John Boylan we developed theoretical rules to choose the best method from the individual approach and the grouping approach. However, a very important issue is yet to be addressed: how to put items into seasonally homogenous groups. Previous researchers either relied on company definition or statistical clustering. These methods are reasonable but are not optimal. Miller and Williams (2003) compared the individual approach with two shrinkage methods. They also established a set of rules to choose the best out of the three. We compared the two sets of rules empirically and found they were competitive to each other. A further step would be to combine the strengths of the two approaches to achieve more improvements. Although a very important research area, this is still generally under researched due to its complexity. This proposed research aims to narrow the gap by developing theoretically coherent and applicable rules to combine the individual, grouping and shrinkage approaches. The need for such a research project can be justified from both an academic and practitioner perspective. In this research, we aim to establish a grouping mechanism to divide series into seasonally homogeneous groups, develop a the ortical rule to compare the individual, grouping and shrinkage approaches together, and to analyse the implication of forecasting improvement on stock control. Our methodology is deductive in the sense that universally applicable rules are sought to be developed. However, due to the complex nature of the problem under investigation, the research strategy cannot be purely deductive. Established theory is to be applied to both theoretically generated and empirical data with the objective of identifying issues that will be subsequently incorporated and reflected back to the theory. This will go through several loops before the final conclusions/recommendations will be reached. In these respects, the research strategy can be best characterised as semi-deductive or a very well-framed simulation-intensive exploratory investigation. This research problem is complex by nature. However, a good theoretical understanding, linked with fully operational rules will have a significant academic contribution and commercial benefit. Two companies have agreed to collaborate on this project by providing data and relevant information. We expect to see such solutions improve forecasting accuracy. We also strive to examine the implications on inventory control

policies, as in reality forecasting and inventory control are well interacted. Therefore, for both forecasting and inventory control purposes, this is a timely and novel project.
Duration: 07/2009 – 07/2012
Coordinator: Prof. A. Syntetos, University of Salford

10. **Full title:** Information Quality for Asset Management
Short description: the current economic scenario, organisations in the UK and around the world are under increasing pressure to reduce costs, meet tougher performance and production targets, comply with regulatory requirements, and maximize return on assets. Therefore, these organisations are looking for opportunities to reduce the cost of maintaining their assets, improve the performance of those assets through improved decision making, and gain competitive advantage. It is widely acknowledged that decisions made are only as good as the information available at hand to make those decisions. Consequently, it becomes imperative to these manufacturers to gather useful information about their assets throughout their lifecycle for efficient management and control. The overall vision for the research proposed here is to help UK industries maximize value generation from their assets through effective management of information quality and decision-making. There is a need for a comprehensive framework for quantitative assessment of information quality in the context of asset lifecycle decisions. The following research questions define the research directions for this project. 1. What information quality dimensions are critical for managing and improving asset performance and how can they be measured?2. How can we maximize asset performance by optimizing decision strategies during the asset lifecycle? The objective of the project is to develop quantitative measures for information quality in the context of asset management decisions and to develop methodologies to optimize information quality and decision strategies throughout the asset lifecycle. The novelty in the decision optimisation problem considered here is that the aim is not to simply optimize immediate decisions, but will consider the impact of one decision on subsequent decisions and hence the complete lifecycle of the asset, thereby minimizing total cost of ownership of the asset to its user. In addition, this project addresses a key gap in current body of knowledge - optimisation of IQ. Here we aim to examine the cost implications of improving various IQ dimensions, and optimise IQ with an objective to support optimal decision-making and hence asset performance. Issues such as possible trade-offs that may exist between the different IQ dimensions will also be examined in this task. In addition, an information quality audit tool will be built based on a robust theoretical model for use by industry to assess the information quality performance of asset management systems. The research will benefit industry practitioners, especially those who manage complex industrial assets through the development of performance measurement and improvement tools. In addition, it will help technology providers to define next generation asset management solutions that optimize asset performance. To address this challenge, this proposal defines a three-year programme aimed at the development of tools and methodologies to assess asset information systems and to optimize asset lifecycle decisions. The research activities are grouped into four Work Packages:WP1 - Modelling Asset Lifecycle Management DecisionsWP2 - Information Quality Assessment WP3 - Asset Performance OptimizationWP4 - Industrial PracticeThe first three Work Packages represent the research activities and the fourth work package groups together the industrial activities

within the project. WP1 and WP2 build the foundation for this research by developing models and tools for asset lifecycle decisions and assessment of IQ dimensions. WP3 forms the core development activity in this programme, where we develop optimization tools for asset performance as well as IQ. Finally, WP4 consolidates the activities related to industrial interaction within the project.
Duration: 04/2009 – 09/2012
Coordinator: Dr. A. Parlikad, University of Cambridge

11. **Full title:** Prototyping Open Innovation Models for ICT-Enabled Manufacturing in Food and Packaging
Short description: The aim of the Prototyping Open Innovation Models cluster is to design and develop a new crowd sourced food and package design and innovation platform comprised of a suite of ICT tools for state-of-the-art manufacturing processes and implementing "customers in the loop" co-creation product development processes. The platform and the tools will enable (i) Harvesting content from the crowd and lead users, (ii) Synthesising content into an actionable format, and (iii) Integrating design and production systems. The idea for the platform is inspired by behaviours that are emerging on social media sites that see participants congregate around a current issue (citizen journalism - Arab Spring), ICT problems (user fora), leisure activities (maker/hacker communities - Ikea Hacker, Hackerspaces, food hacking), knowledge (Wikipedia), citizen science (Nasa's Stardust@home), and create and share content around such aspects. We are in an age of participation, where consumers no longer need to be on the periphery of development. Companies are increasingly finding that ideas and innovations originate from outside their organisations. 'Crowd-sourcing' is gathering pace, as companies seek to tap into the global knowledge base through their 'open innovation' strategies. Brands need to develop new relationships with Prosumers in which they may become a substantial part of the design and development process. We propose to apply this model of behaviour to explore opportunities for open innovation whereby a disparate group of individuals congregate around food and packaging design and production (two of the largest industry sectors in the UK). Packaging is not only a container, but it is one of the means of communication of the product that will make it recognized and remembered.
Duration: n.a.
Coordinator: Dr. S. Baurley, Brunel University

12. **Full title:** The Language of Collaborative Manufacturing
Short description: Today's machines and products are so advanced in terms of their materials, form, construction, control and drive systems that they require expertise and resource that extends beyond the reach of even the world's largest organisations. As a consequence, the design, development and manufacture of, for example, a modern aircraft is undertaken by a large globally distributed network of organisations. While defining this network poses a design problem by itself, it is the challenge of managing such large, highly distributed, high value projects that is of upmost concern to industry presently. This is not only because of the recent spate of high profile cost overruns, delivery setbacks and collapsed projects, but also because of aspects of leakage of intellectual property, exposure to risk, and difficulties capturing design records, lessons learned, decisions and rationale.

Engineering projects of the sort previously described are critically dependent upon two key toolsets. These are electronic communication tools (e.g. email) and digital objects (reports, CAD models and simulations). These communication tools and digital objects are fundamentally related. Engineers around the globe communicate electronically in order to create and evolve digital objects which are the basis for the design, manufacture, assembly, delivery and maintenance of products and machines. It is this relationship and co-evolution of communication and digital objects that lies at the heart of every engineering project, embodying not only the engineering work itself but also control of intellectual property, decision making, rationale and problem solving. For these reasons, it is proposed that, through an understanding of the relationship and co-evolution of communication and digital objects, it is possible to improve the management, control and performance of engineering projects. The vision of this research will be realised through a suite of ICT tools that embody new methods and approaches for capturing and analysing the content and evolution of engineering communication and digital objects, and new methods and approaches for generating, representing, interacting with, and interpreting what are defined as signatures of in communications and digital objects. The term signature is used to represent a meaningful relationship between one or more dimensions of communication and/or digital objects at a point in time or over a period of time. The research programme firstly considers the two dimensions of communication and digital objects. The aim here is to characterise what are referred to as the "language of collaborative manufacturing" (content of communication) and "patterns of evolution of digital objects" (construction and changes to digital objects) and to explore means of classifying content and structure, and means of generating signatures.
Duration: n.a.
Coordinator: Prof. B.J. Hicks, University of Bath

I.1.3 Italy

The following projects funded by the Italian government have been identified to be relevant for concepts related to ICT architectures and services for manufacturing:

1. LOGIN
   Full title: Logistica integrata (Integrated Logistics)
   Short description: Development of a system for management of physical and data flows through the whole production process, from raw material acquisition, to delivery to the customer. The solution is specifically focused for SME and micro-enterprises.
   Expected results and benefits: to improve cooperation among producers and logistic suppliers; creation of an HUB for the management of the solutions supporting the integrated logistics
   Programme: Industria 2015
   Duration: finished in 2013
   Coordinator: DAISY-Net

2. NUVOLARES
   Short description: Implementation of digital processes for distribution of products from a network of SMEsin the Food sectors, using a Cloud Computing platform. Such Platform is maintained and operated by a consortium of Italian Universities based on Regione Puglia.

