DiFac: an integrated scenario for the Digital Factory

Marco Sacco[1], Claudia Redaelli[1], Ciprian Cândea[2], Alexandru V. Georgescu [2]

[1]*ITIA-CNR Institute of Industrial Technology and Automation*
Via bassini 15, 20133 Milano, Italy, marco.sacco@itia.cnr.it, claudia.redaelli@itia.cnr.it

[2]*ROPARDO S.R.L*

Reconstructiei Nr. 2A - 550129 Sibiu, Romania, ciprian.candea@wpcs.ro, alexandru.georgescu@wpcs.ro

Abstract

Digital Factory is a comprehensive approach of network of digital models, methods, and tools - including modelling, simulation and 3D/Virtual Reality visualization- integrated by a continuous data management. (DiFac brochure, 2007). This paper describes the results of the research project named DiFac (FP6-2005-IST-5-035079) founded by the European Commission. DiFac realized a suite of results able to drive manufacturing SMEs from Digital to Virtual Factory. The DiFac Integrated Scenario illustrates the modularity and scalability of the project results. The paper shows a not so far in the future daily life in a possible manufacturing factory named SECONDA Laser Machine. Different actors in various parts of the world re-design a new product in a collaborative and delocalised way, re-organize the production line evaluating it with simulation and ergonomics and finally use the new technologies as Virtual and Augmented reality for designing the new laser machine and maintaining it efficiently.

Keywords

Digital Factory, new technologies, integrated scenario, iPortal, Collaborative Manufacturing Environment (CME)

1 Introduction

The aim of DiFac (Digital Factory for Human-Oriented Production System) is to develop an innovative, collaborative manufacturing environment (CME) for the next generation of digital factories to support the competitiveness of Small to Medium Enterprises (SMEs).

If the larger companies have already adopted *virtual reality* tools in their production chain, the SMEs are still looking for more customised and economical affordably solutions: more suitable for their dimension and less expensive (Consoni et al. 2006, Sacco et al. 2004 and Mancini et al. 2004).

New technologies applications can help SMEs to innovate their process, product and production side but it can also support the purchasing step, maintenance and training. DiFac results can be easily applied to SMEs because they are portable and cost limited. The enterprise can decide to have only some of the solutions answering to specific needs.

Within a digital factory, virtualised environments facilitate the sharing of factory resources, manufacturing information and knowledge, and support collaborative design, planning, production, management and training among different participants and departments. DiFac created a set of solution (software, methodologies and guidelines) for supporting group work in an immersive and interactive way for supporting these manufacturing activities. This paper concerns the presentation of the integrated scenario where, in a day not so far in the future, the manager of a hypothetical laser machine builder company called Seconda organize her daily work activity, new product design and production, maintenance and training with help of new technologies.

2 From Digital to Virtual Factory

Around 230.000 European Manufacturing enterprises with 20 and more employees provides 34 million people with work. (Manufuture SRA, 2006). The new paradigm for reinforcing the European manufacturing reality made by SMEs is the use of new technology. As we can read in FuTMoN report (future of Manufacturing In Europe 2015-2020 – the challenge for sustainable development): "Not only does RTD (Research Technology Development) drive new developments in manufacturing, but more importantly, manufacturing is the contextual driver for more RTD"

Digital Factory is a comprehensive approach of network of digital models, methods, and tools - including modelling, simulation and 3D/Virtual Reality visualization- integrated by a continuous data management. (DiFac brochure, 2007)

Various are the factory challenges to be faced for entering in new market as: providing competitive industrial goods, supporting services at decreased prices or high quality production, by overcoming the customer expectations. Manufuture strategic Agenda identified some priorities for future competitiveness and sustainability:

1. New high-added-value products and services
2. New business models
3. New manufacturing engineering
4. Emerging manufacturing science and technologies
5. Transforming RTD and educational infrastructures

In the industrial transformation model here below illustrated, the virtual factory concept can be located in the third pillar.

