Enterprise Information Systems Design, Implementation and Management: Organizational Applications

Maria Manuela Cruz-Cunha  
*Polytechnic Institute of Cavado and Ave, Portugal*

João Varajão  
*University of Trás-os-Montes e Alto Duoro, Portugal*
Chapter 29
Multisite PLM Platform:
A Collaborative Design Environment

George Draghici
Politehnica University of Timisoara, Romania

Anca Draghici
Politehnica University of Timisoara, Romania

ABSTRACT

Today, product development is a result of a collaborative design process in network. Taking into consideration this fact, a National Research Network for Integrated Product and Process Engineering (INPRO) has been created. The present chapter presents the relevant items for building a PLM multisite platform for collaborative integrated product development based on the common researches developed in the INPRO project and network. The authors argue this approach by presenting the collaborative distributed design process, the product model and the PLM multisite platform for collaborative integrated product development. Based on these was built a collaborative multisite platform that join together the methodology, methods and tools for Product Lifecycle Management (PLM), Knowledge Management (KM) and Human Resources Management (HRU), examples of good practice. The core of the proposed approach is the product lifecycle model which is the base for the proposed collaborative product development methodology and the multisite PLM platform architecture. The presented research results were gained from our implication in the project “National Research Network for Integrated Product and Process Engineering – INPRO” (contract no. 243 / 08.09.2006). The model of building such collaborative design environment was inspired by the Virtual Research Laboratory for a Knowledge Community in Production (VRL-KCiP) a Network of Excellence project (contract no. FP6-507487). From 2008 the authors extended their research at the European level, in the context of a Lifelong Learning Programme, Leonardo da Vinci - Transfer of Innovation (contract nr. FR/08/LLP-LdV/TOI/117025), “Certified Integrated Design Engineer – iDesigner” in which they used the collaborative platform for the students and researchers professional qualification and certification.

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INTRODUCTION

The Specificity of Collaborative Distributed Design

The product development process has changed dramatically in the last time because of the progresses in the information and communication technology field. Nowadays, the product development is a result of a collaborative design process in network (Shpitalni, Guttman, & Bossin, 2005). Integrated product and processes development supposes to consider all the knowledge about the product lifecycle from the beginning of product design stage, by integrating the user requirements, with the quality, terms and costs constraints (Draghici, 1999), (Usher, Roy & Parsaei, 2005). Therefore, we can talk about the whole product lifecycle integration and management (Stark, 2005). The design of successful and sustainable products is increasingly linked to mastering the challenge of the complexity and multidisciplinary nature of modern products in an integrated fashion from the very earliest phases of product development.

In the same time, many product development projects require cooperation between research teams with different competence, which can be also, geographically distributed. When such a project/product team is set up, all the require knowledge must be considered to solve a certain design problem in a collaborative environment. Design engineers are increasingly confronted with the need to master several different engineering disciplines in order to get a sufficient understanding of a product or service. Competence in the major aspects of the whole product lifecycle is a key element of the skills they require to be able to conceive a product design that fulfils the requirements of all the different actors involved in the product’s lifecycle as well as the constraints imposed by their individual environments. Likewise, engineering teams are getting increasingly interdisciplinary, and thus there is a strong demand for a mutual understanding and collaboration between domain expert team members.

In the following will be explained the specificity of human resources interaction, in the new context of the collaborative distributed design process for better understand the need for building such environment. When a product is designed through the collective and joint efforts of many designers, the design process can be called as collaborative design. This work has to be done by taking into consideration the product lifecycle processes by including those dispersed functions such as design, manufacturing, assembly, test, quality and purchasing as well as those from suppliers and customers.

The main goals of such a collaborative design team might include optimizing the mechanical function of the product, minimizing the production or assembly costs, or ensuring that the product can be easily and economically serviced and maintained etc. Since a collaborative design team often works in parallels and independently using different engineering tools distributed in separate locations, even across various time zones around the world, the resulting design process may then be called distributed collaborative design.