Programme: POR 2007/ 2013
Duration: 2011-2013
Coordinator: ARES consortium

3. IMPULSO

   Short description: IMPULSE project aims to realize a system for the management and control of transport and logistics of goods at different geographic levels: medium/long range and metropolitan areas. Info solution deals with the development of an Automatic Guided Vehicle (AGV), for the automation of unloading/loading operations and storage facilities of goods by means of transport. IMPULSO project aims to develop new technologies and capabilities aimed at improving operational management and transport of goods, starting from the characteristics of "cooperation" and "open standards", also guarantee of the highest levels of security.

   The system is based on the presence of specific pivot areas:

   > Freight Villages: joint areas of goods between the long and middle range. Usually they are either a termination point or the initial phase of the transport.

   > Metropolitan Distribution Centers (CDM), preferably located on the edge of the metropolitan area.

   > District Buffer (DB), or temporary goods storage areas located in urban districts.

   Programma: Industria 2015
   Duration: 2010-2013
   Coordinator: Vitrociset s.r.l.

4. TINAPICA

   Full Title: Turning Information iNto Action, Production, Installation, maintenanCe and Assembly
   Short description: Ideation, development and evaluation of an integrated platform for the optimisation of production, assembling and maintenance cycle of products.
   Programme: Industria 2015 –Made in Italy
   Duration: 2010-2013
   Coordinator: ItalSystem s.r.l.

5. WFR

   Full Title: The Web Fitting Room
   Short Description: The project has developed a a web based system (called eFitRoom) that enable communication among the final customer and the fashion company that use such information to optimize the production process and the delivery of the customized item.The (physical) Fitting room is equipped with sensors and device to collect and dispatch to the web the consumer's measures. Within the shop, the consumer can see the virtual fashion collection, based on his measures and other preferences, visualised on an avatar. Personlaised orders are collected and information about prices and expected delivery time are returned to the client. The collected information are than used to optimise the ad-hoc supply chain. Finally, datamining solutions elaborate data from all the customers to support the strategic choices of the fashion firm.

Coordinator: ASM s.r.l.
Programme: Industria 2015 – Made in Italy

6. MI FIDO
Full Title: Made-in-Italy Fashion IDentity and Originality
Short Description: MI-FIDO provides solution to prevent forgery of "Made in Italy" products. The solution consists of two main components:
   - A labelling system based on the use of RFID to guarantee protection against any forgery action of the products equipped with this technology
   - A system for the analysis of the information concerning movements of products, to ensure the detection of any anomalous case and to reinforce security along the Supply Chain.

   Programme: Industria 2015
   Duration: 2011-2013
   Coordinator: Present s,p,a,

I.1.4 Portugal

The following Portuguese projects have been identified to be relevant for concepts related to ICT architectures and services for manufacturing:

1. NODES
Full title: Network engineering systems in uncertainty contexts
Short description: Development of a tool for optimal strategic network planning of an energy network under uncertainty; integration of the planning tool with a distributed decision support tool for the energy network.
Duration: finished in 2010
Coordinator: n.a.

7. Cogninet
Full title: Cognitive Semantics in Collaborative Networks
Short description: Web based platform for conceptual models development by group editing, discussion and negotiation. It enables teams including domain specialists, knowledge engineers and terminologists, to build together a conceptual representation of a domain.
Duration: finished
Coordinator: n.a.
Website: www.conceptME.pt

8. REMobi
Full title: Network of Excellence for Mobility
Short description: n.a.
Duration: finished in 2011
Coordinator: n.a.

9. CUMULONIMBO
Full title: A Highly Scalable Transactional Multi-Tier Platform as a Service

Short description: CumuloNimbo aims at developing a radically new Platform as a Service that will provide high scalability (100+ service nodes) without sacrificing data consistency and ease of programming.
Duration: n.a.
Coordinator: Marta Patiño-Martinez, Universidad Politécnica de Madrid, mpatino@fi.upm.es

I.2 European projects

I.2.1 Projects from the Factories-of-the-Future PPP

Since the FoF (Factories of the Future) initiative from the EC and EFFRA focuses on both, ICT and manufacturing, the respective EFFRA-Database has been searched for projects to be considered during this analysis.

1. 3D-HIPMAS
   Full title: Pilot Factory for 3D High Precision MID Assemblies
   Short description: 3D-HiPMAS will overcome these challenges by providing the EU industry with a pilot factory based on 4 key technological building blocks enabling the manufacturing of low costs and high precision 3D multi-materials parts: 3D high precision plastics micro-parts, 3D high definition conductive tracks, 3D precision electronics components assembly, 3D reliable and robust online monitoring and quality inspection system. These four technologies will be integrated in order to launch the future EU pilot factory.
   Duration: 10/2012 – 09/2015
   Coordinator: Clemens Pecha, Hahn-Schickard-Gesellschaft für angewandte Forschung e.V., clemens.pecha@hsg-imit.de
2. ADDFACTOR
   Full title: ADvanced Digital technologies and virtual engineering for mini-Factories
   Short description: ADDFactor achievements will be focused on two different levels of manufacturing solutions, which will be placed:
   At retail environment, to consider products simple and/or reduced in terms of assembled components (i.e. orthotics or modular fashion heels and plateau); And at district level when the products are complex and the manufacturing procedures cannot be scaled at local level (i.e. sport shoes or complete customized fashion shoes). Within this overall project concept, ADDFactor will structure its activities towards the achievement of different objectives, from diagnostic devices to advanced design tools in order to convert personal data in individual product specifications. The manufacturing is then guaranteed by a local manufacturing through novel ultra-fast and auto-configurable machines.
   Duration: 09/2013 – 08/2016
   Coordinator: Synesis Consozio con Attivita Esterna, info@addfactor.eu
3. ADVENTURE
   Full title: ADaptive Virtual ENterprise ManufacTURing Environment
   Short description: In order to cope with the demand for flexibility and fast-paced business innovation, there is a need for an integrated, yet framework, environment which is able to establish, manage, monitor, and adapt virtual factories. This needs to be based on the requirements of the manufacturing processes at a deep technical level to provide easy, flexible interoperability with minimal user skills especially to support SMEs. ADVENTURE will deliver this platform and the accompanying tools by providing a holistic environment for plug-and-play virtual factories based on cross-organisational manufacturing processes.
   Duration: 09/2011 – 08/2014
   Coordinator: TU Darmstadt, contact@fp7-adventure.eu
4. AIMACS

Full title: Advanced Intelligent Machine Adaptive Control System
Short description: The added value of AIMACS is that this project will concentrate on generating new methods for efficiency improvements during the use phase, rather than the design phase, increasing the efficiency of existing machines and reducing the need for machines to be replaced, in turn reducing waste.
Duration: 08/2010 – 07/2013
Coordinator: Dr. Peter Pruschek, DMG Electronics, Peter.Pruschek@Gildemeister.com

5. AMEPLM
Full title: Advanced Platform for Manufacturing Engineering and Product Lifecycle Management
Short description: The objectives of the project are to engineer an ontology that serves as an interoperable model and integrating element for an open engineering system: the amePLM Platform. Also, to develop an open engineering platform based on existing tools and libraries, by special consideration of open-source software. The research and development of tools to assist in product and process development, analysis, virtual testing and optimization based on heuristic methods and simulation that operate on knowledge represented by information which is structured by means of an ontology is another objective as well as to devise a visualization module to enable cross-disciplinary collaboration and remote consultation approaches.
Duration: 10/2011 – 09/2014
Coordinator: Fraunhofer-Gesellschaft – Institute for Industrial Engineering

6. APPS4AME
Full title: Engineering Apps for advanced Manufacturing Engineering
Short description: Apps4aME aims at the comprehensive consideration of ICT-based support of Manufacturing Engineering in all the above mentioned domains, called advanced Manufacturing Engineering (aME). The different life cycles will be aligned by the development of a reference model that provides a detailed overview of all relevant domain specific and inter-domain interdependencies. This life cycle-oriented model enables an integrated product design, process development, factory planning as well as production planning and factory operation. All stakeholders in these activities will be supported by Engineering Apps (eApps) that will be conceived, developed and validated with two industry-driven scenarios, implemented in three demonstrators: automotive, machining and food industry.
Duration: 12/2012 – 11/2015
Coordinator: Fraunhofer IPA, Johannes Volkmann, Johannes.volkmann@ipa.fraunhofer.de+