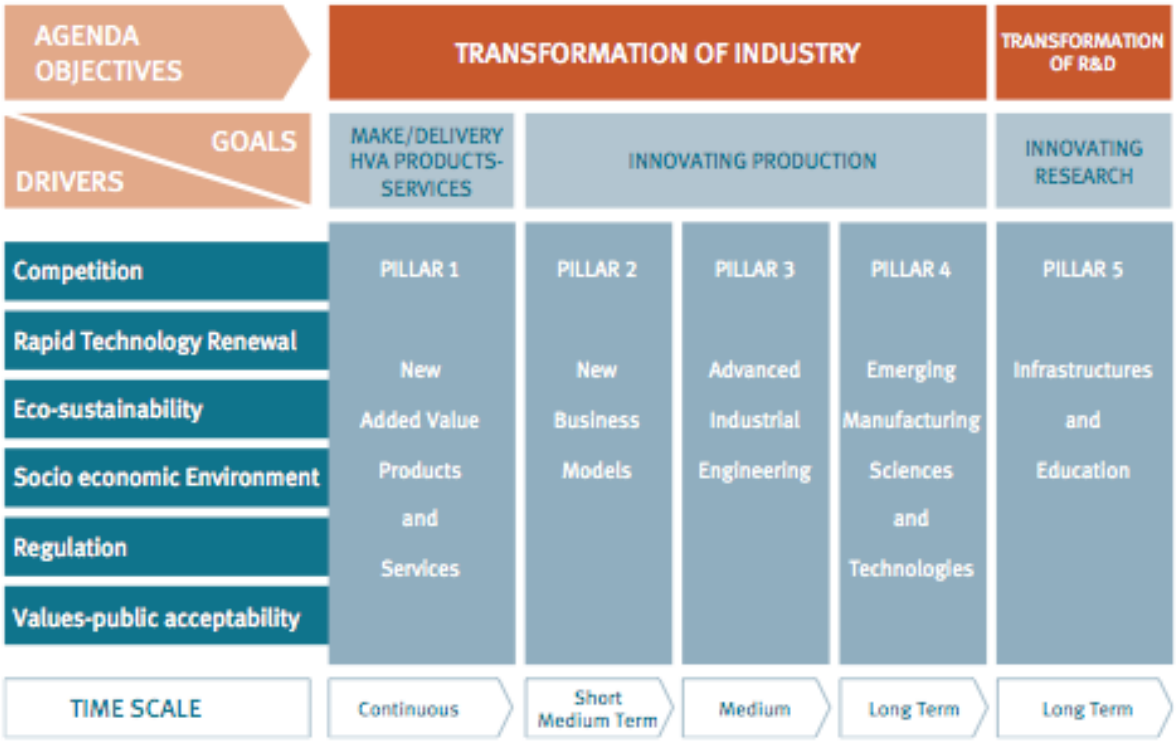

Figure 1: Manufuture industrial transformation model [Manufuture SRA, 2006]

Manufacturing enterprises have to rearrange their organizational structures to be proactive through the changes foreseen in manufacturing processes and markets. Future factory planning and optimisation take into consideration the whole product life cycle, from design to recycling and disposal phases.

Present situation of new technologies application is the **Digital Factory.** Manufacturing realities use a wide range of engineering, planning tools and applications to integrate efficient and effective new information and communication technologies into manufacturing processes. Digital representation is a static model of manufacturing path, methods and tools. The future will be the Virtual Factory, passing from the digital representation of the some factory and manufacturing phases, to the virtual factory entirely virtually represented with processes dynamically up-to-date. To project the factory and manufacturing processes in the future, simulation and 3-D/virtual Reality models, methods and tools will be essential.

The digital factory approach (and the virtual in the future) has many advantages:

- Collaboration among people working on the same project in different places but at the same time.
- Reduction of production times and material waste based on permanent changes performed only virtually on mock-ups of new products. Decision making and innovation process becomes free and interactive.
- The knowledge repository will be a common place where people can find any kind of stored material (designs or documents) in different versions.
- Common working place for collaborating in remote situation where members of a network act and operate on various stages of the same production chain.
- Improved workers efficiency and safety through training and learning on virtual production lines and equipments or even training in emergency situation.

In achieving these objectives new and innovative methods, technologies and tools have to be employed in planning and permanently optimisation of the factory operation and its corresponding manufacturing processes (Westkämper, E., Winkler, R., 2002).

