1. DIFAC PROJECT

The DiFac project aims at the development of an innovative Collaborative Manufacturing Environment (CME) for next-generation digital manufacturing. The DiFac CME will be used as a framework to support group work in an immersive and interactive way, for concurrent product design, prototyping and manufacturing, as well as worker training. It will provide support for data analysis, visualization, advanced interaction and presence within the virtual environment, ergonomics analysis, and collaborative decision-making.

1.1. INTRODUCTION

DiFac (Digital Factory for Human Oriented Production System) is the acronym of an IMS (Intelligent Manufacturing System) carried out in three different Regions (South Korea, Europe and Switzerland). The objective of the overall project is to develop an innovative, collaborative manufacturing environment (CME) for the next generation of Digital Factories to increase their competitiveness and flexibility incorporating 4 key elements: Product, Processes, Resources and Human aspects (PPR+H).

The IMS DiFac project consists of 4 workpackages:
- WP1 – System integration and administration;
- WP2 – Human modeling;
- WP3 – Collaborative VRE for digital manufacturing systems;
- WP4 – Enterprise resource planning interface.

The BioMechatronics centre of Sungkyunkwan University was the coordinator of the IMS DiFac project.

The Korean Project was composed by the following partners:

<table>
<thead>
<tr>
<th>#</th>
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<th>Short</th>
<th>Type</th>
<th>Role in the project</th>
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<td>IND</td>
<td>Cable tech.</td>
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<td>2</td>
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<td>SKKU</td>
<td>UNI</td>
<td>Ergonomics</td>
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The European project (FP6-2005-IST-5-035079) was funded within the FP6 under ICT priority addressing "Collaborative Working Environment. Twelve partners from 7 different European countries compose the DiFac consortium:

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<th>Country</th>
<th>Type</th>
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<td>ITIA-CNR</td>
<td>I</td>
<td>R&amp;D</td>
<td>Virtual environment and presence</td>
</tr>
<tr>
<td>2</td>
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<td>F</td>
<td>SME</td>
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<td>GR</td>
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<td>6</td>
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<td>IPA-FhG</td>
<td>D</td>
<td>R&amp;D</td>
<td>Factory planning</td>
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<td>TTS</td>
<td>I</td>
<td>SME</td>
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<td>I</td>
<td>IND</td>
<td>Laser cutting machine</td>
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<td>Pantelis Pashalidis &amp; Sons S.A</td>
<td>PPS</td>
<td>GR</td>
<td>IND</td>
<td>Fabrics and Carpets</td>
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The Swiss Project is composed by the following partners:

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<th>Short</th>
<th>Type</th>
<th>Role in the project</th>
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</thead>
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<td>Institute of Computer Integrated Manufacturing for Sustainable Innovation</td>
<td>ICIMSI</td>
<td>R&amp;D</td>
<td>Semantic Web &amp; RF-ID</td>
</tr>
<tr>
<td>2</td>
<td>Laboratory for Production Management and Processes</td>
<td>EPFL</td>
<td>UNI</td>
<td>ERP</td>
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<tr>
<td>3</td>
<td>Sage SA</td>
<td>SAGE</td>
<td>SME</td>
<td>Software house</td>
</tr>
<tr>
<td>4</td>
<td>CEMEX Global Center for Technology and Innovation</td>
<td>CEMEX</td>
<td>IND</td>
<td>Cement</td>
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</tbody>
</table>
1.2. DiFac Project GOALS and Organisation

The primary objective of IMS DiFac was to consider human aspect during the product/process/factory life cycles. This will lead to an improvement of human safety reducing the industrial accident ratio. Human factors and ergonomics were considered to be the cornerstone to underpin the international project and go through the regional projects. In addition, this project developed the collaborative manufacturing environment for digital factory activities and introduced also the human-web-based ERP interface to enhance the factory productivity and speed up the product development process.

