



## NATIONAL RESEARCH NETWORK FOR INTEGRATED PRODUCT AND PROCESS ENGINEERING, INPRO

George DRĂGHICI, Anca DRĂGHICI, Eugen PAMINTAS, Cristian TURC

**Abstract:** *The paper presents the relevant aspects for building the National Research Network for Integrated Product and Process Engineering (INPRO) that was initiating under the finance of the CEEEX Program. Based on the principles of integrated engineering and by building a collaborative virtual environment, 121 members (73 PhD, 37 PhD. students, 9 researchers and 2 master students) from 9 research centers, localized in the Universities of Timisoara, Bucharest, Iasi, Brasov, Bacau, Suceava, Sibiu and Oradea and a national research institute have decided to share their competencies and knowledge in the field of integrated product and process engineering. The integration of each partner in the INPRO network and the work modality are shown in the Joint Program of Activities. The main actions that are described in the paper are the creation, consolidation and development of the network, initiation and development of jointly executed research activities and spreading of excellence. Based on these some conclusions are elaborated in the end.*

**Key words:** *integrated product and process engineering, research-development-innovation, research network, research platform, communication, knowledge management.*

### 1. INTRODUCTION

Integrated engineering can be defined as a methodology, which allows integrated and simultaneous design of product, and its processes as manufacturing, maintenance, recycle etc. (Draghici, 1999). Integrated product and process development supposes to consider for product design all phases of its life cycle, in which the user requirements, quality problems, terms and costs are integrated (Ulrich, 2004), (Usher, 2005). Therefore, we can talk about the whole product life cycle integration and management (Stark, 2005).

Many product development projects require cooperation between research team with diverse competence, which are geographical dispersed. When such a project/product team is set up, all needed knowledge must be considered to solve a certain conception problem in a collaborative environment. The product development process has changed dramatically in the last decade because of the progresses in the IT field. Nowadays, the product development is a result of a collaborative design process in network (Shpitalni, 2005).

The researches in the field of integrated product and process engineering are developed by research centers, laboratories from universities all over the world. In Europe 24 of them are partners in the Network of Excellence (NoE) *Virtual Research Lab for a Knowledge Community in Production* (VRL-KCiP), financed by the sixth Framework Program (FP6) of the European Commission (Tichkiewitch, 2005).

At the national level, the scientific research has a spread tendency, because of the low capacity of using and sustaining the research results by industry. The academic research has to be improved because of the result integration in the academic courses. So far, the main research-development-innovation (RDI) fields are cor-

related with those established by the European Commission for R&D. Therefore, there is an initiative for integrate the national scientific research in the European Research Area (Anton, 2006).

The project INPRO network attend strategic objectives in high RDI 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 ERA'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 the Universities of Timisoara, Bucharest, Iasi, Brasov, Bacau, Suceava, Sibiu and Oradea and a national research institute. They 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 (UPT), by the Integrated Engineering Research Centre (CCII), the leader of the proposed project, in the European Network of Excellence (NoE) *Virtual Research Lab for a Knowledge Community in Production* (VRL-KCiP).

The project sustains RDI activities that include fundamental, applicative researches of pre-competitive level and which are made together by the INPRO network's partners. This following: integration, increasing quality and performance activities; development of a long time partnership between the partners and *regional research centers* establishment: South Pole (Bucharest), East Pole (Iasi-Suceava-Bacau), Central Pole (Brasov-Sibiu), West Pole (Timisoara-Oradea), as it is shown in Fig. 1. The regional research centers will concentrate the scientific research and the human and material resources of high