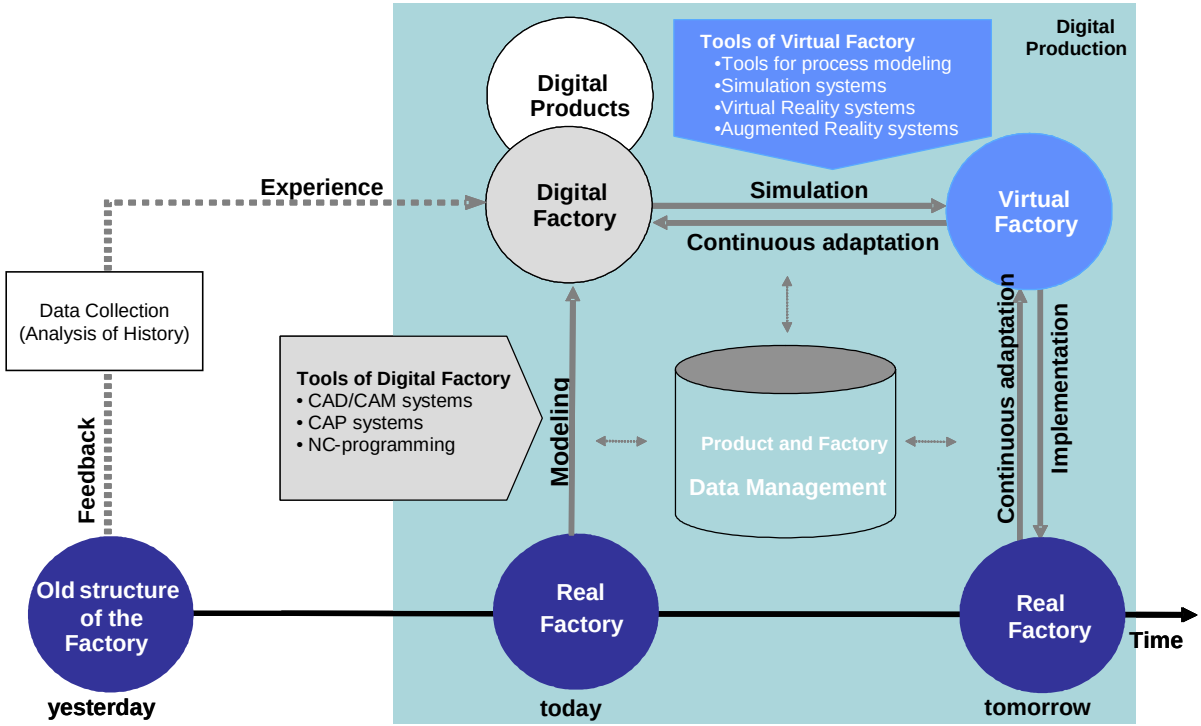

Figure 2: The phases of planning the factory structures: from old existing structure (yesterday factory), to the real structure as it is (digital factory), to the desired structure of tomorrow (virtual factory) [IPA 2007]

3 The entry point: the iPortal

DiFac solutions are accessible through a unique entrance point: the *iPortal*. It is a web-portal customized for the DiFac suite.

As depicted in Fig. 3, 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 filtered with given access rights. iPortal database stores data from each DiFac application. At the iPortal level projects related actions are defined and managed via *User and Role management component*. iPortal is using J2EE technology – portlets and developed upon the *Liferay* portal framework (details below).

iPortal provides conceptual integration of business processes related to the digital activities, and functional integration through the portlets technology.

DiFac iPortal has the following features:

- Single Point of Entry: single sign-on capabilities between users and various other systems. This requires a user to authenticate only once. Access control lists manage the mapping between portal content and services over the portal user base.
- Integration: the connection of functions and data from multiple systems into new components / portlets.
- Personalization: users can customize the look and feel of their environment.
- Permission: the ability for portal administrators to limit specific types of content and services users has access to.