Johansen used time-space 2D matrix to examine cooperative works (Johansen, 1998). The matrix categorizes collaboration into synchronous and asynchronous patterns, shown as Figure 1. This space-time matrix cannot fully represent the emerging collaboration trends. For example, collaboration may happen among different geographically dispersed companies, or within the same company but between two distributed divisions. Here we extend the matrix to a three-dimensional time-location-group space, defined as O (T, L, G) to describe when, where and who are collaborating (Chen et al, 2005).

Compared to the Johansen’s time-space matrix, which is a very useful and concise reference to the particular design circumstance, the proposed 3D time-location-group matrix not only looks at whether participants are in the same place, but
also whether they are operating (prepared, ready for the collaborative process) at the same time or not. By this 3D matrix, there can be considering whether participants are in the same company or group (Chen et al, 2005).

In the collaboration domain, enterprises are usually only concerned the security of data flow; however, the collaboration systems’ architecture and their patterns should also be taken into consideration. Very often, in the domain of one enterprise, the design platforms, such as operation systems, types of network, development tools, database systems, CAD software, etc. are usually heterogeneous, whilst configurations and facilities are often different from company to company. This will result in different architectures and different system functionalities for collaborative design.

As shown in Figure 2, based on the time-coordinate, we define synchronous and asynchronous collaboration. Considering the data location, modeling kernel and functionalities of collaborative design, the tasks can be centralized or distributed. For the participants of collaborative design, it can be inter-enterprise, intra-enterprise or extra-enterprise. Due to the different patterns of collaboration models, it may result in different architectures and solutions for the realization of distributed collaborative design frameworks and finally, environment (Chen et al, 2005).

Collaborative design issues are due to: different groups of people, often with different expertise in accord with the product life cycle phases (like design engineers, technological design engineer, manufacturing engineer, marketing experts, distribution experts, accounters or economist specialists, service and maintenance specialists, recycling specialists etc.) and that can belong to different enterprises, at different places, but having to work together in a specific product design process.

Designing complex products (such as aircrafts or automobiles) requires a tremendous collection of expertise, knowledge, technology and tools. Design resources are often distributed. Participants

Figure 1. Johansen matrix (after: Johansen, 1998)

Figure 2. Co-design patterns in 3-dimension
Multisite PLM Platform

may be in different places as well. Integrated concurrent product development is realized by leveraging modern information and communication technology (ICT) to coordinate people, processes, tools and technologies. Companies (SME more often) and medium-sized suppliers are looking for an inexpensive way for geographically dispersed teams to jointly develop products together over the Internet. Traditional CAD/CAE functionalities nowadays are very often dispersed.

How can design actors manage an efficient inter-relationship (different people relationships) to attend the collaborative design process final objective?

Considering the scenario of collaborative design, a key characteristic is linked with the human relationship development in the context of their professional evolution (including their learning needs, too). For this reason there have been consider the development of the collaborative distributed design environment that is related to the actors-conceptor behavior (that have to be an efficient desired behavior) oriented to the design process objectives’ attending (the final design solution accepted by each actor involved in the process that better satisfied customer/user).

**Brief Description of the Research Organizational Context**

These were strong arguments that determine the establishment of the National Research Network for Integrated Product and Process Engineering (INPRO). The idea behind such network was to overcome fragmentation by applying the network principle to research.

The INPRO network project attend strategic objectives for excellence in research, development and innovation through critical mass concentration at national level of human and materials resources of high value in the field of integrated products and process engineering in Romania and link them at the European Research Area’s priorities, objectives and specific activities. The project joint 121 members (73 PhD, 37 PhD. students, 9 researchers and 2 master students) from 9 research centers, localized in different universities of Timisoara, Bucharest, Iasi, Brasov, Bacau, Suceava, Sibiu and Oradea and a national research institute. The project partners have decided to share their competencies and knowledge in the field of integrated product and process engineering. The project proposal is based on the idea of linking the Romanian scientific research to the European research using the bridge created by the participation of the Politehnica University of Timisoara, by the Integrated Engineering Research Centre, the leader of the proposed project, in the European Network of Excellence (NoE) Virtual Research Lab for a Knowledge Community in Production (VRL-KCiP, www.vrl-kcip.com).