7. ARUM
Full title: Adaptive Production Management
Short description: The aim is to develop mitigation strategies to respond faster to unexpected events. Therefore the knowledge base has to be enriched for real-time decision support, to detect early warning and to accelerate learning. Our approach is based on a new generation of service orientated enterprise information platforms, a service orientated bus integrating service-based architecture and knowledge-based multi-agent systems (MAS). A holonic MAS combined with a service architecture will improve performance and scalability

beyond the state of the art. The solution integrates multiple layers of sensors, legacy systems and agent-based tools for beneficial services like learning, quality, risk and cost management. Additionally the ecological footprints will be reduced. The ARUM solution will run in two modes: predictive and real time simulation. The predictive mode supports the planning phase whereas the real-time operations mode supports dynamic, time-, cost- and risk-oriented re-planning of operations.
Duration: 09/2012 – 09/2015
Coordinator: Arnd Schirrmann, EADS Deutschland GmbH, Innovation Works (EADS), coordinator@arum-project.eu

8. BIVEE
   Full title: Business Innovation and Virtual Enterprise Environment
   Short description: The BIVEE project aims to develop a rich framework, i.e., a software environment that includes business principles, models, and best practices, to promote innovation in VE environments. The work plan of BIVEE emphasizes impact achievement. To this end it has been based on two different trial applications (in furniture and in high-tech equipments) with both organised into two major trial phases: phase one for monitoring the course of production before the introduction of BIVEE environment and phase two where the VE achievements are assessed as having the BIVEE environment in place.
   Duration: 09/2012 – 09/2015
   Coordinator: Massimo Canducci, Engineering Ingegneria informatica, massimo.canducci@eng.it

9. CAPP-4-SMES
   Full title: Collaborative and Adaptive Process Planning for Sustainable Manufacturing Environments
   Short description: The CAPP-4-SMEs project is aimed at enhancing the competitiveness of European companies, particularly SMEs, in sustainable manufacturing environment by collaborative and adaptive process planning against changes, knowledge-based and integrated process simulation towards first-time-right processes, event-driven function blocks for on-board adaptive process control, machine availability monitoring for real-time job routing and a Cloud-based services platform for cost-effective and easy access over the Internet.
   Duration: 12/2012 – 11/2015
   Coordinator: Prof. Lihui Wang, Department of Industrial Production, KTH, Royal Institute of Technology

10. CLOUDFLOW
    Full title: Computational Cloud Services and Workflows for Agile Engineering
    Short description: The aim of CloudFlow is to enable engineers to access services on the Cloud spanning domains such as CAD, CAM, CAE (CFD), Systems and PLM, and combining them to integrated workflows leveraging HPC resources. CloudFlow will build on existing standards and components to facilitate an as-vendor-independent-as-possible Cloud engineering workflows platform. Open Cloud Computing Interface (OCCI), STEP (for CAD and CAE data) and WSDL (for service description and orchestration) are amongst the core standards that will be leveraged. The key aspects (from a technical and a business

perspective) are: Data, Services, Workflows, Users and Business models including Security aspects. CloudFlow will conduct two Open Calls for external experiments investigating the use of the CloudFlow infrastructure in new and innovative ways, outreaching into the engineering and manufacturing community and engaging external partners. Each of these two Open Calls will look for seven additional experiments to gather experience with engineering Cloud uses and gaining insights from these experiments.
Duration: 07/2013 – 12/2016
Coordinator: Prof.Dr. André Stork, Fraunhofer, info@eu-cloudflow.eu

11. CLOUDSME
Full title: Cloud based Simulation platform for Manufacturing and Engineering
Short description: The CloudSME project will develop a cloud-based, one-stop-shop solution that will significantly lower these barriers, provide a scalable platform for small or larger scale simulations, and enable the wider take-up of simulation technologies in manufacturing and engineering SME's.
The CloudSME Simulation Platform will support end user SME's to utilise customised simulation applications in the form of Software-as-a-Service (SaaS) based provision. Moreover, simulation software service providers and consulting companies will have access to a Platform-as-a-Service (PaaS) solution that enables them to quickly assemble custom simulation solutions in the cloud for their clients. The CloudSME Simulation Platform will be built on existing and proven technologies provided by the project partners and partially developed in previous European projects.
Duration: 07/2013 – 12/2015
Coordinator: Dr. Tamas Kiss, University of Westminster, T.Kiss@westminster.ac.uk

12. COMVANTAGE
Full title: Collaborative Manufacturing Network for Competitive Advantage
Short description: A continuous evaluation of the ICT and business model considering use cases throughout the project will verify the added-value of ComVantage for European industry. The utilisation of existing technologies, a close user approach, and an incremental project set-up will provide sound concepts ready for fast production.
Thus implementing ComVantage will increase lean communication, agile and highly efficient production processes, cost control and a low carbon footprint.
Duration: 09/2011 – 08/2014
Coordinator: SAP AG, dissemination@comvantage.eu

13. CORENET
Full title: Customer-oriented and eco-friendly networks for healthy fashionable goods
Short description: The most important elements of the project are a reference model, which enables sustainable and collaborative supply networks to address, orient and coordinate organisational, technological and knowledge management issues; web virtualisation systems which enable the production of healthy clothes and shoes to take place within design environments which are both collaborative and productive; the support for quick set-up of ad-hoc production networks for small lots or single items production including the use of sustainability benchmarks; innovations in production processes related to customisation via

the adoption of rapid manufacturing technologies for optimised digital printing and laser engraving.
Duration: 06/2010 – 05/2013
Coordinator: TXT e-solutions SPA, http://www.corenet-project.eu/contact

14. CTC
Full title: Local flexible manufacturing of green personalized furniture Close To the Customer in time, space and cost
Short description: The CTC project aims to support European Industry to adapt to global competitive pressures by developing methods and innovative enabling technologies towards local flexible manufacturing of green personalized products close to the customer in terms of features offered, place of fabrication, time to deliver, and cost.
Duration: 06/2013 – 05/2016
Coordinator: SCM GROUP SPA, scmgroup@scmgroup.com

15. CUSTOMPACKER
Full title: Highly Customizable and Flexible Packaging Station for mid- to upper sized Electronic Consumer Goods using Industrial Robots
Short description: This project aims to develop a scalable and flexible packaging tool to aid human workers in packaging a range of goods. The idea is to automate the packaging process so that several production lines of various consumer goods, mostly heavy goods such as TVs, can be amalgamated into one packaging line. To achieve these goals, CustomPacker will bring together the skills of human workers with the precision and dexterity afforded by robots. The final goal is to achieve one setup which is able to package a high variety of products and components using a programmable system architecture. Notably, the system will include an innovative feature to recognise the worker's intentions, namely if it realises that the worker is due to walk over to it, eventually it will be able, for example, to hand over a tool to him/her, thus streamlining the production process even further.
Duration: 07/2010 – 06/2013
Coordinator: Prof. Dr.-Ing. Frank Wallhoff, TU München, wallhoff@tum.de

16. E-CUSTOM
Full title: A Web-based Collaboration System for Mass Customization
Short description: The e-CUSTOM project aims to overcome the challenges faced by European manufacturers by developing innovative approaches, making possible to prepare unique product designs, manufacture these products and communicate them on a mass basis. The innovative approach of e-CUSTOM supports the higher alignment of production with customer demand, while shortening design time for personalised products by up to 15%.
Duration: 06/2010 – 05/2013
Coordinator: University of Patras

17. EASE-R3
    Full title: Integrated framework for a cost-effective and ease of Repair, Renovation and Re-use of machine tools within modern factory
    Short description: The EASE-R3 project aims at developing a novel Integrated framework for a cost-effective and easy Repair, Renovation and Re-use of machine tools within modern Factory (machining shop floor), oriented both to SME and large OEM/end-users, and covering the entire life cycle of the system (from design stage throughout operative life).
    Duration: 07/2013 – 06/2016
    Coordinator: Fidia SPA, info-pd@fidia.it

18. ECHORD
    Full title: European Clearing House for Open Robotics Development
    Short description: In the context of ECHORD, small-scale projects, so-called "experiments" are conducted. After the third and final call was closed, ECHORD now consists of more than 80 experimenting partners who will carry out more than 50 experiments. Via these experiments, ECHORD will bring about a large-scale introduction of robotic equipment into European research institutions. This is expected to result in both tangible and measurable outcomes in terms of the accelerated development of technologies, as well as the deployment of robotics technology into new scenarios for the direct application of research results.
    Duration: 01/2009 – 09/2013
    Coordinator: TU München, Department of Informatics VI, echord@in.tum.de