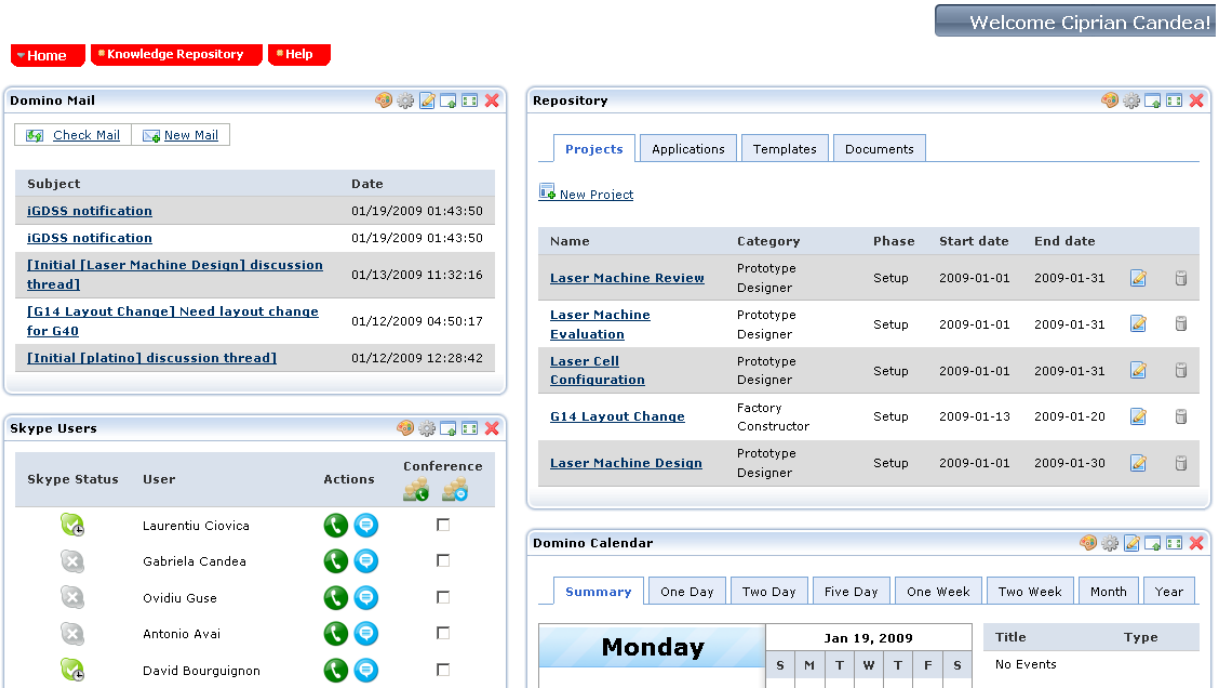

Figure 3: iPortal Dashboard

3.1 iPortal components

The most important components of iPortal are the following:

- *Project Repository* is the component that implements the project concept in iPortal; it allows the users to create/open/edit or delete projects and also to manipulate project templates
- *Wiki* is the component that supports contents generation, it is implemented using the XWiki software

- *iGDSS* is the component (actually an entire system that stands behind iPortal) that offers decision support functionalities.
- *Knowledge database* or *document library* component is a centralized file storage and retrieval system

Other components designed for improving the user in his collaboration activities are: Calendar, Mail, Message Board, Notes Portlet, Skype Integration Portlet etc.

The sections below contain a presentation of the main components followed by a brief description of possible iPortal implementation (section 3.1.5).

3.1.1 Project repository

The *project* concept is implemented under the Project Repository of the portal. The interface allows defining a new project or open/modify an existing one. When a new project is created it automatically appears into all iPortal integrated applications. The wiki part of the portal contains those documents inherited from previously defined template.

3.1.2 Wiki component

Wiki component supports content generation and project templates. It is implemented using the XWiki software. Any user can create documents for sharing his experience and expertise with community members or simply exchange ideas with professionals that are part of the entire virtual environment.

XWiki is advanced *wiki software* which includes a number of professional features:

- User rights management (by wiki / space / page, using groups, etc...)
- PDF export
- Full-text search
- Version control
- Content and site design Export and Import
- Plugins, API, Programming...

On top of this, XWiki is also an application wiki that allows the creation of objects and classes within the wiki.

3.1.3 iGDSS (Group Decision Support System) component

In order to support the Collaboration Manager in offering decision support functionalities the developers used an already existing solution, called iGDSS. This is designed to be a collaborative decision-making support system with safety, utility, efficiency, effectiveness, and usability. The development of iGDSS is based on the principles of GDSS, interactive software and related development techniques. By taking advantage of abundant information on the Internet, networking and database technologies, iGDSS provides decision-makers: comprehensive information access to internal and external data, communication facility, and friendly interface with multiple-user access.

The iGDSS component provides intelligent workflow and decisional support customized for specific DiFac needs, enhancing organizational memory; decision-making tools (brainstorming, voting, categorize etc.) integrated within iPortal and customized for DiFac flows. Advantage of using integrated decisional support tools into DiFac means better quality group decision for their tactical and operational activity.