The specific strategic objectives followed by the creation of the INPRO network were:

- Setting up a manufacturing knowledge base in the field of product and processes integrated engineering;
- Increasing research activities performance, stimulating excellence for facilitating the access to the EU research programs;
- Enhancing of the human resources education process by including the young PhD. students in the joint research activities and by assure the access to the disseminating activities in the INPRO network and the connection with VRL-KCiP NoE;
- Facilitating motilities inside the INPRO network (at the national level) and the VRL-KCiP NoE (at the European level);
- Better valorization of the existing material research base and research cost reduction by creating the possibility to common use of the partners’ extant infrastructure;
- Managerial skills development in the scientific research field and increasing the capacity for new financial resources identification.
The operational objectives are:

- Creation, consolidation and development of the INPRO network;
- Initiation and development of jointly executed research activities;
- Spreading of excellence.

The specific strategic objectives were realized by the Joint Program of Activities. It consists of managerial aspects for organizing the INPRO network, but also the methods and tools that are used for the virtual collaborative environment development. This will support the building of a knowledge sharing culture in INPRO virtual organization.

The partners' collaboration and synergy in the national research network INPRO (Draghici & Draghici, 2007) was adapted to the actual requirements of product development. In this context, was built a collaborative multisite platform for product and its associated processes (Draghici, Savii & Draghici, 2007), (Draghici, Savii & Draghici, 2008), that join together the methodological approach, methods and tools for Product Lifecycle Management (PLM), Knowledge Management (KM) and Human Resources Management (HRU).

In this chapter are presented: the product lifecycle model which is the core of the proposed collaborative product development methodology, the human resources competencies database development, and the multisite PLM platform infrastructure.

**PRODUCT LIFECYCLE MODEL**

**Product Model Development**

Many of the world’s most successful brands create breakthrough ideas that are inspired by a deep understanding of consumer’s lives, their needs and constraints, and use the principles of design to innovate and build value. This is crucial as innovation very often has to account for vast differences in cultural and socioeconomic conditions. In order to be able to do so, design engineers need to develop a good level of competence about the whole system they conceive, and about its environment.

For the classic “non-integrated” design methodology a lot of tools called “Design for ...” have been developed, which allow taking into account one specific domain (assembly, maintenance, manufacturing, etc.). Such tools are made to optimize one specific view, disregarding the fact that the global optimization of a system is in general not to be achieved by the local optimization of a series of components. Moreover, what normally has to be a constraint for the system is transformed into an objective function in these systems: Does an assembly have to be minimized, or is it sufficient to respect its operability if in another solution it can be less costly or complicated?

Integrated product design considers that the different constraints previously cited are the aim of different actors who have to control them but who “belong to the same world” (Boltanski & Thevenot, 1991). The common goal is to reduce the cost, to reduce the time to market, to take into account sustainability and to increase quality. Such actors have to work in a concurrent engineering context, having access to a common product model where they can have their own contextual views. They have to respect the just need which consists of giving a constraint on the system as soon as possible if such a constraint can be proved (Brissaud & Tichkiewitch, 2000).

Integrated product design thus does not seek to optimize one single objective, but rather aims at finding the best compromise solution under multiple, often coupled restrictions that are imposed by the actors and environments of the whole product lifecycle. They typically concern issues like manufacturability, assembly/disassembly, modularity, testability, product variant creation, environmental sustainability, product-service optimization, maintainability, cost minimization,
etc. It goes without saying that Integrated Design Engineers are not supposed to master all the associated complex disciplines by themselves. They should, however, be able to understand domain experts, and be able to translate their requirements into their design tasks.

The collaborative product development model integrates knowledge from all the product lifecycle activities. For the product lifecycle representation there can be used different methods and modeling languages. Among them, there have been choose the IDEF0 (integrated Definition Method) (www.idef.com/pdf/idef0.pdf) as our preliminary research approach. This allows researchers to define the platform needs and also, its future structure.