Here below the objectives of the single regions:

- the KR focuses on improving human safety in general factory scenarios.
- the EU addresses presence, collaboration and ergonomics within a digital factory for product design, factory construction and training activities.
- the CH aims to provide an integrated, company-wide information management system as well as an ERP-human web based interface for the human-oriented and collaborative digital factory.

Korean partners mainly worked on two workpackages, WP1 and WP2, while the EU and Swiss partners were responsible for WP3 and WP4 respectively. Figure 1 illustrates the correlations and integrations among those workpackages, which are carried out by all 3 regions. It is shown that the DiFac hub plays a key role of the information carrier for system data exchange and integration. Information and data exchange is always something really delicate, having a system for exchanging information with high level of security and let the data be read by different systems is something crucial in industrial world, moreover among different countries. Four categories of digital information (Product, Process, Resource, Human) will be standardized and exchanged by the PPRH integrator.

![Figure 1: IMS-DiFac system architecture](http://www.difac.net)

More information is available on the web at [http://www.difac.net](http://www.difac.net).
1.3. TECHNICAL ACHIEVEMENTS

1.3.1. EU DiFac

Nowadays, the manufacturing companies use a wide range of engineering, planning tools and applications to integrate efficiently and effectively new information and communication technologies into manufacturing processes. Digital representation is a static model of manufacturing path, methods and tools. The future is represented by the Virtual representation where simulation tools and specific applications are used in order to make the representation and the processes dynamic and up-to-date.

A digital factory is a virtualised environment that facilitates the sharing of factory resources, manufacturing information and knowledge, supporting the collaborative product review, the factory planning, the management and the training among different participants. DiFac EU result is not just a software platform, as it is composed of a set of software, methodologies and guidelines integrated in a suite where the entry point is represented by a web portal (Fig. 3).

The project is built on the three pillars and the three digital activities components are developed on the top of them. See the following pictures.

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**Figure 2. DiFac conceptual Framework**

The software-view shows that the framework is logically described by components, tools (that provides a set of services) and methodologies; all are linked among themselves.

The DiFac framework is composed by 6 components. They are divided in three Pillars (Group Presence Modeler, Immersive Integrator and Collaboration Manager) and three Digital Activities or DA (Prototype Designer, Factory Constructor and Training Simulator).

---

**Figure 3. DiFac Framework Architecture**
Each component (both the digital activities as well the pillars ones) contains a number of tools providing different functionalities and has been validated by an integrated scenarios. Such software tools has been developed within the project or just integrated if they already existed as products. The main idea is to avoid the redevelopment of such tools that can be considered already giving the appropriate functionalities in respect of presence, collaboration and ergonomics aspects. One of the main project goal is the realisation of a framework suitable for SMEs use.

The three pillars gives to the project the basis for understanding the direction the software development has for building an effective environment.

The main interest of an enterprise is the production and the product. The innovation of DiFac is to have the human beings as centre of the technological application and production. Ergonomics takes into account the peoples’ needs and capabilities in design, implementation and operation. Presence measures the sense of using a VE in a natural and no mediated way, finally the collaboration deals with the establishment of solutions for collaborating through new technologies and media.

The methodologies for evaluating Ergonomics, Presence and Collaboration assure that the human beings remains always the centre of the digital factory. Giving the industrial the possibility to evaluate by himself these indicators is the innovation. But this is the crucial point of the project: the possibility to access to a set of customizable solution from a web site.

iPortal is indeed, a web-portal, customized for the DiFac suite. It is a virtual location with a dashboard-like interface integrating all DiFac modules and therefore offering the user a central information point. Users can log-in and access information. Here below a screenshot of the iPortal is presented and some of its functionalities can be perceived.
Figure 5: iPortal home page. The entry point for DiFac EU results

The Integrated scenario
The integrated scenario has been developed to test the DiFac solution in its wholeness as well as to demonstrate the following aspects