19. ENEPLAN
    Full title: ENergy Efficient Process pLAnning system
    Short description: In the proposed project the main object is the development of manufacturing systems that will be highly flexible, and, at the same time, closely adapted to the single product. These manufacturing systems need for an engineering tool able to cover the whole plant operation, from the overall planning of the plant operation (such as the routes that the product follow within the plant and the scheduling of the production) down to the individual process programming (such as process operation, energy efficiency etc).
    Duration: 10/2011 – 10/2014
    Coordinator: Prima Industrie SPA, http://www.primaindustrie.com/en/contact-us/contact-form/

20. EPES
    Full title: Eco-Process Engineering System for Composition of Services to optimize product life-cycle
    Short description: The project will develop a novel 'eco-process engineering system' (EPES) which will be composed of a comprehensive platform enabling a dynamic composition of services adaptable to the different products and operating conditions, supporting Product Service System. It will consist of a set of ICT tools aimed to: An easy configuration/adaptation of new services; storing, reusing the knowledge gathered in order to improve the services and develop new ones with the objectives of continuous improvement of products in operation along its life cycle and applying up-to-date technologies for the end of life disposal of the products; the same in order to improve future product designs.
    Duration: 09/2011 – 08/2014

Coordinator: Fundacion tecnalia Research & Innovation, http://www.epes-project.eu/en/contact/

21. EUROC
    Full title: European Robotics Challenge
    Short description: The project aims at sharpening the focus of European manufacturing through a number of application experiments, while adopting an innovative approach which ensures comparative performance evaluation.
    Each challenge is launched via an open call and is structured in 3 stages
    Duration: 01/2014 – 12/2017
    Coordinator: Prof. Bruno Siciliano, UNINA, siciliano@unina.it

22. EXTREMEFACTORIES
    Full title: On-the-cloud environment implementing agile management methods for enabling the set-up, monitoring and follow-up of business innovation processes in industrial SMEs.
    Short description: The project proposes the conception of a collaborative internet-based platform with semantic capabilities (by means of ontology modelling) that implements a new methodology for the adoption of a systematic innovation process in globally acting networked SMEs.
    The platform will be built upon a service-oriented architecture, implementing semantic functionalities. This platform will provide SMEs with services to support them in any step of the innovation life-cycle: problem detection, inception of ideas, and prioritisation of ideas, implementation and follow-up.
    Duration: 09/2011 – 02/2014
    Coordinator: Innopole SL, info@extremefactories.eu

23. FACTORY-ECOMATION
    Full title: Factory ECO-friendly and energy efficient technologies and adaptive autoMATION solutions
    Short description: The Factory-ECOMATION project will enable European manufacturing industries to overachieve Europe 2020 program targets developing breakthrough innovations for cost-effective, highly productive, energy-efficient and near-zero-emissions production systems, by means of: the definition of a holistic perspective of the economically and ecologically oriented production environment; the development of a comprehensive sensing, monitoring and data evaluation system which could grant access to an organic view of all the materials, energy, wastes and emissions flows within the factory; the extension and development of new technologies to increase energy efficiency by reducing its consumption at machinery and production level, and by recovering it whenever wasted; the development of advanced emissions abatement technologies; the introduction of a new adaptive management and automation platform to optimize production taking into account not only productivity targets but also eco and energy-oriented ones.
    Duration: 10/2012 – 09/2015
    Coordinator: SUPSI, http://www.semanticweb.it/factory-ecomation/contact-us/

24. FLEXINET
    Full title: Intelligent Systems Configuration Services for Flexible Dynamic Global Production Networks

Short description: This project aims to provide services that support the design and provision of flexible interoperable networks of production systems that can rapidly and accurately be re-configured. The metaphor employed is 'to start with an new business idea in the morning and have all required data and networks understood by the afternoon'.
To achieve this FLEXINET takes the view that new product-service global production network modelling methods and models are needed that can model business cases and identify the critical network relations and knowledge that underlies the business operation.
Duration: 07/2013 – 06/2016
Coordinator: Bob Young, Loughborough University, R.I.Young@lboro.ac.uk

25. FOFDATION
Full title: The Foundation for the Smart Factory of the Future
Short description: FoFdation will establish a universal manufacturing information system based on a "data integration" standard such as STEP and its EXPRESS language, which allows individual entities and their associated devices to share data in a common format. This foundation will then allow the Smart Factory architecture to be implemented based on a high bandwidth 'manufacturing information pipeline' for data interoperability.
Duration: 06/2010 – 05/2014
Coordinator: Airbus Operations SAS, info@fofdation-project.eu

26. GLONET
Full title: Glocal enterprise network focusing on customer-centric collaboration
Short description: This project aims to develop a novel way to commonly represent/provide information and knowledge (e.g. catalogue of products, brochures, process descriptions, best practices, company profiles, etc.) which needs to be shared/exchanged among different stakeholders in the collaborative environment as dynamic software services that may upgrade in time; generate user-customized interfaces which dynamically adjust to different stakeholders, supporting their access and visualization needs; provide these services through the cloud, to be available to anybody, at any time, from anywhere.
Duration: 09/2011 – 08/2014
Coordinator: Spiros Alexakis, CAS Software AG

27. HEPHESTOS
Full title: Hard Material Small-Batch Industrial Machining Robot
Short description: Hephestos will develop a paradigm that shall provide standard industrial robots with break-through techniques in production planning, programming and real-time control system. Based on established computer-aided-manufacturing frameworks, Hephestos will optimize production planning through the automatic generation of robotic program, taking into account specific robot signature i.e. robot system kinematic and dynamic characteristics, as well as models of processes (milling, grinding, polishing etc.), that are essential for the robotic application in hard material machining.
Duration: 09/2012 – 10/2015
Coordinator: Gerhard Schreck, Fraunhofer IPK, gerhard.schreck@ipk.fraunhofer.de

28. I-RAMP[3]
Full title: Intelligent Reconfigurable Machines for Smart Plug&Produce Production

Short description: The project aims at creating innovative solutions in order to improve the competitiveness for this industry sector. This goal will be reached by a new concept for fast and optimized ramp-up and operation of production lines with heterogeneous devices. By this, significant reduction of time and efforts during the setup and re-configuration of production will be reached. At the same time, production costs will be reduced by increasing the efficiency of manu-facturing.
Duration: 10/2012 – 09/2015
Coordinator: Harms & Wende GmbH & Co KG, info@harms-wende.de

29. IMAGINE
Full title: Innovative End-to-end Management of Dynamic Manufacturing Networks
Short description: The project will implement a novel comprehensive methodology for the management of dynamic manufacturing networks. This provides a consolidated and coordinated view of information from various manufacturing sources and systems, enables service-enhanced product, production lifecycle and responsive manufacturing processes throughout the value chain. The implementation, testing, evaluation and dissemination of the IMAGINE methodology and supporting ICT platform will be driven by 'Living Labs' in major industrial sectors.
Duration: 09/2011 – 08/2014
Coordinator: Intrasoft International SA, contact@intrasoft-intl.com

30. IMAIN
Full title: A Novel Decision Support System for Intelligent Maintenance
Short description: As for maximizing project impact, iMain project is strongly committed to deployment issues, including innovation and implementation actions focused on value chains and bridging the gap from research to market. To that end, iMain emphasizes on the commercialization of results, taking also into account the needs of post-project monitoring of commercialization, which will be conducted after the end of the project in order to assess the achievement of the requested funding and for promoting the project as an effective innovation mechanism.
Duration: 09/2012 – 08/2015
Coordinator: Fraunhofer IWU

31. INTEFIX
Full title: INTElligent FIXtures for the manufacturing of low rigidity components
Short description: INTEFIX aims to increase the performance of the machining processes by the use of intelligent fixture systems, allowing the monitoring, control and adaptation of the process to obtain suitable results according to precision, quality and cost requirements. The main outcome of INTEFIX project will be the integration of new and state of the art technologies (sensors, actuators, control algorithms, simulation tools...) applied to the workpiece handling systems to develop intelligent and modular fixtures capable of modify the behaviour and interactions between the process and systems in machining operations; reducing time and costs with improved performance and capabilities.
Duration: 07/2013 – 06/2016
Coordinator: Oscar Gonzalo, Polo Tecnológico de Eibar, oscar.gonzalo@tekniker.es

32. KAP

Full title: Knowledge, Awareness and Prediction of Man, Machine, Material and Method in Manufacturing

Short description: KAP stands for knowledge of past performance and awareness of the present state, enabling the prediction of future outcomes. By creating transparency through the usage of data generated on the shop floor, every existing resource can be used as efficiently as possible. This guarantees the effective coordination of man, machine, material, and method. In order to achieve this, the KAP research project will focus on production performance indicator definitions, including aspects of sustainability and energy-efficiency. Techniques such as complex event processing and data stream analysis will compute these indicators on-the-fly to provide effective real-time monitoring. Data mining in combination with OLAP can support problems with diagnosis and resolution. Perceptually efficient visualisations will communicate the production performance indicators to decision-makers in a format which can help reduce cognitive workload and effectively aid improvments of situational awareness.