IDEF0 is a method designed to model the decisions, actions, and activities of an organization or system. IDEF0 was derived from a well-established graphical language, the Structured Analysis and Design Technique (SADT).

The followed purpose is the deep analyze of each product lifecycle activity, under different aspects: the role of each activity, sub activities deployed, the transform parameters, the supports that allowed the development and control of an activity, the information exchange. In this context, IDEF0 method best attend the declare purpose. Each activity can be representing under a modular and graphical form, using arrows with a specific signification. One activity transforms input into output data. The activity development need assistance tools and control tools that allowed its development start or control.

For the representation of the product lifecycle model there have been used the iGrafx 2007 software (www.igrafx.com), which contained the IDEF0 module.

The superior level diagram A0 (Figure 3), has defined by the product lifecycle specific activities:

**A1 Activity: Needs analysis.** The objective is to identify and formulate the needs for product development. The initiation of this activity is determinate by many factors as: a new market perception, an idea and technical and/or commercial un-satisfaction user perception. These correspond to some marketing function roles. The result of this activity is the product task book.

**A2 Activity: Design.** Product design can be defined as an entirety of activities and processes which allow us to pass from the idea of a new product (or improving an existent one) to information (drawings, programs, etc) which allow the production launching and ensure the product's use and maintenance (Perrin, 2001), (Prudhomme, 2000). Among design models the most representative is the model of Pahl and Beitz (1984), which is based on a design seen as a hierarchical, sequenced phases, the predominant logic being the convergence. At the origin of each new technical object, there is a specific problem to solve and a goal to focus on. The first phase of design consists in establishing the desired technical and economical specifications. The next phases consist of comprehending the design as a process of an increasingly defining process of adopted solution or like a bridge from a function (abstract form) to a solution (certain form). In the conceptual design
phase, after a functional analysis and a study of possible technical alternatives available for each function and sub-function a concept for the design object is usually chosen. The goal in the embodiment design phase is to determine the shape and the dimensions of the artifact. During the detail design phase are mentioned the components of the product and are formalized the papers needed for preparing the supply and manufacturing the components.

The A2 activity’s inputs are the product task book and the feedback information from manufacturing, use and disposal phases. Using design methods and the study of possible alternatives there can be chosen the conceptual solution which followed the embodiment design and detailed design phases; the process planning is then, defined. Finally, is defined the product file and the manufacturing file that are needed for the following activities associated with the product manufacturing and use. Companies that design successfully have carefully crafted Product Creation Processes (PCP) that extends over all phases of product development from initial planning to customer follow-up. Their PCP is their plan for continuous improvement. The decision to develop and operate under a PCP is a corporate one. Successful operation of a PCP requires extensive cooperation among a firm’s marketing and sales, financial, design, and manufacturing organizations. In the idealized account of the PCP, everyone cooperates, desired quality is achieved, and the product succeeds in the marketplace. In practice, the process is difficult and full of conflict and risk. Converting a concept into a complex, multi-technology product involves many steps of refinement. The design process requires a great deal of analysis, investigation of basic physical processes, experimental verification, complex tradeoffs between conflicting elements, and difficult decisions. Satisfying the different and conflicting needs of function, manufacturing, use, and support requires a great deal of knowledge and skill.

A3 Activity: Manufacturing includes preparation and resources allocation for the components manufacturing deployment and for product assembly and so, it becomes ready for delivery. The information results from the manufacturing phase are included in the manufacturing management file that can be use for product design improvement.

A4 Activity: Use. The manufactured product has delivered to the user and his/her expectations have to be satisfied through the use phase. During the use phase, the product is liable to maintainable
operations. In the use process all the information are record in the using product file and they had used for the product design improvement, too.