- DiFac solution supports group work in an immersive and interactive way, for concurrent product design, factory design and optimisation as well as worker training.
- The three digital activities are integrated into a new solution. That means: changes in the data handled by a component are reflected in other components and data can be exchanged between the software tools where it is needed.
- The outcomes of the 3 pillars (i.e. Presence Modeller, Immersive Integrator and Collaboration Manager) have increased the tools’ functionalities, composing the DiFac solution, from the key pillars of collaboration, presence and ergonomics
- DiFac solution is modular and scalable
- DiFac solution provides enhanced and integrated solutions to end users needs who are partners in this project

The following hypothetic companies, based on the DiFac partners, are supposed to be involved in this scenario; these are the actors and their roles:

- SECONDA company which is a laser machine producer
- PACOM company, a customer interested to purchase a cutting laser cell
- A new IT consortium providing the DiFac Solution. The R&D DiFac partners headed by ROPARDO could compose this consortium.
It's possible to imagine that the important customer, PACOM company, has ordered a new laser cell from the “SECOND” company composed by a PLATINO laser cutting machine which has to be customized in order to meet special customer’s needs. So the SECONDA general manager decides to lunch a new internal big project whose main goal is to design and assemble this new laser cell named “New PLATINO laser cutting cell.” It is composed by a customized PLATINO laser cutting machine and all the needed peripheral components such as, input and output conveyor belt systems, protections, junctions, etc. Clearly this new cell will be settled in the customer layout and has to comply with physical restrictions, safety rules, technical constraints, etc.

SECONDA general manager, in accordance with her advisors, decides to use DiFac solution to support this important project to take advantage of collaborative, presence and ergonomics features provided by this solution.

Alternative machine designs (sub components) are proposed in order to meet the customer requirements. However one of them has some implications on the production process because of few the modification. In order to better assess these implications, the production process is analysed with Factory Constructor, one of the digital activities provided by DiFac solution.

The design and assembly teams use the Factory Constructor for carrying on feasibility studies as well as finding out solutions for the shop floor in order to machine the new components. Moreover ergonomic considerations related to the new layout can be analysed. Such a issue can be very complex, but, in this integrated scenario, it will be simplified in order to be easily understood by everyone. It's extremely important to define a simple but a complete and impressive scenario able to demonstrate the innovative solutions to manage group work in an immersive and interactive way to SMEs, the future potential customers.
After having assessed the process implications of the customized components, design and assembly team will use the DiFac decision support system for taking the final decision on the customized laser machine. This system allows ranking votes based on different criteria and different weights. When the customized PLATINO laser cutting machine design has been finalized, the maintenance procedures have to be revised. DiFac solution is able to manage this issue. The maintenance procedures along with the modified procedures due to the customization can be uploaded on DiFac solution in order to provide an efficient remote maintenance service.

![Production Plant Design and Simulation](image)

**Figure 8: Production plant design and simulation**

Due to the fact the shop floor has been re-planned, it’s very important, for safety reasons, that workers are re-trained to manage emergency situations properly. DiFac solution is used by SECONDA company to set up a new workers training project for updating the training scenario and training blue collars. The new IT company/consortium will provide the DiFac solution and its customization to SECONDA. This solution can be installed on company server locally or it can be provided in outsourcing. The project result is a framework composed by a set of software and service for helping the European SMEs to cope with new landscapes the market design. DiFac industrial partners are already using virtual and augmented reality for designing a new factory layout or reviewing products or again training employees in emergency situations. DiFac results are scalable and the user can decide to have the environment in a virtual room and navigate with a 3D mouse or simply on his laptop. The solutions are affordable; the user can access to the iPortal and have from there software or indication to access to web based tools. The future of such technologies is sure: stronger entering into the productive side of the market. The capacity of adaptation of the SMEs could be the extenuating circumstance for conquering success in the market.
1.3.2. KR DiFac

The Korean project results achieved are:

- Definition of the PPR+H (Product, Process, Resource, Human) schema in XML for the representation of data within the digital factory
- Definition of methodologies and algorithms for the human body simulation
- Realisation of simulation tool for studying the ergonomic of the work-place
- Integration of the knowledge and expertise into the PPR+H schema (IMS task)

The PPR+H concept is a new "Paradigm" combining Product, Process, Resource and Human information in order to simultaneously improve productivity and workers' safety.