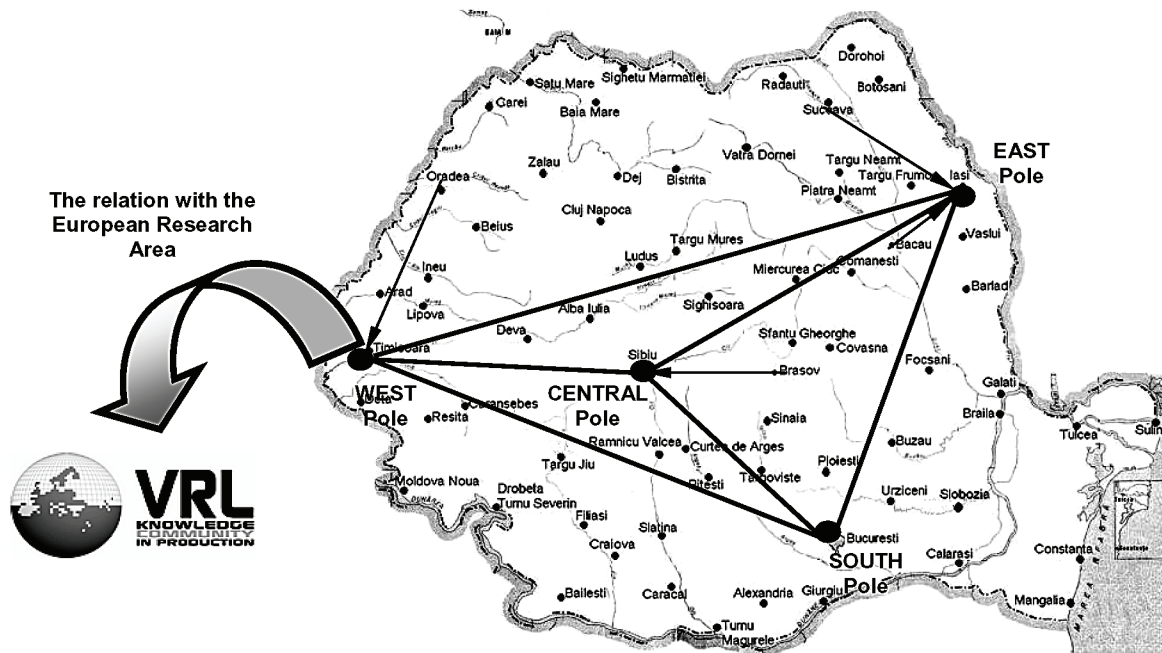


Fig. 1. The relations between the research poles inside the INPRO network and the link with the European Research Area.

performance from their region, by taking into account their local specific/conditions but, also, for their adapting and integration at the national level.

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

- setting up a manufacturing knowledge base in the field of product and processes integrated engineering;
- increasing research activities performance, stimulating the specialized research team foundation in the priority r&d fields and 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 the mobilities inside the inpro network and the vrl-kcip noe;
- superior 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 can be realized by the Joint Program of Activities depicted in Fig. 2. 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 the virtual organization, as INPRO network is.

## 2. CREATION, CONSOLIDATION AND DEVELOPMENT OF THE INPRO NETWORK

### 2.1. Partners integration and network's organizing and development

These is 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.* We will use the SWOT method for the diagnosis of the internal and external environment regarding the INPRO network. Based on this, we will elaborate the strategic priorities of the network. The procedure will be applied 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 will be developed for the industrial needs identification regarding research, development and innovation. Each partner will distribute and collect the questionnaires in his geographical area. The marketing research will be applied each year for the vision up-date.

*Define a knowledge map and a competence profile in order* is necessary to know about the current expertise of each member. The creation of a research network requires the acceptance (understanding) of terms (knowledge) set that have to be used for allowed the collaborative environment creation. This common terminology is named ontology. There are defined six categories of concepts about the product lifecycle that determine the first level of the ontology: design, production, assembling, using,

