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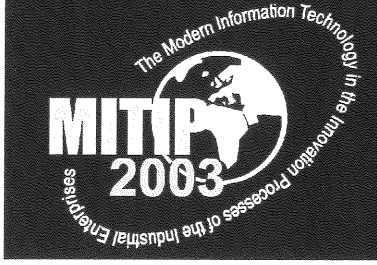

German Research Center for Artificial Intelligence

September 4-6, 2003 Saarbruecken/Germany

THE MODERN INFORMATION TECHNOLOGY IN THE INNOVATION PROCESS OF THE INDUSTRIAL ENTERPRISES

MITIP 2003

5th International Conference September 4 – 6, 2003
Saarbruecken, Germany

Proceedings of the Institute for Information Systems
Editor: Prof. Dr. Dr. h. c. mult. August-Wilhelm Scheer
Issue No. 176

ISSN 1438 5678

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BPR MODELLING INSIDE A FRAMEWORK OF ISO 9000 QUALITY MANAGEMENT SYSTEM

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Abstract: **This paper presents a case study of a business process reengineering. The proposed approach is in compliance with ISO 9000 standards. A roadmap of the sequence of different activities required for reengineering within the framework of the standards are illustrated and modeling techniques needed for process designing discussed. Examples of reengineering and modeling of processes are illustrated considering the case of a company in the textile field. Considerations and future development of the suggested roadmap are proposed.**

Index Terms: **process reengineering, ISO 9000, modeling techniques, process approach.**

I. INTRODUCTION

Within the current framework of market globalization and the increasing number of competitors, organizations are forced to change their processes to achieve performance improvements. A prompt response to the market, to the changing needs of customers and of all interested parties of the organization implies a controlled, flexible and efficient business process.

Attention on the importance of the process and its effective management is now given by the new set of ISO 9000:2000 Standards regarding Quality management System. The proposed aim of the ISO specification is to give companies more opportunities to meet needs and expectations of the customers. Attention is shifted from the procedures documentation to process definition, improvement and, if necessary, reengineering. The new point of view in quality systems entails the attainment of objectives rather than carrying out activities.

This paper explores a case study of a company dealing with high value textile materials.

An intervention was planned and carried out to build a system in compliance with the ISO 9000 Standards and the expressed objective of the company.
Within the framework of activities related to the implementation of the quality management system, the renovated several processes in order to attain improvements in efficiency and effectiveness.

In this paper the applied methodology of the intervention and the process-oriented modeling techniques, suitable to describe the sequence of performed activities, are highlighted.

On the basis of this work, the different steps needed to carry out the transition from an old management system to a new one, according to the ISO Standards, were defined and described. Furthermore, a modeling approach was elaborated to support the improvement of business processes and establish links to the standards. Different modeling techniques can be followed in order to schematize the organization activity. The $IDEF_0$ technology, used to model actions, activities and decisions of an organization or a system, were introduced and utilized to schematize the main processes of the company.

The explanation of the methodology is associated with the description of related activities performed. Examples of models are reported and in particular the process regarding the purchase of raw materials is investigated.

A team composed of interdisciplinary people in the company and the department of Industrial Engineering of University of Perugia studied the model and implemented the new structure. Considerations about the activities performed, difficulties, advan-

tages and needs of improvements, found during the implementation of the quality management system are highlighted and illustrated in the next paragraphs.

II. CASE STUDY

The implementation of a quality management system in compliance with ISO 9000 is investigated in a firm that imports raw fibers (cashmere, angora, silk) from the Asian continent and, after stringent controls on their quality and a short transforming process, sells the materials worldwide to major producers in the textile industry. The organization is located in an industrial district, characterized by the presence of several companies involved in the textile field.
Less than 20 people are employed in the organization, which is managed and supervised by the entrepreneur and his family. The total revenues exceed 35 M-Euros per year. This high revenue, compared with other entities of a similar workforce, depends on the high value of the managed goods. The employees of a branch office located in Beijing carry on relations with the suppliers, perform quality controls on the raw materials at the supplier's sites and supervise the shipment process. The company was founded in the '40s and immediately specialized in collecting angora rabbit hairs in the local area and later throughout Italy. During the first years, products were classified in a few typologies and the main companies in the field of the textile industry soon became customers of this organization. Throughout the '70s and '80s, the firm established contacts in the Chinese area in order to find new suppliers and new products, firstly cashmere and then silk. Nowadays, the company is specialized in collecting and providing worldwide the high quality materials mentioned above.

The increase in market and in the related activities prompted the management to redefine the business process, in order to increase effectiveness and efficiency, to define resources and responsibilities, to document the performed activities. Furthermore, the familiar context of top-management was not always able to cope with the global competition, characterized by an increasing number of suppliers from several countries worldwide, which generally don't respect high quality and reliability standards, but undercut the current price system. This context forced the company to innovate their business process and to orient the organization into the requirements of ISO 9001 standards.
The objectives expected from the intervention concerned the creation of a lean management system able to support the current activities, the improvement of the business process, the introduction of a system able to guarantee the quality of the products and to help the company in competitiveness and efficiency.

A previous attempt to attain the ISO 9000 certification was abandoned due to the high resources required and a low-value approach based mainly on setting up a documentation system, with the related risk to compel the business to stringent and too restrictive procedures; this was a common risk for many different industries that applied the old quality system of ISO 9001:94.

III. THE ISO 9000 FRAMEWORK

ISO 9000 is a set of standards used in organizations in order to develop and document their quality management systems. Following the older version of the year 1994, the introduction of the new standards has entailed an increasing interest in quality management and process reengineering in all types of industries and has prompted new issues: monitoring customers' satisfaction, quality objectives and continual improvement.