The Korean consortium defined PPR+H schema and developed PPR+H integrator. Using these two components they developed DiFac hub for the web based service.

Regarding to human safety in virtual workspace, a human upper body model has been developed and also validated to improve the accuracy of the kinematic/kinetic upper body model. This solution can provide the results of the biomechanical analysis such as joint kinematic/kinetic results and also the ergonomic analysis.

![Figure 9: Concepts of integration framework for DiFac](image)

Figure 10 shows the concept of the PPR⁺H schema for DiFac integration. It consists of 5 sub-schemas: product, process, resource, human, and PPRH relation schema having definitions of PPR and human relationship.

![Figure 10: The concept of PPR+H schema for DiFac](image)
Korean DiFac result consists of a commercial PDM system, PPR+H Integrators and Web services which support data exchanges among diverse DiFac applications. The PPR+H schema plays an important role for the exchange of PPR and human models and information. Using the PPR+H Hub, it is possible to apply digital factory models and information to engineering works, and to manage all results of each engineering work. The PPR+H Hub is designed to integrate various digital factory applications and other enterprise-wide information systems, which have digital factory models and information related to PPR and human. The PPR+H Integrator can handle XML files in PPR+H schema using PPR and Human information from diverse applications or legacy systems in a company. As shown in the figure, there are three kinds of PPR+H Integrators, such as DiFac Application Adapter, XML Adapter, and PLM Adapter.

DiFac KR validated its result with a case study in automotive field. They developed an ergonomic simulation module using the developed human upper body model and demonstrated the simulation module.
1.3.3. CH DiFac

The Swiss IMS DIFAC project covers WP4 of the full IMS DIFAC project and deals with the development of next generation information and knowledge management solutions for the enhancement and improvement of mainly transactional information provided currently by traditional ERP tools. Therefore, the Swiss DiFac project proposes the development, testing and diffusion of new technologies such as Semantic Web, Discrete Event Simulation and RFID to be integrated to ERPs to support their evolution providing new functionalities for human-centric knowledge needs and incorporating sustainable innovation concepts.

Many industrial sectors in developed countries base their competitiveness on their innovation capacity and the high level of competence/knowledge acquired through high R&D investment. The R&D efforts are mainly undertaken directly by companies, including the SME’s, which usually in Europe account for more than 90% of the private sector. Nevertheless, to remain competitive new technologies and methods should continuously be tested, implemented and diffused.

ERP systems are now widespread also in SMEs, they provide transactional information management and analysis to organizations. However, mere software implementations, though useful, do not provide a complete solution to enable the development of a new manufacturing environment where knowledge is captured, stored and reused by distributed knowledge workers that collaborate along the product life-cycle. This explain the need of creating new and more comprehensive ICT tools and concurrently of developing new governance models, capable of fully exploit the results of the proposed ICT tools.

Nowadays ERP systems are still the cornerstone of the ICT applied in industrial environments. However, other ICTs, such as electronic commerce solutions and RFID, are taking more and more importance and can significantly contribute to the optimisation of the processes spanning the overall product life-cycle. Nevertheless, these new ICTs cannot deploy all their benefits because currently they are not properly integrated with ERP systems. For instance, tracking and tracing capabilities made possible by the usage of RFID in manufacturing facilities can increase their competitiveness by allowing new functionalities such as inventory management and safety compliance. Tracking and tracing can be applied to:

- raw materials, work in process, finished products, tools in order to optimise the production and logistic flows;
- employees to prevent incidents when approaching to hazardous materials;

Another weakness of ERP systems is the difficulty to optimise the production scheduling process due to different disturbances that affect the overall production system and prevent the real-time sharing of updated and meaningful information. Therefore, in order to facilitate the decision-making process the ERP system should also be integrated with simulation tool allowing the development of “what-if scenarios and the optimisation of the production scheduling.