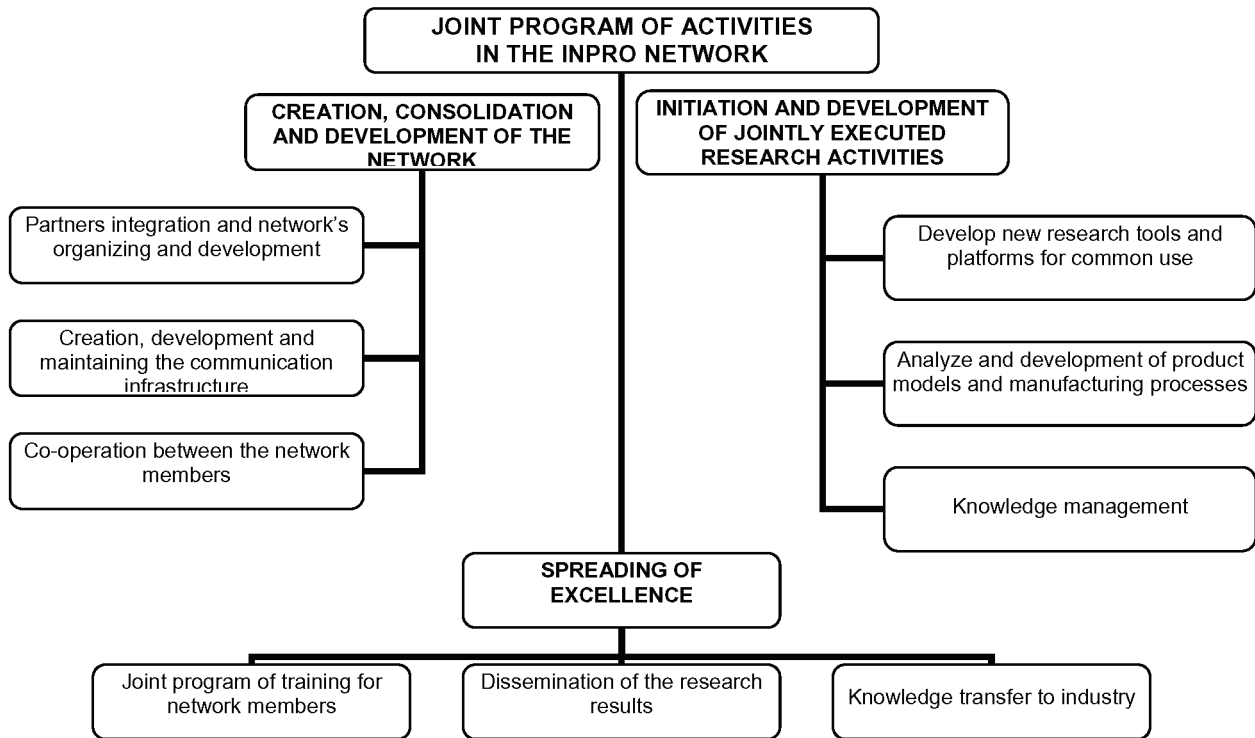


Fig. 2. The INPRO network's joint program of activities

disassembling, and end-of-life. Collecting the competencies of each member in INPRO network (opinion poll, questionnaire) will build the preliminary ontology and the knowledge map (Access database). These will be actualized each year.

*Development of a policy to strengthen the relations between the research activities.* The methods and tools that will be applied are in the field of researchers' motivation and implication.

## 2.2. Creation, development and maintaining the network communication infrastructure

This will focus on defining, developing and managing common tools for internal and external communication and knowledge sharing. The work phases are:

*Definition of tools for internal communication.* Will facilitate the collaborative work in the virtual environment. The tools that will be used are visio-conference equipment, servers and specific software for the knowledge management and sharing, common knowledge databases.

*Definition of tools for external communication* will support the activities for the spreading of excellence from the network to the external environment. The network's web page will include information about the partners, the activities developed, results, news, e-journal and a section for the monthly report for the researchers work.

*Demonstration of software tools and, where is possible, making them available to other partners through the Internet.* The software own by the partners will be available to all INPRO network members through Internet and they will support the common research.

The INPRO network decided very early to lean the joint work of the members and a part of the work dissemination on a visioconferencing (VC) system. This will

allowed the easy relation with the VRL-KCiP NoE, by using the existing system and experience of the Politehnica University of Timisoara. The VC system consists of four remote VC of the INPRO network sites across the country, established in each research pole. A collaborative usage of the system for:

- training and common research activities;
- collaborative work (working group, application sharing, phd. thesis presentations etc.);
- management of the network (the meetings of the partners' managers);
- inpro network activity archiving and streaming;
- work jointly with industrialist, in the european research area with the vrl-kcip noe.
- the meaning that the system must support:
  - ip or isdn communication;
  - an international service;
  - interactive multi-sessions for the partners;
  - high quality and service.

Based on the requirements of the system and on the fact that in Timisoara is a Polycom visioconference system (already connected with the VRL-KCiP NoE), the same system will be install in the other pole centers (Bucharest, Iasi and Sibiu). In Fig. 3 we presented the VC system architecture.