3.1.4 Knowledge database

This component is a *document library* that provides users with centralized file storage and retrieval access with check-in / check-out functions as well possibility to add Meta information tags. Users can work on same file version improving cooperation and quality into DiFac projects.

Knowledge database creates organization memory that can be accessed / reused for new projects/decisions as experiences. This document library can be accessed using the *document explorer application* through the WebDAV internet protocol.

3.1.5 Implementation details

iPortal is a modern J2EE-web based application that can run on Linux as well as on Windows servers, and it integrates with other DiFac solutions and / or with other enterprise software. The Collaboration Manager uses industry standards such as XML, Web Services, and J2EE to enable a better integration with all other DiFac software.

iPortal is a customized version of *Liferay Portal*, offering those portlets that our solution needs. They are: calendar, message board, news and announcements, file and document management, custom company public and private space with the possibility for each registered user to create its custom space and so on.

The secure environment, identity management and SSO (Single Sing-On) is provided by *iSecurity*. iSecurity is a mature, original java-based framework built upon server-client architecture offering management services, SSO capabilities that replaces the ones provided by Liferay Portal, custom directory connectors and a secure environment. Having the iSecurity framework developed the iPortal and additional developed portlets/applications are full integrated with it creating a mature, enterprise collaborative solution for customers, suppliers and employees.

4 The Integrated Scenario

This section presents a concrete scenario of a hypothetical factory called Seconda that is a laser machine builder that receive an order for a new customized product. The following paragraphs present the different actors of the scenario, their roles and duty in relation with the problems to be solved and the solutions that DiFac proposes.

4.1 The subjects and the story

The following hypothetic companies are the actors of the Integrated Scenario and they are mirror of real enterprises partners of DiFac consortium:

- SECONDA company which is a laser machine producer (in the consortium there's PRIMA INDUSTRIE that is an Italian producer of 2 and 3D laser cutting machines)
- PACOM company, a customer interested to purchase a cutting laser cell (COMPA is a Rumanian automotive industry)

A new IT consortium providing the DiFac Solution. It will be composed by the R&D DiFac partners, who worked on the different following solutions headed by ROPARDO, who developed the already presented iPortal.

Here is the story of the Scenario. PACOM orders a new laser cell from SECONDA. It's composed by a PLATINO laser cutting machine which has to be customized in order to meet special customer's needs.

SECONDA general manger creates a new internal project whose main goal is to design and assembly this new laser cell named "*New PLATINO laser cutting cell.*" For producing the new Platino machine, three are the main goals to be reached:

1. Design a customized Platino cutting laser machine
2. Design the laser cutting cell
3. Re-plan some parts of the actual shop floor

SECONDA general manager uses DiFac solution to support this project to take advantage of collaborative, presence and ergonomics features provided by this solution.