![Figure 12: Swiss DiFac Project Methodological Framework](image-url)
The approach, shown in previous figure, is based on three main activities, which will be described in the following sections:

- Implement an integrated company wide information management system
- Develop a new ERP-human simulation interface
- Explore the RFID technology integration with the ERP

**Semantic Web based SMARTBRICKS BPM tool**

To speed up the product development and manufacturing processes and at the same time improve its performance in terms of costs and quality, companies require a new collaborative environment where the process of knowledge creation and sharing are similar to that characterising the “open source” pattern successfully applied to software development. Such knowledge-based environment should promote rapid decision making and facilitate the concurrent performance of operations, thus reducing time-to-market. Knowledge Management (KM) involves the management of a social process that supports knowledge creation and sharing enabling its transfer between individuals.

Actually traditional ERPs do not effectively and efficiently provide the required information and knowledge to all the different users that operate in different business processes. Therefore, a new conceptual model should embrace the different layers in which different stakeholder interests, needs and knowledge are reflected for the same process. This new model should be developed to identify the different perspectives in which distributed stakeholders create, obtain, manage and reuse knowledge contents for the same business process along the complete life-cycle in distributed locations.

Therefore the SMARTBRICKS tool, being developed in WP1 of the Swiss DIFAC project by CEMEX Research Group and SUPSI, integrates BPM and KM concepts. SMARTBRICKS Web based tool will enable CEMEX employees to share, develop and reuse BPM contents usually embedded in workers as tacit knowledge by developing and testing the AWI Semantic Web based tool. The main selected bricks for the CEMEX prototype: BPM Wiki, Training, Methodologies, Best Practices, Business Process Architecture (BPA), Process Change Management (PCM) and Research Project. This WP also includes the development of an adequate governance model to enhance collaboration and trust among employees.

Ontologies are implemented in AWI keeping the compatibility with the data structure characterising the PPR+H hub. In AWI some classes are specialized and new classes are introduced in order to also take into account the dimension linked with BPM and more generally management information, both explicit (mainly transactional) and implicit.

**New ERP-human simulation interface**

Information is one of the most valuable resources for manufacturing companies and supply chains as many data have to be exchanged daily to ensure the production activities. In an ideal world, all the conceivable data would be recorded in real time and quickly handled to present accurate reports to the users. Of course, it is a utopia because current computers and software can’t manage such volumes of data. Moreover, capturing so many data would be very expensive in terms of hardware and implementation costs. Thus, it is essential to identify the most useful data and to concentrate only on them. Three levels of aggregation can be defined:

- "Strategic data" leading to potential improvements at the supply chain level
- "Production data" leading to potential improvements at the company level
- "Raw data" to be captured at the shop floor level
Actual production management software (ERP, MES – Manufacturing Execution System -, etc.) do not rely on accurate and up-to-date shop floor data as the classical manual collection is time consuming, error prone and not real time. Major improvements are expected from an automatic capture of shop floor data. The project investigates which information have to be exchanged between ERP and shop floor workers and define the structure of a new interface that will allow an enhanced communication. This will allow monitoring in real time the shop floor performance and being able to use this information to better manage the production processes.

Currently companies do not see as a priority the necessity to transfer at the shop floor level a certain amount of information in order to improve the productivity. Despite this, it is developed the structure of the visualisation means to be used for showing this information to the workers will conclude the development of the bi-directional ERP-human interface. However, prior to implement the bi-directional ERP-workforce interface further efforts are required to convince decision makers about the potential benefits of this kind of tools.

Another challenge for traditional ERP systems is the difficulty to optimise the production scheduling process considering the different disturbances that affect the overall production system. Discrete event simulation (DES) can be used for evaluating the operating performance before the implementation of a specific system/strategy. DES allows to analyse the performance of the “as-is” configuration on the basis of various market environments, described by various “what if scenarios”, leading them to better planning decisions and capture the systems dynamics by using probability distributions. Thus, DES could be used to improve manufacturing facilities and logistics by providing a tool to compute throughput, support the master scheduling, optimize resources, model the supply chain including suppliers’ capacities, constraints, and transportation times and modes, etc. Suitable commercial simulation software is identified, taking into account not only the quality results but also its user friendliness and the availability of visualisation tools, which will help the simulation expert not only to correctly interpret the simulation results but also to transform them into useful knowledge to optimize the system under analysis.