Duration: 09/2010 – 12/2013

Coordinator: SAP AG

33. KNOW4CAR

    Full title: An Internet-based Collaborative Platform for Managing Manufacturing Knowledge

    Short description: The Know4Car project will attempt to make knowledge management and collaboration more effective throughout the product lifecycle, supporting the capture and the systematic organization of knowledge in the form of manufacturing templates. Furthermore, Know4Car will develop faster, easier, error-free user-interfaces for data entry/checking in the shop floor along with serious games options for instantaneous knowledge retrieval, training and/or design purposes.

    Duration: 09/2011 – 08/2015

    Coordinator: http://www.know4car.eu/

34. LINKEDDESIGN

    Full title: Linked Knowledge in Manufacturing, Engineering and Design for Next-Generation Production

    Short description: The LinkedDesign project aims for user-centric lifecycle information management. LEAP will therefore provide specific knowledge exploitation solutions such as design decision support systems and collaborative reporting. LEAP will provide a context-driven access to federated information and knowledge and foster cross-discipline collaborations between users by novel approaches for collaborative engineering.

    Duration: 09/2011 – 02/2015

    Coordinator: SAP AG

35. MANUCLOUD
Full title: Distributed Cloud product specification and supply chain manufacturing execution infrastructure
Short description: The project ManuCloud has been setup with the mission to investigate the production-ICT related aspects for this transition and to develop and to evaluate a suitable ICT infrastructure to provide better support for on-demand manufacturing scenarios, taking multiple tiers of the value chain into account. On this path, ManuCloud seeks to implement the vision of a cloud-like architecture concept. It provides users with the ability to utilise the manufacturing capabilities of configurable, virtualised production networks, based on cloud-enabled, federated factories, supported by a set of software-as-a-service applications.
Duration: 08/2010 – 07/2013
Coordinator: Ursula Rauschecker, Fraunhofer IPA, info@manucloud-project.eu

36. MANUCYTE
Full title: Self-learning modular manufacturing platform for flexible, patient-specific cell production
Short description: Currently, personalised cell cultivation is only carried out through laboratory-scale manual processing. This makes the process highly dependent on human interaction, reducing accuracy and reproducibility.
To overcome these issues and make the patient-specific cultivation of cells available for a wide range of applications, ManuCyte will develop this technology to boost the efficiency of personalised cell cultivation, with a view to quality, throughput and costs.
Duration: 05/2010 – 04/2013
Coordinator: Ursula Rauschecker, Fraunhofer IPA, info@manucyte-project.eu

37. MICRO-FAST
Full title: A FAST process and production system for high-throughput, highly flexible and cost-efficient volume production of miniaturised components made of a wide range of materials
Short description: The aim of the project is to develop a completely new manufacturing system for the volume production of miniaturised components by overcoming the challenges on the manufacturing with a wide range of materials (metallic alloys, composites, ceramics and polymers), through: (i) developing a high-throughput, flexible and cost-efficient process by simultaneous electrical-forming and electric-fast-sintering (Micro-FAST); (ii) scaling up the process to an industrial scale; (iii) further developing it towards an industrial production system for micro-/nano-manufacturing. These will be enabled/supported by developing: (i) a new machine concept: Micro-FAST CNC Machine; (ii) an innovative inline monitoring and quality inspection system; (iii) innovative multiscale modelling techniques for the analysis of the micro-structural behaviours of materials and its interactions with the production processes; (iv) new tooling techniques for high-performance tools, and (v) high-performance nano-material systems.
Duration: 09/2013 – 02/2017
Coordinator: MBN Nanomaterialia

38. MSEE
    Full title: Manufacturing SErvice Ecosystem
    Short description: The MSEE system will be implemented by an ecosystem of models and services distributed at the level of: i) the single manufacturing enterprise, ii) its value network and business ecosystem and iii) the 'Future Internet' of knowledge models and services. Alignment of the distributed heterogeneous enterprise models, as well as interoperability of the relevant applicative and utility services will be the two main technical challenges of the project.
    Duration: 10/2011 – 09/2014
    Coordinator: TXT e-solutions, http://www.msee-ip.eu/
39. MUSIC
    Full title: MUlti-layers control&cognitive System to drive metal and plastic production line for Injected Components
    Short description: This project is about the development and integration of a completely new ICT tool, based on innovative Control and Cognitive system linked to real time monitoring, that allow an active control of quality, avoiding the presence of defects or over-cost by directly acting on the process-machine variables optimization or equipment boundary conditions. The Intelligent Manufacturing approach will work at machine-mold project level to optimise/adapt the production of the specific product and can be extended at factory level to select/plan the appropriated production line. The sensors calibration and quality control of measurements will be the pre-requisite of Intelligent Sensor Network to monitor the real-time production and specific focus will be also devoted to Standardization issues.
    Duration: 09/2012 – 08/2016
    Coordinator: Nicola Gramegna, EnginSoft Spa, n.gramegna@enginsoft.it
40. PAN-ROBOTS
    Full title: Plug And Navigate ROBOTS for smart factories
    Short description: PAN-ROBOTS consortium proposes a new generation of flexible, cost effective, safe and green AGVs in combination with advanced infrastructure systems. Those advanced AGVs will be able to transport material and products in modern factories based on autonomous on-board path planning and navigation to enable high flexibility. The perception system to guide the AGVs through the factory will be based on a novel cooperative approach. Advanced on-board sensors will be combined with infrastructure sensors to enhance the cost effectiveness and increase safety. The fleet management will be intuitive and easy to use by workers without specialized training. In addition the installation time and costs will be dramatically reduced by semi-automated plant exploration supported by a localization approach utilizing already existing landmarks and an advanced pallet handling system which detects and picks the pallets autonomously.
    Finally, the developed generic system will be exemplarily validated in the production process of a bottling company and against the needs provided by the already established PAN-ROBOTS user group.
    Duration: 11/2012 –10/2015
    Coordinator: Kay Fuerstenberg, SICK AG, kay.fuerstenberg@sick.de
41. PLANTCOCKPIT
    Full title: Production Logistics and Sustainability Cockpit

Short description: This research project aims to incorporate existing enterprise resource planning systems, as well as MES (Manufacturing Execution Systems), SCADA (Supervisory Control and Data Acquisition) and special-purpose solutions. They provide the integration of visibility and process needed to be able to actually identify potential and optimise intralogistics processes with respect to yield, quality, energy consumption and other such indicators.
Duration: 09/2010 –08/2013
Coordinator: SAP AG

42. POWER-OM
Full title: Power consumption driven Reliability, Operation and Maintenance optimisation
Short description: Power-OM propose to use the electric current consumption monitoring and profiling, as an easy to implement condition based maintenance (CbM) technique, and manage it also as a way to improve the overall business effectiveness, under a triple perspective: Optimizing maintenance strategies based on the prediction of potential failures and schedule maintenance operations in convenient periods and avoid unexpected breakdowns; managing energy as a production resource and reduce its consumption; providing the machine tool builder with real data about the behaviour of the product and their critical components.
Duration: 08/2012 –07/2015
Coordinator: Aitor Alzaga, Fundacion Techniker, aitor.alzaga@tekniker.es

43. PREMANUS
Full title: Product Remanufacturing Service System
Short description: The goal of PREMANUS is to overcome the asymmetric distribution of information in the end-of-life (EoL) recovery of products, with a special emphasis on remanufacturing. To achieve this goal, PREMANUS will provide an on demand middleware which combines product information and product services within one service oriented architecture.
In addition to closing the information gap, the PREMANUS middleware would compute EoL-specific key performance indicators (KPIs) based on product usage data and make recommendations to its users regarding the viability (in terms of profitability, scope, and time) of remanufacturing a product.
Duration: 09/2011 –08/2014
Coordinator: SAP AG

44. PRIME
Full title: Plug and PRoduce Intelligent Multi Agent Environment based on Standard Technology
Short description: PRIME aims to create new solutions for deployment by SMEs of highly adaptive, reconfigurable self-aware plug and produce assembly systems, which will use multi-agent control, dynamic knowledge sharing, integrated monitoring, and innovative human-machine interaction mechanisms. These next generation assembly systems equipped with PRIME technology will be able to proactively support rapid reconfiguration, adaptation, error-recovery, and operational performance improvement. This will lead to a dramatic cost

and time reduction of deploying and maintaining complex assembly systems on demand and improve their effectiveness.
Duration: 09/2005 – 12/2007
Coordinator: Eric Goderniaux, IBM