**A5 Activity: Disposal.** The used product is disposed, at the end of his life cycle. The first action is the disassembly and the components and materials sort in remanufacturing parts that can be inputs for other product assembly components; recycled materials that can be inputs for the supply chain; stored wastes components that have to be destroyed and storage, resulting wastes. All the output information included in the disposal product file can be use for the product re-design improvement, too. Each activity module is the object of a progressive decomposition in diagrams, which contain sub activities, till the elementary detailed level.

**Collaborative Distributed Design Support and Implementation**

In technical terms, collaborative product development in terms of the system- and process-oriented view elaborated in the previous chapters is based on the integration of Product Lifecycle Management (PLM), Enterprise Resource Planning (ERP), Supply Chain Management (SCM) and Customer Relationship Management (CRM) solutions (Figure 4). Integrated design engineers not only have to be able to work with these tools, but they also need to understand how they link the different teams and actors that are involved in the product lifecycle.

Although in human terms collaborative engineering is based on the support of the organization, it is very much facilitated by the awareness of each engineer about his role in the process, as well as the roles of others. Collaborative design involves product designers, manufacturing engineers, and representatives of purchasing, marketing, and field service in the early stages of design in order to reduce cycle time and improve manufacturability. This practice helps resolve what is often called the designer’s dilemma, the fact that most of product cost, quality, and manufacturability are committed very early in design before more detailed information has been developed.
The key to the successful use of collaborative design concepts is the ability to organize and manage concurrent processes and cross-functional and typically distributed teams effectively. Obtaining this know-how is not a matter of studying textbooks but rather demands a balanced blend of solid experience and of theoretical background. This is what the professional seminar program to be conceived in this research shall convey in sector- and national-specific contexts.

**HUMAN RESOURCES COMPETENCIES DATABASE**

The human resources data base, in the context of a virtual organization like INPRO, was a complex task considering the partners’ specificity and their heterogeneous. Human resources management was linked with the organization creation, consolidation and development and, also with its sustainability.

Partners’ integration and network’s organization and development were activities focus on adapting the organizational activities of the network through a strategic plan, for developing and maintaining a continuous vision of industrial needs, identify the most demanding market requirements, defining the knowledge map and a competence profile regarding the current expertise of each member. In addition, there will be developed a policy to strengthen relations between the research activities. The work phases are:

- Definition of a strategic plan for the partners’ integration - using the SWOT analysis method for the diagnosis of the internal and external environment regarding the INPRO network there have been elaborate the strategic priorities of the network. The procedure was applied in each year for the strategy up-date;
- Developing and maintaining a continuous living and upgraded vision on future industrial needs. A marketing research by opinion poll method and a questionnaire tool were developed for the industrial needs identification regarding research, development and innovation activities and/or support. Each partner has distributed and collected the questionnaires in his geographical area. The marketing research is developed each year for the vision up-date;
  - Define a knowledge map and a competence profile;
  - Development of a policy to strengthen the relations between the research activities.

The roadmap for setting up such a network, like INPRO, involves the creation of a group initially consisting of 6-8 research teams or labs, establishing links and scientific cooperation with external labs and building ties with industrial partners. Obviously such a network is not primarily hierarchical in nature, and cooperation cannot be dictated from above. The topics and subjects covered and researched are extremely diverse, to some extent uncontrolled, and constantly changing. Thus, we can assume that networks are adaptive and flexible but hard to manage and coordinate.

Hence, the need for ontology in networks is apparent. The ontology of the network must be much more extensive than normally required in SMEs and is more likely to capture information measured in larger companies. Furthermore, network ontology creation is not an evolutionary process. Nevertheless, networks need a clear ontology (along with a commitment to use it), first and foremost for knowledge mapping. Such a knowledge map must be created to define and classify the knowledge available in the network and to associate each knowledge topic with the labs/partners that have the appropriate expertise. Yet, the ontology must be specific to the network and limited to its scope. In this chapter, we concentrate on a specific national network, as INPRO. This network focuses on all aspects of the product life cycle, as shown schematically.
Consideration of any knowledge base, knowledge-based system, or knowledge-level agent must be based upon some formal conceptualization, either implicit or explicit (Gruber & Olsen, 1994). This is true for the product lifecycle as well. That is, a body of formally represented knowledge must be based upon a conceptualization: the objects, concepts, and other entities that are assumed to exist in that area of interest and the relationships that hold among them. This type of common terminology, or ontology, is used to develop a common understanding of the information in a knowledge domain and to provide the means for automatic searching (Genesereth & Nilsson, 1987).