RFID technology integration with the ERP

The highly advertised advantages of RFID technology, confirmed by the results described in section 3, point out the importance of a seamless integration of this new identification technology with internal systems such as ERPs. Such integration can significantly affect the overall design and operation of ERP systems. As increasing amounts of data become available, the nature of ERP and the infrastructure needed to support the system will change dramatically opening new possibilities to do things previously thought impossible to achieve in practice. One of the most important inputs to ERP is data about objects such as raw materials, work in process, and finished goods.

The actual challenge is the management of the information sent to the ERP which could dramatically grow increasing the integration level of the RFID infrastructure. The integration layer under development is designed in order to minimize the information exchange with the ERP, which requires a very quickly access to the essential data. The project is focusing to develop a RFID-ERP integration prototype taking into consideration the requirements from different factories needs according to their manufacturing typologies: MTS (Make to Stock), ATO (Assembly to Order), MTO (Make to Order) and ETO (Engineering to Order).

The performance of the already installed RFID infrastructure (tags and reader) is currently extensively inspected in a laboratory test-bed. A simple visualisation software has been developed to show in the easiest way possible, how the environment surrounding the tag and the reader can influence the reading performance (see figure 14 and 15).

![Figure 14: Laboratory test bed for assessing RFID tag reading reliability](image1)

![Figure 15: Visualisation software showing in real time the number of readings for each tag (white = many; purple = a few)](image2)
This allows to determine if some modifications to the physical infrastructure are required. Moreover, the middleware developments, to be undertaken in order to ensure a reliable and efficient data acquisition and sharing with the ERP system, are identified. In parallel, a business process analysis and reengineering is proposed in order to identify if a more structured environment can be provided (process simplification and standardisation) and to define the characteristics of the user interface allowing to manage the different contexts in which a reading takes place, thus to specify which of the various potential “actions” is actually undertaken.
1.4. COLLABORATION

The three projects were able to fully cooperate thanks to the structure proposed and thought the following main integration topics:

- Integration within the PPR+H schema of the knowledge and expertise information
- Integration between Simulation (EU-CH), ERP (CH) and Factory Constructor
- Integration of ergonomics simulation into the iPortal and Factory Constructor
- Integration of Presence outcomes and semantic-web

The first step for the integration was made through the utilisation of the Semantic web for supporting the knowledge management for the Factory Constructor (FC) scenario. The Semantic Web is an evolving extension of the World Wide Web in which the semantics of information and services on the web is defined, making it possible for the web to understand and satisfy the requests of people and machines to use the web content.

The semantic web developed in the Swiss regional project and its integration into the iPortal allowed the knowledge acquisition and management capabilities of DiFac efficiently supporting the digital factory activities.

The FC AWI can be considered as the integration among the Korean and European work with Swiss result. In the following sections the reader can see how the Korean defined characteristics are starting points for further definition of the Factory Constructor world in the semantic web.

Semantic web

The Intelligent Web Application aims at the knowledge structure. The system will create in a collaborative way information keeping information from different persons. The people participating in the application can have different roles and access rights depending of their role in the organization.

The AWI is developed in HTML plus flax. It’s organized with some basic tabs to be further improved:

- Profile: user’s data and profile
- Users: all users of the specific system
- Groups & Permissions: the administrator gives specific permissions to the different users
- Sharing Authoring: a sort of wiki section
- Ontology: knowledge repository
- Individuals: the world with classes definition and properties

![AWI tabs basic functionalities](image1)

The interesting characteristic of the AWI is the inference rules the system uses for collecting information and give them back to the user. These rules can be changed without changing the world structure. Immediate output is a graphical representation of the knowledge and their relations.
The Factory Constructor word

In order to achieve the integration of the factory constructor the complete data model has been represented in the knowledge repository. In the Ontology there’s the model of the FC world with different classes. Each class has properties and relations. In the next sections there are some example for the different entities.