45. QCOALA
Full title: Quality Control of Aluminium Laser-welded Assemblies
Short description: QCOALA is focused on energy-efficient, environmentally-friendly and agile manufacturing, through the feedback of in-line information into the production line relating to monitoring and inspection, allowing for process control and continuous quality improvement, as well as waste reduction. Whereas the aim of the project is to produce smarter and more energy-efficient manufacturing, the applications addressed in the project are categorised in the green, 'alternative' energy market.
Duration: 09/2010 – 08/2013
Coordinator: Paola de Bono, TWI, http://www.qcoala.eu/contact/index.jsp

46. REEMAIN
Full title: Resource and Energy Efficient Manufacturing
Short description: Based on the knowledge of who are the energy consumers in manufacturing REEMAIN offers 3 solutions. 1) Innovation in technologies for better use of renewables. 2) Predictive simulation models for production. 3) Factory energy and resource planning tools.
These solutions will first be validated at the Fraunhofer IWU "Research Factory". After that, REEMAIN demonstration activities will take place in 3 different strategic EU factories: Bossa textiles, Gullon biscuits and SCM foundry. Through these factories, REEMAIN will demonstrate to industries which account for more than 50% of CO2 emissions and more than 20% consumption of electricity in industry. These industries represent a balance between carbon-embodied production and energy intensive sectors.
Duration: 10/2013 – 09/2017
Coordinator: Fundacion Cartif, cartif@cartif.es

47. ROBUSTPLANET
Full title: Shock-robust Design of Plants and their Supply Chain Networks
Short description: The RobustPlaNet project aims at developing an innovative technology-based business approach that will drastically change the current rigid supply chain mechanisms and the current product-based business models into collaborative and robust production networks able to timely deliver innovative product-services in very dynamic and unpredictable, global environments. This technology-based business approach will allow distributed supply networks to efficiently deliver innovative product-services to customers with extremely high service levels (at least 95%) in global markets characterized by demand and variant turbulence, thus particularly exposed to worldwide disruptive (mainly economic) events. The development of this new business approach is based on four major pillars, namely (i) innovative supply services, (ii) innovative product-services enabled by ICT, (iii) innovative methodologies for decision-making integrating the plant and the supply network level and (iv) innovative business and assessment models for value creation based on partnership.

Duration: 10/2013 – 09/2016
Coordinator: Magyar Tudomanyos Akademia Szamitastechnika

48. S-MC-S
Full title: Sustainable Mass Customization - Mass Customization for Sustainability
Short description: The S-MC-S project aims to define and research a new production process called sustainable mass customisation. This is an emerging paradigm which combines the efficiency of mass production with the benefits of customisation. Mass customisation also brings several advantages in terms of sustainability, as goods are produced only as and when necessary and according to precise customer specifications. This reduces waste, thereby significantly reducing energy consumption and cutting manufacturing costs.
Duration: 05/2010 – 04/2013
Coordinator: SUPSI

49. SELSUS
Full title: Health Monitoring and Life-Long Capability Management for SELf-SUStaining Manufacturing Systems
Short description: The vision of SelSus is to create a new paradigm for highly effective, self-healing production resources and systems to maximise their performance over longer life times through highly targeted and timely repair, renovation and up-grading. These next generation machines, fixtures and tools will embed extended sensory capabilities and smart materials combined with advanced ICT for self-diagnosis enabling them to become self-aware and supporting self-healing production systems. Distributed diagnostic and predictive repair and renovation models will be embedded into smart devices to early prognosis failure modes and component degradations. Self-aware devices will built on synergetic relationship with their human operators and maintenance personnel through continuous pro-active communication to achieve real self-healing systems. This will drastically improve the resilience and long term sustainability of highly complex manufacturing facilities to foreseen and unforeseen disturbances and deteriorations thereby minimising energy and resource consumption and waste.
Duration: 09/2013 – 08/2017
Coordinator: Fraunhofer IPA

50. SENSE AND REACT
Full title: Sense&React - The context-aware and user-centric information distribution system for manufacturing
Short description: Sense&React will combine a factory wide network of sensors with mobile devices of the users and intelligent manufacturing information management in real-time, in order to: Distribute the facility's information considering context and the user role; successfully aggregate and manage data from factory-wide sensor networks as well as from various data sources (MES, ERP), analyze and deliver them in a context-based manner to different users; reduce the user's cognitive load; provide simple and easy to use user interfaces.
Duration: 10/2012 – 09/2015
Coordinator: Dr. Sotiris Makris, University of Patras, http://www.sense-react.eu/?page_id=68

51. SKILLPRO
    Full title: Skill-based Propagation of Plug&Produce-Devices in Reconfigurable Production Systems by AML
    Short description: The objective of SkillPro is to bring the vision of a smart reconfigurable manufacturing system into application. It considers a modern production system as a combination and collaboration of cyber-physical assets that offer different skills. SkillPro provides an extension of the Plug-and-Produce paradigm using knowledge about the skills of the diverse automation system components and about their composition and cooperation and is based on the open standard of AutomationML.
    Duration: 10/2012 – 09/2015
    Coordinator: KIT, Institute for process control and robotics

52. SUPERFLEX
    Full title: Develop and demonstrate a 'Mini-factory concept for production of personalized skin care products for elderly population
    Short description: SuperFlex manufacturing concept of central factory and mini-factories extensions raises a mechanism for sophisticated options analysis of products to be designed and produced at operational level. An advanced cloud based ICT platform will include: An integration of the manufacturing IT system for distributed control and monitoring of the production network [Enterprise Resource Planning; Secure Information Systems; Manufacturing Execution Systems; Standard for the Exchange of Product model data]; a new Cyber physical system-enabled infrastructure approach for equipment integration; a decision support system for cosmetic formulations according to biomarkers profile, expert evaluation and client requirements; mobile device supported customer feedback system.
    Duration: 09/2013 – 08/2017
    Coordinator: Dr. Z. Maor, Ahava-DSL

53. SUPREME
    Full title: SUstainable PREdictive Maintenance for manufacturing Equipment
    Short description: The objectives of SUPREME are: To develop and use most advanced signal and data processing dedicated to predictive maintenance and energy consumption reduction; to implement these tools in an industrial demonstrator; to develop, exploit and diffuse new tools for predictive maintenance.
    Duration: 09/2012 – 08/2015
    Coordinator: Vladimir Carli, NASP, vladimir.carli@supreme-project.org

54. T-REX
    Full title: Lifecycle extension through product redesign and repair, renovation, reuse, recycle, strategies for usage and reusage-oriented business models
    Short description: The T-REX project supports such transition in the capital goods industries by developing and experimenting conceptual tools, with three practical demonstrators in the transportation (lift truck), machine tools and robotics assembly domains. T-REX will develop: A business model suited for the new landscape that changes the way products are offered and customer relationships managed; Product design techniques to extend the lifecycle, to foster upgrading and renovation, and to support serviceability; service design methods to develop new services consistent with the business models and re-engineering existing

services; tools for asset Health management, customizable to the industry requirement, and a new lifecycle oriented accounting tool.
Duration: 10/2013 – 09/2016
Coordinator: Fundacion Tekniker

55. TAPAS
Full title: Robotics-enabled logistics and assistive services for the transformable factory of the future
Short description: TAPAS will focus on the following tasks: Development of mobile robots with arms to make logistical tasks more flexible by collecting, as well as transporting, the parts needed at any given time and delivering these to their relevant locations; automation of assistive tasks which naturally build on logistical tasks, such as preparatory and post-processing work, e.g. pre-assembly or machine tending with inherent quality control, since the simple movement of parts around the shop floor does not generate value in itself.
Duration: 10/2010 – 03/2014
Coordinator: Rainer Bischoff, KUKA, Rainer.Bischoff@kuka.com

56. VENIS
Full title: Virtual Enterprises by Networked Interoperability Services
Short description: The VENIS project is aimed at providing the a new level of interoperability between Large and Small Enterprises, according to Virtual Enterprise paradigm: A distributed web-based repository will be implemented in order to connect the existing information systems; a set of lightweight web services will be developed for a smart exchange of the common data based on legacy email systems; the local business processes will be modelled and linked by a distributed business engine mechanism, in order to assist the work in joint businesses and create novel synergies in marketing competition.
Duration: 09/2011 – 02/2014
Coordinator: Engineering Group Italy

57. VISTRA
Full title: Virtual Simulation and Training of Assembly and Service Processes in Digital Factories
Short description: VISTRA aims at the development of a comprehensive platform for simulation, documentation and training of manual assembly processes based on advanced ICT-technologies and concepts, such as auto-generation and re-use of data, realistic physical behaviour, game-based learning, advanced user-interaction and cross-disciplinary information sharing. VISTRA will support the European labour-intensive industries in two ways: it will allow for the training of workers in a way which is more efficient, straightforward and resource-saving than today's methods, and it will enable production engineers to analyse assembly processes before physical mock-ups exist.
Duration: 09/2011 – 08/2014
Coordinator: Dominic Gorecky, DFKI**,** Dominc.Gorecky@dfki.de

I.2.2 Projects from Artemis

Artemis (**A**dvanced **R**esearch & **T**echnology for **EM**bedded **I**ntelligence and **S**ystems) is a JTI (Joint Technology Initiative) which, together with the EC funds industrially relevant research projects.