In the present research, the first step in building the product lifecycle ontology involves identifying the current competences of the members of the cooperative project, as well as industry requirements. The goal of this ontology is threefold: 1) so people can understand and describe what they do in order for others to read about and understand it; 2) so software agents can search relevant information; and 3) so humans can examine the information as well. The ultimate goal is to achieve something that can be understood by non-experts as well by machines, so that both can codify and personalize the knowledge in the network.

Hence, a preliminary ontology for the product lifecycle was devised to determine and map the competences of the INPRO network’s members. This was the second phase of the research approach for defining the input knowledge resources of the PLM multi site platform. This formal conceptualization of the product lifecycle domain was used then as the basis for applying the genetic search algorithms for selecting the required research groups. The hierarchy in the preliminary ontology was based upon discussions and interactions among experts in the field from different partners. As a result of this meeting, the following six categories were determined for the first level of the hierarchy: Design, Manufacturing, Assembly Use, Disassembly, End-of-Life (Shpitalni, Guttman, & Bossin, 2005). The initial (top level) components

**Product Lifecycle Ontology**

![Diagram of product lifecycle ontology](image-url)

**Figure 5. Schematic description of the product lifecycle**

**Figure 6. Top level components of the product lifecycle ontology considered in the INPRO project**
of the product lifecycle ontology are shown in Figure 6.

Based on recommendations and suggestions from colleagues and implicit knowledge of experts in the fields, each category was then sub-divided, and a questionnaire was devised and distributed among the participating research groups. Figure 7 illustrates part of the questionnaire (related to manufacturing) circulated to determine the expertise of each group.

Six concept categories were defined, which determined the first hierarchical level in the ontology: design, manufacturing, usage/maintenance, end of life cycle. Each category was further divided and a form was designed and distributed to the network members. A snippet from the ontology, created using Protégé (Protégé, 2007, http://
protege.stanford.edu), for the design stage, is presented in Figure 8.

**Building the Knowledge/Expertise Map**

Information about the network members’ expertise are processed following a bottom-to-top scheme, starting from those of the persons and ending with that of the network. To be able to automate the data processing, at least partially, for each field in the form which indicates the presence of a competence, the value 1 was assigned, the rest being left with the value 0 (blank).

The first map shows the personal competencies and was created by summing the fields towards the ontology root. A synthesis of the competencies can be done by computing the percentage of the persons in the network that have competencies in each field.

Two significant values result were obtained: (1) the number of competency fields in the domain of the product life cycle for each partner (department/laboratory), and (2) the number of competency fields for each partner, grouped by products. One must note that a greater number of competencies for a person does not mean that this has a greater global level of competency than another person, with a lower number, but possibly with more impact and visibility at international level (in a narrower field). Another map shows the competencies at the network partners level (Tables 1 and 2).

The analysis of the map can yield information about the poor covered zones (empty spaces in the tables) by certain partners or at the network level, i.e. indications about the domains in which the
The network must work to gain competencies through the training procedures of human resources.

Creating the Database with the Network’s Human Resources Competencies

The data from the forms were extracted in a neutral format (CSV), and then used to create a usual database (by importing data from CSV text files). For the Microsoft Access application, splitting the data into three tables was necessary, because of the great number of fields (255+255+253). The three tables were linked by relations using key fields. In order to find the person with certain competencies, a usual Access query is launched (Figure 9) or using SQL.

An Internet based interrogation is in train to be finished, using MySQL. This creates the possibility to query the (sole) competencies database by each partner, from his office or from anywhere an Internet link exists.