Some technical aspects of the VC system are:

- polycom vsx 7400: good quality video codec, good quality audio codec, «jungle» connection, proprietary solution;
- central mcu: polycom acord mgc 50: highest technical solution, friendly interface, proprietary solution (polycom);
- commercial issue: there is a national dealer for polycom and he will assure 3 years of services for vc

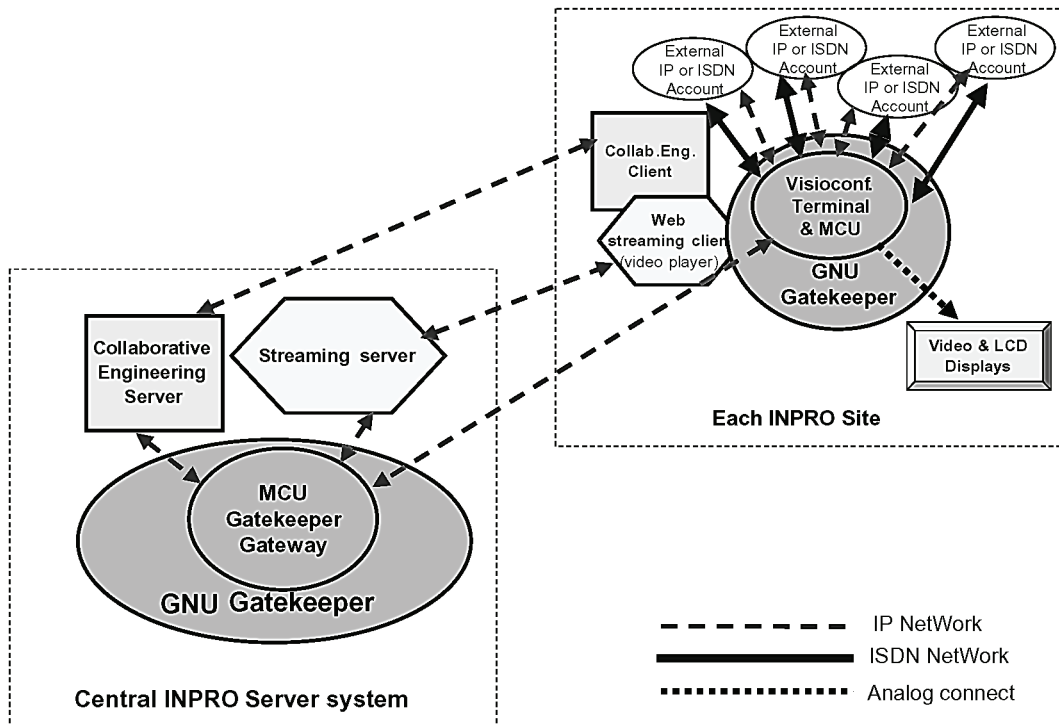


Fig. 3. The visio-conferencing system architecture.

terminals, displays and mcu server. in addition, they will offer other facilities like initial training, hot line and system up-grade.

### 2.3. Cooperation between the network members

With the aim to sustained the collaboration between partners, but also with other national and international Networks, there will be formed an *Adviser Council*. It will gain a specialist from each Pole Center, which is PhD advisor and has experience in collaboration with external partners and in European research projects or mobility. The main attributes of the Adviser Council are: the graduate projects', master and PhD programs' thematic elaboration; the PhD supervisors and reviewers database creation – for facilitate the co-supervision of PhD. programs; establishing of the internal rules and documents needed for the co-supervision of PhD. programs; supporting a legislative initiative that can facilitate the co-supervision PhD. diploma recognition in the European Area; creating a database consists of the international research and mobility programs that can facilitate the PhD. programs and the research in well-known European Labs, including visiting professors; specializing of a group of councilors for internal and external research programs' applications development; elaborating of a complete Guide for internal/external mobility regarding the students, PhD. students and the researchers. This will focus on encouraging mobility of the partners, their common work for articles and books and co-ordinating the PhD topics (joint supervision of PhD students). The phased are:

*Encouragement of mobility.* Exchange of personnel and cooperation on diploma student projects and master projects are important integration aspect that has a great interest for all the network members.

*Co-ordination of PhD topics, initiation of joint supervision of PhD students.* In order to facilitate the exchange of PhD students we have to create a database of subjects and candidates for PhD research. This database will be used to support joint supervision of students as defined just before, and in order to allow the PhD thesis presentation in the network frame.