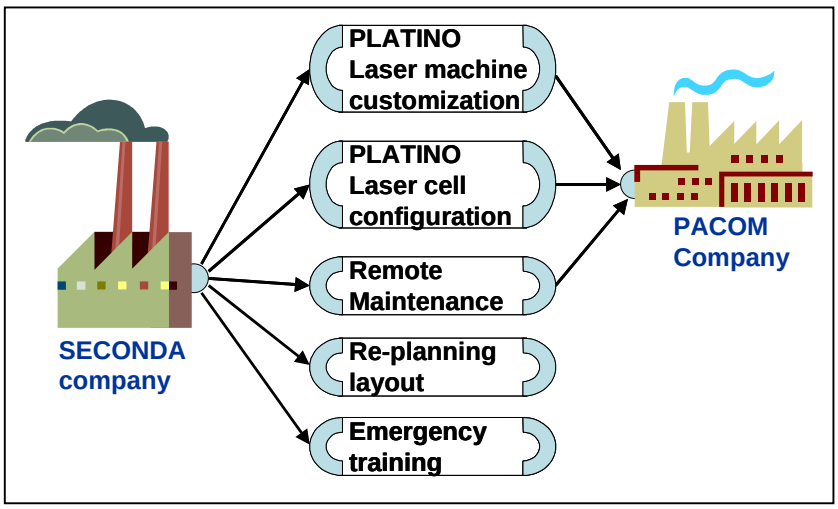

Figure 4: Integrated scenario sub projects

When the design phase starts, two designers in different locations work on the same piece in a collaborative way in real time. At the end the designers find two possible solutions for the same head of the machine. After discussed about the possible selection with the general manager, and being them unable to decide, the prototype designer starts an evaluation session using DiFac decision support system specifying the evaluation criteria: name, description, weight, and others as benefits or costs. Different persons are called to express their opinion about the two options: general Manager, the Assembly Engineer, the prototype designer and the Factory Planner and at the end of the voting session the second one has been selected. The project has to be sent to the production sector: it has some implications on the production process because of few modified components. In order to better assess these implications, the production process is analysed with Factory Constructor, one of the digital activities provided by DiFac solution. Moreover ergonomic considerations related to the new layout can be analysed. The new shop floor can be visualized in an intuitive and user friendly way and the workers can verify the effective ergonomic and collaborative level of their own workstation and give back some suggestions to the Factory Planner. The proposed new lay out passed through a web based simulation process that detects the bottle neck in production and suggests to the factory planner solutions for a definitive construction of the production shop floor.

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 workers training project for updating the training scenario and checking blue collars' preparation.

Pacom can collaborate in its machine definition. The virtual prototype design tool allows the project manager to present the new machine to the customer who can make some changes in collaboration with the project designer.

When finally the machine is settled at PACOM premises, DiFac tool provides the maintenance procedures using an Augmented Reality solution. All new maintenance procedures are uploaded on DiFac iPortal in order to provide an efficient remote service. A technician is available for specific remote maintenance service using the Augmented Reality techniques.

4.2 The problems and the solutions

The integrated scenario has been written as test bed for DiFac solutions. It demonstrates 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 in emergency moments or for machine maintenance.

- the various partners' results are integrated into a comprehensive 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.
- DiFac solution is modular and scalable
- DiFac solution provides enhanced and integrated solutions designed following project end users' requirements.

5 Conclusion

This paper describes the Integrated Scenario that summarized DiFac project solutions and shows a possible real use for solving SMEs' production needs.

The toolset is composed by:

- software as the factory constructor, the prototype designer, the production simulation and the remote maintenance
- methodologies as questionnaires for Ergonomics, Collaboration and Presence for immediate understanding the effectiveness of the virtual environment
- guidelines for checking factory conditions and understand the most appropriate DiFac solutions to be applied

The DiFac results is a prototype to be further improved, the new IT company/consortium will provide the DiFac solution and its customization to the companies. Other competitors have similar solutions (i.e. Simens PLM solution and Delmia) but their target is the large industry. DiFac results are scalable the SME can decide to use the environment in a virtual room and navigate with a 3Dmouse or simply on a laptop. The solution can be installed on company server locally or it can be provided in outsourcing.

References

Consoni Florenzano Souza, M., Sacco, M., Vieira Porto, A.J. (2006), "Virtual manufacturing as a way for the Factory of the Future. Special issue on E-Manufacturing and web-based technology for intelligent manufacturing and networked enterprise interoperability", Journal of Intelligent Manufacturing, 17/6, December 2006, Springer Verlag, ISSN 0956-5515.

Costantinescu C., Durr M., Sacco M., (2008), Innovative VR environment for factory and process planning: DIFac, ICE conference, Lisbon July 2008

DiFac consortium, Project brochure

DiFac consortium, Project Newsletter

DiFac consortium, Project web site

DiFac Consortium, D42

EC, Manufuture: Strategic Research Agenda, reporto of the high-level group, September 2006

EC, Future of Manufacturing In Europe 2015-2020 – the challenge for sustainable development

Mancini, F., **V**iganò, G., Liao, Z., Sacco, M., Boër, C.R., The Virtual Factory: A Semi-immersive Interactive 3D Environment. *SCSC 2004, Summer Computer Simulation Conference*, 25-29 July 2004, San Jose, CA, USA.

Sacco M., Redaelli C., Constantinescu C., Lawson G., D'Cruz M., Pappas M., "DiFac: Digital Factory for Human Oriented Production System", HCI - Human Computer Interaction conference, Beijing (PRC), 25-27 July 2007.

Westkämper, E., Winkler, R., 2002, The Use of System Modelling for the Intelligent Planning, Scheduling and Control of Agile Manufacturing. In: The 35th CIRP-ISMS „Manufacturing technology in the information age", 12-15 May, Seoul, South Korea, p. 644 – 655.

www.delmia.com

www.plm.automation.siemens.com