Projects from this initiative which are focussing on ICT concepts which also might be relevant for manufacturing are introduced in the following.

1. SOFIA
   Full title: Smart Objects For Intelligent Applications
   Short description: SOFIA will create an Open Innovation Platform (OIP) providing the interoperability that allows interaction between multi-vendor devices. For this, it will create interaction models and embedded devices that support a variety of "smart spaces" and a variety of users, and develop methods, techno-economic structures and toolkits for the deployment of smart environments and for the development of services and applications based on them. It will also define scenarios to demonstrate the capabilities of the OIP in personal spaces, indoor spaces and cities.
   Duration: 01/2009 – 12/2011
   Coordinator: Petri Liuha, Nokia, petri.lihua@nokia.com

2. INDEXYS
   Full title: INDustrial EXploitation of the genesYS cross-domain architecture
   Short description: INDEXYS will develop a cross-domain instantiation of the GENESYS embedded system architecture, for Industrial-grade exploitation on real-world platforms in Railway, Aerospace, Automotive and Industrial Control domains. INDEXYS expands the GENESYS approach by implementing and integrating architectural services into prevailing (real-world!) platform solutions. A key goal of INDEXYS is legacy integration, for plat-form providers – by integrating new architectural services into legacy platforms – and for platform users – by supporting legacy applications. INDEXYS addresses robustness wrt. design faults and physical faults by diversity and component replication. INDEXYS targets ARTEMIS-JU Sub-Programme 5: "Computing environments for embedded systems" by developing new concepts for composable component integration, re-usable dependability services, and a cross-domain tool-chain based on OMGs Model Driven Architecture.
   Duration: 04/2009 – 05/2012
   Coordinator: Andreas Eckel, TTTech Computertechnik AG, andreas.eckel@tttech.com

3. iLAND
   Full title: mIddLewAre for deterministic dynamically reconfigurable NetworkeD embedded systems
   Short description: iLAND will develop enabling technologies for modular, component-based middleware for networked systems that demand deterministic, dynamic functional composition and reconfiguration. To reach this goal, bounded time composition algorithms and dynamic reconfiguration algorithms will be developed for service-based networked application. Also, combined resource management will be performed to achieve adaptation to changing needs due to environmental or programmed changes. They will be based on deterministic platform enhancements. A specification for deterministic dynamic reconfiguration and composition, and its integration in tools will be developed.
   One outcome of the project will be three application demonstrators and a laboratory prototype: remote video monitoring, home healthcare, and highly dynamically reconfigurable early warning system using public transport carrier infrastructure.
   Duration: 03/2009 – 03/2012
   Coordinator: Francisco Gomez-Molinero, Visual Tools S.A., fgomez@visual-tools.com

4. EMMON
   Full title: EMbedded MONitoring
   Short description: The quantified goal of the project is to create an integrated framework of technologies for large scale and dense wireless sensor networks that allow effective monitoring for more than 10,000 devices. EMMON will perform technological research of new, efficient, and low-power consumption communication protocols, embedded middleware with better overall energy-efficiency, fault-tolerance and reliability for large scale monitoring, remote command & control operational systems for end-users and development of network planning and deployment tools to facilitate and assist those same deployments.
   Duration: 03/2009 – 03/2012
   Coordinator: Délio Emanuel Chang de Almeida, PMO, http://www.artemis-emmon.eu/contact.html

5. CESAR
   Full title: Cost-efficient methods and processes for safety relevant embedded systems
   Short description: CESAR targets significant reduction of overall development time and effort, between 30% and 50%, using a Reference Technology Platform (RTP). The aim is, within 5 years, to double the number of European technology providers and SMEs joining the CESAR ecosystem and reduce by 50% the cost of integration, configuration, deployment, and maintenance of tool-chains.
   The Domain-SP's provide information about their gaps and needs in safety-critical devleopment to the Innovation-SP's. The Innovation-SP's turn solutions over to the Domain-SP's who are evaluating them in applied pilot applications. The process described represents an innovation cycle that will be repeated 2 times in CESAR.
   Duration: 03/2009 – 03/2012
   Coordinator: Gerhard Griessnig, AVL List GmbH, cesar@avl.com

6. ACROSS
   Full title: ARTEMIS CROSS-Domain Architecture
   Short description: ACROSS is a research project that aims to develop and implement an ARTEMIS cross-domain reference architecture for embedded systems based on the architecture blueprint developed in the European FP7 project GENESYS. ACROSS will result in the design of a generic Multi-Processor Systems-on-a-Chip (MPSoC) and a first implementation in an FPGA. Using the core services of the ACROSS-MPSoC, a library of middleware services will be realized in the ACROSS project. Another significant result of the project will be a general design methodology, supported by appropriate adaptable tools, for the implementation of ACROSS-based applications. The benefits of the cross-domain architecture will be shown in demonstrators from the targeted application domains.
   Duration: 04/2010 – 03/2013
   Coordinator: Sibylle Kuster, Vienna University of Technology, kuster@vmars.tuwien.ac.at

7. ESONIA
   Full title: Embedded Service-Oriented Monitoring, Diagnostics and Control: Towards the Asset-Aware and Self-Recovery Factory
   Short description: In the ESONIA project, a plan for an asset-aware and self-recovery plant will be elaborated through pervasive heterogeneous IPv6-based embedded devices and by

bringing on-board specialised services, glued through a middleware capitalising the service orientated approach. Expected outcomes are greater predictability of plant behaviour and visibility, reduced safety risks, enhanced security and cost efficiency.
This will be applied in industry for the first time, in order to support continuous monitoring, diagnostics, prognostics and control of assets, regardless of their physical location.
Duration: 03/2010 – 02/2013
Coordinator: Ilkka Lehtinen, Hermia Ltd, ilkka.lehtinen@hermia.fi

8. iFEST
Full title: industrial Framework for Embedded Systems Tools
Short description: iFEST will specify and develop an integration framework for establishing and maintaining tool chains for the engineering of complex industrial embedded systems.
iFEST is not really about developing new modelling technologies, nor about developing new tools as such. iFEST is concerned with establishing tool chains through the use of integration technology which is tool-independent. iFEST's main contribution will be in the definition and implementation of models and meta-models both for the targeted application domains and for existing tools. Supported by the iFEST framework, these models and meta-models will allow different tool chains to be derived. In iFEST meta-modelling approaches will be used to automatically implement necessary tool chain interfaces. These interfaces will provide the sought for interoperability of tools.
Duration: 04/2010 – 03/2013
Coordinator: Knut Rimstad, ABB AS, http://www.artemis-ifest.eu/contact

9. SIMPLE
Full title: Self-organizing Intelligent Middleware Platform for manufacturing and Logistics Enterprises
Short description: The main goal of SIMPLE is to research and deliver an intelligent, self-organizing embedded middleware platform, designed for the integration of manufacturing and logistics. SIMPLE will address the self-organization and cooperation of wireless sensors and smart (RFID) tags for federated, open and trusted use in the manufacturing and logistics applications. SIMPLE will develop a novel and complete sensor and RFID based embedded middleware platform for manufacturing and logistics applications and validate the platform in scenarios dealing with holistic lifecycle management for manufacturing, distribution, recycling and disposal of goods.
Duration: 06/2010 – 05/2013
Coordinator: Kostas Kalaboukas, SingularLogic, kkalaboukas@singularlogic.eu

10. WSN-DPCM
Full title: Wireless Sensor Network-Development, Planning, Commissioning, and Maintenance
Short description: This project will address large-scale application of Wireless Sensor Networks (WSN) by developing an integrated platform for smart environments comprising a middleware for heterogeneous wireless technologies, an integrated engineering tool for quick system development, a planning tool and a commissioning & maintenance tool. Two demonstrators will be built to evaluate the impact of the middleware and tools.
Duration: 10/2011 – 09/2014

Coordinator: Luis Redondo, Métodos y Tecnología de Sistemas y Procesos S.L (MTP), lredondo@mtp.es