## 3. INITIATION AND DEVELOPMENT OF JOINTLY EXECUTED RESEARCH ACTIVITIES

The activities presented below take into account the new paradigms of virtual enterprise and distributed design processes. This objective of the INPRO network deals with a strategy decomposed in three main activities, which we presented in the following.

### 3.1. Develop new research tools and platforms for common use

This environment is the base for future collaborations and synergies by integrating the partners in each Pole within and outside the network. The work phases are:

*To develop a common knowledge base to support collaborative RDI activities within the network.* The methods and tools that will be used focused on the inventory of the actual resources of the partners and a database creation, which will be available to all partners on Internet.

*To provide knowledge management and engineering tools.* We shall buy and install specialized software as: MindManager, TextMining.

*To contribute to different content aspects of the common toolbox* (process knowledge for early design evaluation, cost modeling frameworks and re-use knowledge

and other). There will be created software applications for knowledge management and integrated design.

### 3.2. Analyze and development of product models and manufacturing processes

These two basic concepts will be the support for knowledge modeling. The modeling final step will concern the complete life-cycle processes of product and the corresponding knowledge, in order to allow a fast and a priori performance evaluation of the product during the design process. In addition, this work will focus on a large and complete state-of-the-art survey in many technological fields of production, processes, strategies and practices, with respect to both scientific and industrial reference. The work phases are:

*The definition of a product life cycle model with integration of external service partners.* The goal is to make a critical analyze of the existing models (double cube, multi-view, integrated product etc.) and in an original manner, by integration and extensions, we will obtain a new model.

*Development of life cycle controlling models to analyze the economic, environmental and social impacts.* We propose develop methods and tools to analyze the material consumption during processing, the energy consumption, the generated losses, the needs of maintenance, repair, re-cycling and re-use in economics terms. There is substantial evidence that such economic models should be available during the early design stages in order to evaluate the potential impact on life cycle. These methods will be held in a technical-economical model for the economical life-cycle impact evaluation. The model testing and validation will be realized by the contribution of the interested industrial companies.

*To take into consideration rapid prototyping processes such as Reverse Engineering (RE), Rapid Prototyping (RP) for tele-engineering and rapid manufacturing.* The goal is to study and investigate the existing RE and RP methods and processes used by the partners and develop new researches and applications.

### 3.3. Knowledge management

This is an activity developed based on the ICT techniques in order to constitute a very innovative network for future dissemination, both in Romania and at a European level. The knowledge material itself, the reasoning mechanisms based on the knowledge related to production fields will have to be implemented in a distributed web-based platform accessible to the network partners. During a second phase, training sessions will be defined and implemented in order to ensure major dissemination efficiency to the industrial community in Romania. The various reports will permit all partners to achieve a real appropriation of the good practices in knowledge-based applications for production. This will also accelerate the access and dissemination of the concepts, methods and tools to the high level training in the topics of design engineering, production engineering and industrial engineering. The work phases are:

*To collect and formalize knowledge about production processes by defining the actual limits (related to cost),*

*publishing examples of use, good practices, etc.* The knowledge collection will be realized using communication methodologies, using questionnaires, and the formalization and structure of the knowledge in maps is made with MindManager.

*Collection and formalization of knowledge about virtual design and manufacturing.* The research is developed in the same way as below.

*Providing knowledge in process simulation, remote analysis, simulation and visualization of process parameters.* The research is developed in the same way as below.

*Definition of knowledge management methodologies and tools for sharing knowledge and applications for demonstration inside the Network,* such as: ontology based systems, AI-tools for knowledge management in production, including data mining and machine learning techniques. For the knowledge capitalizing, using and common disposal, we will use web tools.

*Development of new working methods based on new methods for knowledge and communication management.* We will elaborate new work methods regarding the ITC tools and Internet platform. There will be developed new methods for process optimization that will allow the interoperability of the application for the product realization.

## 4. SPREADING OF EXCELLENCE

### 4.1. Joint program of training for network members

This activity will aim at knowledge sharing in the INPRO network using the visioconference system. Here are developed advanced training and educational procedures, which will address students, researchers and key staff of the network's members. The work phases are:

*Creation of a cycle of distributed conferences* using the technique of video-conferencing. There have to be minimum 3/partner each year, alternatively hosted by each Pole centers of the network. Each year there will be made a CD (distributed in the network) with all the presentation on visioconferences.