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<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
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Multisite PLM Platform

Table 2. Competencies at the network partners level: II Products

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Figure 9. An Access query about competencies

THE ARCHITECTURE OF THE MULTISITE PLM PLATFORM

Based on the preliminary researches concerning the product lifecycle representation and the human resources competencies capitalization and explore, there have been developed the collaborative multisite PLM platform. The main objective and motivation of this approach was to build a collaborative environment for the product design process. The PLM multisite architecture for the collaborative product development is based on the integration of the Product Lifecycle Management (PLM), Enterprise Resource Planning (ERP), Supply Chain Management (SCM) and Customer Relationship Management (CRM) solutions (CIMdata, 2002).

The INPRO universities partners’ PLM platform and the potential industrial partners have been connected through Internet/Intranet and they built the multisite PLM platform of the collaborative product development in network. A client-server architecture has been used inside the network (Figure 10). It consists of a four servers cluster,
Multisite PLM Platform

for: Internet/Intranet (S1), databases (S2), PLM and videoconference system. This is the core of the information technology (IT) architecture definition and design.

A preliminary stage of the architecture development process includes also, the definition and the configuration of the INPRO research network’s web page (Figure 11). This is linked also, with the project operational objectives and the partners’ integration in the research activities. The web page consists of information regarding: the project objectives and activities, partners’ description (link to their own web pages), conferences (scientific events), workshops and meetings that are organized by the partners, research results (with public interest) and the link to the Intranet section that was restricted to the network members only.

Beside the INPRO web page development there have been settled an entire communication system dedicated to the common research work in the network, but also, to the access at some research resources of the European Network of Excellence, Virtual Research Laboratory for a Knowledge Community in Production (www.vrl-kcip.org),

Figure 11. Detail of the INPRO research network web page
Multisite PLM Platform

Table 3. CAD/CAM and PDM systems of each partner involved in the multisite PLM platform

<table>
<thead>
<tr>
<th>Partners Systems</th>
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</table>

Table 3. CAD/CAM and PDM systems of each partner involved in the multisite PLM platform

in the European Research Area (see Figure 11). Also, with the support of the videoconference system the collaboration was possible.

The INPRO partners’ PLM platforms architecture design has included a large diversity of software. To illustrate the large variety of information technology applications used in such context, the list of CAD/CAM and PDM systems of each partner involved in the PLM multisite platform is shown in Table 3.

The most important problem that has to be solved between partners was the compatibility of the design format/representation because of the existing of the different design software. Finally, the Teamcenter Community software solution was the option for harmonizing the design parts delivered by the partners and that have conduct to a final product.

In collaborative product development, partners have to exchange their product data with other partners in order to update their digital mock-up (DMU). It represents an effective problem for data exchange because each partner has to translate other partner’s data to the format of his own CAD and PDM systems. A solution for this problem has been presented in (Guyot et al, 2007). This solution has been adapted for the PLM multisite platform architecture design.

To translate the meta-data into common format and send those to partners there have been built an exchange architecture integrated to the new PDM. The solution is to use a PDM interface that extracts all the DMU’s data in a storage files with an internal format. This interface is the same for all projects. After extraction, storage files are filtering and translating into project’s common format.

The use of a generic PDM interface limits the application customizations for each project: instead of extracting data with the translator of each project, there has been build one interface for all projects. Furthermore, data extraction in internal format allows the project coordinator to run other internal processing on DMU’s. On the other hand, the translation depends on common format so that it cannot be the same development for all projects. Now, the aim is to reduce developments between the different translation processes.

Figure 12 has shown the mechanism of data exchange between partners in a collaborative project. The aim of the new system is to use the
same steps for each project and to reuse mechanisms between projects. So, in the Figure 6, these different steps have depicted. During an export phase, PDM interface extracts geometric data and the whole product’s meta-data (phase 1). Two different translators (phase 2) translate geometric data and meta-data to the common format. When all data are translated, they are packed and sent to partners (phase 3). During an import phase, partner’s data are unpacked (phase 4) and meta-data are translated (phase 5). PDM interface imports translated meta-data and partners’ geometric data (phase 6).