11. SESAMO
Full title: Security and Safety Modelling
Short description: SESAMO will enable the cost-efficient and systematic design, analysis, development and assessment of distributed safety and security critical embedded systems. The results will have broad, cross-domain applicability in numerous strategic sectors of European industry. The SESAMO project addresses the root causes of problems arising with the convergence of safety and security in embedded systems at architectural level. The proposal is to develop a component-oriented design methodology based upon model-driven technology, jointly addressing safety and security aspects and their interrelation for networked embedded systems in multiple domains (e.g., avionics, transportation, industry control). The relevance of the SESAMO results is guaranteed by the involvement of large partners with significant economic interests in safety and security critical systems in the use case domains, a sound group of technology providers (including SMEs) and prestigious research entities with in-depth and complementary multi-domain expertise.
Duration: 05/2012 – 04/2015
Coordinator: Silvia Mazzini, INTECS S.p.A., silvia.mazzini@intecs.it

12. ARROWHEAD
Full title: Arrowhead Process and energy system automation
Short description: ARROWHEAD will provide a technical framework, including solutions for integrating legacy systems, to implement and evaluate cooperative automation through real application pilots in electro-mobility, smart buildings, infrastructures and cities, industrial production, energy production and the “virtual energy” market, leading the way to further standardisation and showcasing the actual impact in real life.
Duration: 03/2013 – 02/2017
Coordinator: Jerker Delsing, Lulea University of Technology, Jerker.Delsing@ltu.se

13. ESCOP
Full title: Embedded systems for Service-based control of Open Manufacturing and Process Automation
Short description: Embedded systems Service-based Control for Open manufacturing and Process automation, or E-SCOP, aims to overcome the current drawbacks for the shop-floor control level, thus improving the state of the art of the overall production control system architecture. This is achieved by introducing an innovative approach based on the combination of embedded systems, ontology-based knowledge management and service-oriented architecture.
Duration: 03/2013 – 02/2016
Coordinator: Sari Rasanen, Tampere University of Technology, sari.rasanen@tut.fi

14. CHARTER
Full title: Critical and High Assurance Requirements Transformed through Engineering Rigour
Short description: CHARTER will develop concepts, methods, and tools for embedded system design and deployment that master complexity and substantially improve the development, verification and certification of critical systems.
CHARTER will ease, accelerate, and cost-reduce the certification of such critical embedded systems by melding real-time Java, Model Driven Development, rule-based compilation, and formal verification. This approach, Quality-Embedded Development (QED), will push software certification to a new level and thereby significantly contribute to the safety and security of the upcoming age of an embedded software society.

Duration: 04/2009 – 04/2012
Coordinator: Scott Hansen, X/Open Company Limited, s.hansen@opengroup.org

15. CAMMI
Full title: Cognitive Adaptive Man-Machine Interface
Short description: CAMMI aims to develop a joint-cognitive system that will balance and optimise operators' workload and thus improve the safety of complex systems such as industrial plants, airplanes or cars operated by people under demanding conditions. Mitigation strategies that balance operator workload based on the operators' situational awareness and working environment will be developed.
Duration: 12/2008 – 12/2011
Coordinator: Magda Balerna, SELEX ES S.p.A., magda.balerna@selexgalileo.com

16. R3-COP
Full title: Resilient Reasoning Robotic Co-operating Systems
Short description: R3-COP will develop a fault-tolerant high-performance processing platform, based on a multi-core architecture, as well as innovative system components for robust perception of the environment including sensor fusion, and for reasoning and reliable action control.
Duration: 05/2010 – 04/2013
Coordinator: Mladen Berekovic, TU Braunschweig, berekovic@c3e.cs.tu-bs.de

17. RECOMP
Full title: Reduced Certification Costs Using Trusted Multi-core Platforms
Short description: RECOMP will establish methods, tools and platforms for enabling cost-efficient (re-)certification of safety-critical and mixed-criticality systems. Applications addressed are automotive, aerospace, industrial control systems, and lifts and transportation systems **Duration:** 04/2010 – 03/2013
Coordinator: Jarkko Mäkitalo, Kone Oyj., Jarkko.Maekitalo@kone.com

18. ASTUTE
Full title: Pro-active decision support for data-intensive environments
Short description: ASTUTE aims to define reference architecture for the development of HMIs, creating a platform for building embedded products that capture and act upon user intentions, taking account of user context and state. For instance, in the automotive domain, information from various sources will be proactively presented to support decisions according to the context by discarding annoying or distracting low-level information.
Duration: 03/2011 – 04/2014
Coordinator: Silvia Castellvi, ATOS Spain S.A., silvia.castellvi@atosresearch.eu

19. D3COS
Full title: Designing Dynamic Distributed Cooperative Human-Machine Systems

Short description: Complex human-machine interplay in advanced automated assistance systems for transport modes requires adequate human-machine cooperation with shared authority. The Distributed Cooperative Human-Machine Systems (DCoS) project will develop affordable methods, techniques and tools that address the specification, development and evaluation of cooperative systems from a multi-agent perspective, with human and machine agents in charge of common system tasks.
Duration: 03/2011 – 02/2014
Coordinator: Jan-Patrick Osterloh, OFFIS, jan-patrick.osterloh@offis.de

20. DEMANES

Full title: Design, Monitoring and Operation of Adaptive Networked Embedded Systems

Short description: DEMANES aims to provide component-based methods, framework and tools for the development of runtime adaptive systems, enabling them to react to changes in themselves, in their environment and in user needs.
Duration: 05/2012 – 04/2015
Coordinator: Antonio Solinas, Akhela

21. VARIES

Full title: Variability in safety critical Embedded Systems

Short description: The main goal of the VARIES project is deliver a platform to help Embedded Systems developers to maximise the full potential of variability in safety critical embedded systems. The focus will be on the safety critical aspects, in particular the impact of reuse and composition on certification. Embedded systems developers constantly confront decisions about using and adapting existing products or product assets versus new developments. And producers of complex embedded systems often face the added problem of assembling parts supplied by different partners. Hence the need for mechanisms that allow safe and trusted integration. In addition to this ambitious goal, the VARIES project will create a Centre of Innovation Excellence (CoIE) for managing variability in Embedded Systems and offer appropriate support for the European Embedded Systems industry.
Duration: 05/2012 – 04/2015
Coordinator: Dominique Segers, Barco n.v., dominique.segers@barco.com

I.2.3 Further European projects focusing on ICT and manufacturing-related application cases

Besides FoF projects, there are also several other projects on European level, funded by the EC e.g. by the ICT work programme or independent activities, which are dealing with ICT in manufacturing. In the following, some examples are given.

1. Autogration
   Full title: Assisting SMEs to participate in global digital supply chains in the automotive sector
   Short description: The main aim of the auto-gration project is to create a way for organisations of all sizes throughout the European automotive supply chain to exchange eBusiness data seamlessly, regardless of their locally installed digital infrastructure. To achieve this, the vision of the project is to develop a data exchange architecture that will accept data from mutually incompatible messaging systems and transform them in such a way as to allow universal communication.
   Duration: n.a.
   Coordinator: Odette international
   Website: http://www.auto-gration.eu

2. CUMULONIMBO
   Full title: A Highly Scalable Transactional Multi-Tier Platform as a Service
   Short description: CumuloNimbo aims at developing a radically new Platform as a Service that will provide high scalability (100+ service nodes) without sacrificing data consistency and ease of programming.
   Duration: 10/2010 – 09/2013
   Coordinator: Marta Patiño-Martinez, Universidad Politécnica de Madrid, mpatino@fi.upm.es
   Website: http://www.cumulonimbo.eu

3. NetChallenge
   Full title: Innovative networks of SMEs for complex products manufacturing
   Short description: The Net-Challenge project main goal is to support the creation and management of non-hierarchical business networks where SMEs can join competencies and resources to succeed on the global market in the design and manufacturing of complex products.
   Duration: 06/2009 – 02/2012
   Coordinator: Luís Carneiro, INESC Porto
   Website: http://www.netchallenge.org/

4. eBizTCF
   Full title: The European initiative for a single standard of digital language for the fashion supply chain.
   Short description: Enabling companies to directly exchange orders and data between their systems, using a single language.
   Duration: n.a.
   Coordinator: n.a.
   Website: http://ebiz-tcf.eu/

I.3 International projects

Besides European projects focussing on ICT for manufacturing, also some international projects have been considered. Some examples are given in the following:

1. RCMP
   Full title: Reconfigurable Cloud Manufacturing Platform
   Short description: The migration to the cloud refers to a consolidation process in which decisions of different interests are involved. Different companies may have different requirements of their cloud solutions. RCMP (Reconfigurable Cloud Manufacturing Platform) delivers reconfigurable cloud solutions for enterprises to agilely implement private cloud, community cloud and public cloud as required.
   Duration: n.a.
   Coordinator: Prof. Xun Xu, University of Auckland, xun.xu@auckland.ac.nz
   Website: http://54.200.226.27/#about

2. MfgCloud
   Short description: This research is to develop a cloud platform to support the aerospace industry for manufacturing parts.
   Duration: n.a.
   Coordinator: University of Beijing