*Harmonization of curricula in the specific domains of manufacturing engineering,* through the review of the curricula in order generalized the experience gained by each partner.

### 4.2. Dissemination of the research results

This task will be held into national and international scientific community. The participation to international conferences in VRL-KCiP NoE will be encourages. The phases are:

*To support the interaction between the national network and international networks and programs.* The network members will have access at the organized visioconference in the VRL-KCiP NoE.

*Organization of seminars or international conferences with academic or industrial destination.* INPRO network partners will co-organize each year an international conference.

*Dissemination of the results in prestigious scientific organizations.* The members of the INPRO network will be ambassadors in national and international scientific organizations. An example is the *Academic Association of Manufacturing Engineering (AUIF)*, which is an association appeared following the initiative of the representatives of the Manufacturing Engineering Departments from the 5 traditional university centers in Romania (Bucharest, Brasov, Cluj, Iasi and Timisoara). Having the headquarters in Timisoara, the association especially intends to promote the professional goals of the university engineering teaching staff, in collaboration with the specialists in the field from the industrial environment and in cooperation with the incumbent state organizations. More information about the AUIF is available at <http://www.eng.utt.ro/auif/>. Mainly, at this association are invited to adhere specialists from the university environment, working within manufacturing engineering faculties or departments, and those specialists who through the nature of their professional activity come into contact with manufacturing engineering.

The association initiates specific cooperation activities with different institutions, participation in national and international programs, editing of informative materials, including the *Academic Journal of Manufacturing Engineering – AJME*. The International Scientific Committee of AJME consists of many persons that are involved in the NoE VRL-KCiP.

AJME can be a good platform to disseminate INPRO network activities, in Romania and other countries. AJME is classified by The Romanian National University Research Council as a B-level journal. At present AJME journal is during the process to meet the ISI recognition.

#### 4.3. Knowledge transfer to industry

This activity wants to create a frame that will facilitate the knowledge transfer to the industrial community in Romania. The phases are:

*Creation of a roadmap for technology transfer.* The Chambers of Commerce and Industry will sustain the knowledge transfer to industry in each partner's area. The dissemination methods are workshops where will be presented the research results obtained by INPRO network.

*Creation of a common inheritance and installation of the tools for the evaluation of the potential openings to Industry.* On the web site INPRO network there will be created a database consists of the practical results and the research themes that were solve for industry by each partner. This database will be up-date each year.

*Definition of a policy for the intellectual protection and the defense of the rights of ownership.* We shall create a guide for the intellectual property rights protection.

## 5. CONCLUSION

Setting up of the national research network in the field of Integrated Product and Process Engineering (INPRO) attend the strategic objectives in high RDI. Also, it derive from the need of reducing the research fragmentation in the field, for building of a common material and human base that assure the possibility for complex researches in modeling and simulation of product and processes associated with their life cycle. It will be create a dynamic structure and a collaborative platform in integrated design that will allows its members to participate in cooperative design projects with industrial applications.

The share information process needs the information change into knowledge. Their variety is from the determination of the product specification to the end of lifecycle, including the processes and the manufacturing systems design.

The integration inside the network will be the base for the communication system development between the partners and for the establishment of a knowledge community.

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### Authors:

Professor George DRĂGHICI, "Politehnica" University of Timișoara, Director of the Integrated Engineering Research Center, E-mail: [gdraghici@eng.utt.ro](mailto:gdraghici@eng.utt.ro)  
 Assoc. Prof. Dr. Eng. Anca DRĂGHICI, "Politehnica" University of Timișoara, E-mail: [adraghici@eng.utt.ro](mailto:adraghici@eng.utt.ro)  
 Assoc. Prof. Dr. Eng. Eugen PAMINTAS, "Politehnica" University of Timișoara, E-mail: [epamintas@eng.utt.ro](mailto:epamintas@eng.utt.ro)  
 Lecturer Dr. Eng. Cristian TURC, "Politehnica" University of Timișoara, E-mail: [cturc@eng.utt.ro](mailto:cturc@eng.utt.ro)