![Figure 18: Class diagram for the FC](image)

The product/process/resources and human

Starting for the schema (PPR+H) for Product/Process/Resources and Human, further definitions have been developed for a more complete design of the FC in the semantic web. Here the Korean product characteristics are indicated with PPR+H, they are inserted in the AWI with no changes.

The product schema has parent and child elements representing the BOM (bill of material) structure of a product. In this schema, “ChildItemRelation” and “ParentItemRelation” represent the product structure. If one of these parts has a sub-assembly or sub-parts, the ‘Item’ element includes “ChildItemRelation”, which defines a unique “ID” of the child object, and “ParentItemRelation” which has the “ID” of the parent one.

“Archive” element represents information of the CAD file containing the geometric information of a part, such as location, format, size, content. Other schemas for process, resource, and human also have this element.

“Feature” element consists of “GripPoint”, “AssemblyPoint”, “TactPoint” and other similar elements having information of coordinate system. “GripPoint” represents a gripping point for human hands, and can be used for generating human postures in ergonomic analysis. “AssemblyPoint” contains a contact point between parts and the relevant coordinate information. “TactPoint” is a point of contact between a part and a manufacturing resource, and is related to movements of resource. The following pictures show the structure of the product schema in the PPR^H schema and the mind map for the process just as an example.

![Product schema](image)
Figure 21: Mind-map for the process
1.5. EXPLOITABLE RESULTS AND GAINED EXPERIENCE

The project has produced several results that can be differently exploited by project partners depending on their nature. IT partners are currently using the software modules developed for supporting their business. Some tools have been engineered for being sold as products or services. Academic partners are using the tools and the methodologies for supporting their consultancies activities to manufacturing companies in several sectors. Moreover, the research topic has been further investigated and a new project has been started. Industrial partners have started the introduction of customised solutions of a subset of the project results.

As summary of the exploitable results we can mention the following:

- **IT partners**
  - Products: iPortal, Factory Constructor, Training Simulator
  - Consultancy: Prototype Designer, Factory Constructor, iPortal

- **Academic Partners**
  - Consultancy: Prototype Designer, Factory Constructor, Presence and Ergonomics methodologies
  - New research

- **Industry**
  - Use of personalised DiFac solutions

Finally, from the core team of the DiFac (both EU and CH) a new project collaborative large project named VFF: Virtual Factory Framework - FP7-NMP-2008-LARGE-2-228595 (with 30 partners, 12M€ costs, 8M€ funded) has been launched.

1.6. CONCLUSION

The DiFac toolset is able to support collaboration among people delocalised in different places. Products are developed nowadays, more and more, among different sites. The users can design, prototype and manufacture through an interactive environment for delivering better quality products and services results of international collaboration. The use of new technologies reinforce SMEs’ competitiveness in both small-medium and large European industry since they provide many benefits:

- **Increased Efficiency**: team members will be able to collaborate anytime, anywhere making faster decisions and gaining approvals instantly.
- **Reduction in Complexity**: the employees will be able to seamlessly work together, and extend communication and collaboration beyond their organisational boundaries.
- **Reduction in Physical Mock-ups**: the DiFac environment will allow testing ideas on digital (virtual) configurations, employing advanced paradigms of immersive interaction and collaborative work without having to rely on large numbers of physical mock-ups or experiments and tests.
- **Enhanced Organizational Intelligence**: the information will be collected and organized in a single place. New members will be able to view all the history and information very quickly and to start working with the other members is less time, thus improving productivity.
- **Highly Skilled Employment**: the novel methods and tools to be used in the DiFac environment development will require highly qualified jobs based upon the necessity for new engineering and IT skills that will support the intelligent design procedures, using high-end simulation technology and knowledge-based approaches to decision making instead of semi-empirical methods and physical testing.
- **Better working conditions**: as a result of the above employees will have the opportunity to work with advanced supporting tools that will make their lives easier and safer.