CONCLUSIONS AND FUTURE WORK

In the framework of the National Research Network for Integrated Product and Process Engineering (INPRO) it was built a collaborative multisite PLM platform for the product development and its associated processes. The proposed product collaborative development model integrates knowledge from the entire product lifecycle. There have been discussed the product conceptual design phase and there have been presented.

In the paper has presented the main aspects that reflect the achieved stage of the project of building the collaborative product development network: the product life cycle model, the network members’ expertise, and the PLM multisite platform infrastructure. The product life cycle model is the base of the collaborative design methodology that has adopted for the PLM multisite platform. The model of collaborative product development integrated the whole lifecycle. For identifying the persons with the required competencies for a specific project, an Access or an Internet usually query has launched, using MySQL. The universities partners’ PLM platforms and the potential industrial partners have connected through Internet/Intranet, constituting the PLM multisite platform of the collaborative product development network.

The future research work is related to the INPRO networks resources valorization in the context of the Certified Integrated Design Engineer - iDesigner project (FR/08/LLP-LdV/TOI/117025) which deals with the creation of a professional modular qualification program with certification for the new job role of an integrated design engineer. This transfer of innovation (ToI) project integrates and transfers the results of other
former EU projects and the only Network of Excellence in Manufacturing and Innovation (VRL-KCiP that have been transform in the EMIRAcle association) but also, some past national projects developed by the partners.

The new results will be transferred to the market in form of job role based training and certificates. The iDesigner project’s partners are: Institute Polytechnique de Grenoble (coordinator) – France (GNP), Poznan University of Technology – Poland (PUT), Politehnica University of Timisoara – Romania (UPT), International Software Consulting Network (ISCN) – Austria and the European Manufacturing and Innovation Research Association a cluster leading excellence (EMIRAcle) – Belgium that is responsible with the dissemination activities and results.

The qualification and certification of integrated design engineers addresses itself at experienced design engineers (as the INPRO network’s members can be considered together with master programs or PhD. students that belong to the partners universities) who want to complement and/or certify their advanced design skills. The students typically aim at a senior or principal engineer position in their design teams, but also, for managing positions. The certificate, however, is not supposed to certify the student’s capabilities as a design team manager. One of the biggest challenges is to conceive a training program that covers the complete skills set in a maximum of three weeks.

Table 4 shows a skill set which provides the basis of our future research and development activities. It is the result of an initial consolida-
tion of our experiences in research, education, as well as in collaboration with industry. Although we consider this skill set already stable, it is supposed to evolve in the course of the project as we involve experts from different industrial sectors, and get the feedback from partners in industry and academia and from students of initial training seminars.

We consider the skill units process competence, systems engineering, knowledge management and sharing, and collaborative distributed design, largely independent of specific industrial sectors, whereas under responsible (aware) design we subsume more specialized skills, which are supposed to be trained using case-studies mainly. As will be developed in the future (2010-2011), the training and certification concept is modular, so that students (target groups) will be able to choose those specialized skills that are relevant to their professions. Most of the competences that are indicated in Table 4 are closely linked to lifecycle engineering knowledge and skills.

**AKNOWLEDGMENT**

We would like to thanks to our research partners that give us constant support and encourage us to develop the PLM multisite platform as a national collaborative design environment. The presented researches have been developed under the financial support of the CEEX program in Romania during the project: “National Research Network for Integrated Product and Process Engineering – INPRO” (contract no. 243 / 2006) and the Virtual Research Laboratory for a Knowledge Community in Production (VRL-KCiP) a Network of Excellence project (contract no. FP6-507487). From 2008 we extend our researches at the European level, in the context of a Lifelong Learning Programme, Leonardo da Vinci - Transfer of Innovation (contract nr. FR/08/LLP-LdV/TOI/117025), “Certified Integrated Design Engineer – iDesigner” in which we use the collaborative platform for the students and researchers professional qualification and certification.

**REFERENCES**