The International Standard fosters the adoption of a process approach in order to develop, implement and improve the effectiveness and efficiency of a quality management system. The guidance to management is based on eight quality principles to be applied in order to lead the organization toward better performances and a continual improvement of the business [6].
Results are achieved more efficiently when all operations and related resources are managed as a process that we can define as a set of interrelated or interacting activities which transform inputs and resources into outputs and can moreover be additionally divided into smaller components and subprocesses [2]. A process approach integrated with a systemic view of the company, i.e. a correct perception and understanding of the system (the company) as a whole, rather than single separated parts or functions, implies focusing on the process itself. The ability to identify a system of processes in the organization is the element that will influence the performance of the company.
Organizations that are focusing on processes, innovation and flexibility find in the ISO 9000 requirements a correct approach to assess the implementation and the development of the quality management system. The importance and the value of the old ISO 9000:1994 standards and the opportunities that they gave have often not been exploited because the related quality system, characterized by elevated bureaucracy and sometimes associated to inflexibility and waste of resources, could not guarantee relevant advantages. One of the major problems was related to the fact that a process-oriented

development did not often receive enough consideration. The ISO 9001:2000 standard sets a new approach no longer dedicated to documentation of procedures.

The purpose of an organization is, according to the ISO guidelines, to identify and meet the needs and expectations of its customers and other interested parties, to gain competitive advantage, and to operate in an effective and efficient manner. Moreover to achieve, maintain and improve overall organizational performance and capabilities [6].

One of the permanent objectives that the organization should pursue is continual improvement. The dynamic cycle of PDCA (Plan, Do, Check, Act) [4] can be applied and is suggested by the standard to keep and continuously improve the effectiveness and the efficiency of the processes at all levels of the organizations.

IV. METHODOLOGY

Following the objective of the continual improvement of processes, aimed at enhancing the organization's performance and benefiting its interested parties, an innovation project, or breakthrough project, according to ISO 9004 definition, has been planned and carried out in the company. Following the current scientific literature [3, 8, 9], different steps have been taken to achieve the proposed objectives. A roadmap of the intervention has been elaborated and reported in figure 1. The roadmap represents a scheme for a typical reengineering process, appropriate for an ISO 9001 perspective.

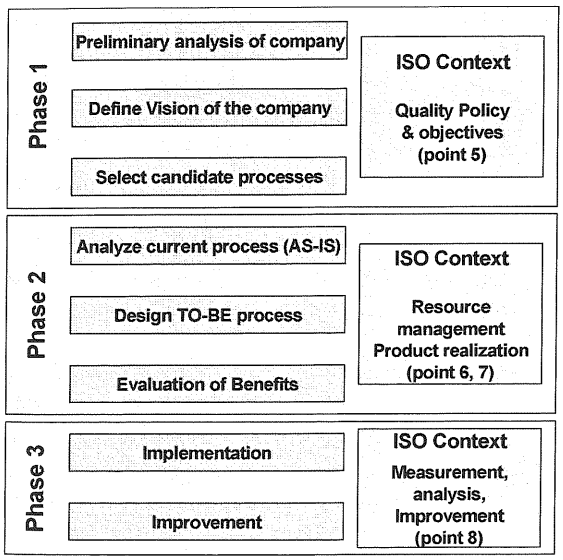

Figure 1: Roadmap of innovation methodology

Attention has been focused on a systemic perspective of the process, entailing the view and understanding of the system as a whole rather than the analysis of its single parts. The ISO 9000 standards introduces the process approach as the application of a system of processes within the organization, involving their identification, interaction and management [6]. Interactions between the components of a process and the external environment need to be consistent with the perceived purpose of the whole process of the system. The ability to identify a system of processes in the organization is the element that will affect the performance of the company. Improvements according with this view entail the consideration of every job as a phase of the business process.

According with the proposed roadmap for innovation, phase 1 is the opening activity to be performed. After a preliminary analysis of the organizational structure of the company and the identification of current roles and responsibilities, a strategic step is required by the top management. In this first stage, in fact, the management has to define the vision of the company, making clear the long-period objectives. Within the framework of ISO Standards, the layout of required quality policy and objectives (point 5 of ISO 9001) represents this step. Policy directs the organization and sets guidelines for the processes development. Long period intents and goals have to be clear to all employees and people of the organization. They must come from the top management through a top-down process.

After this step, on the basis of the declared vision and the first analysis of the business process, opportunities for change should be defined. The choice and number of renovations depends on the available resources and on the effective possibilities to achieve feasible improvements.

Considering the case reported, the application of the first phase involved the acquisition of the necessary background to define a consistent inspection of the company and select the processes to change. Afterward, the management defined a customer-satisfaction oriented mission aiming at supplying materials with expected features on the basis of a detailed classification of products, reducing variations related to the environmental and climatic conditions which in general affect the quality of this typology of goods.

In order to reach this goal, the company needs to make agreements with Chinese producers and select only suppliers that fulfill the given requirements. On the basis of the expressed mission, some critical processes were taken into account in order to start the definition and implementation of changes. Particularly the sequences of activities related to the acquisition of customers' orders, the consequent purchase of raw materials and their control were se-

lected as processes to be reengineered. The firm in fact experienced problems with the quality of incoming goods due to the lack of well-defined control activities and specifications.

In the second phase of the proposed roadmap, a detailed analysis of the selected current process has to be performed. The purpose of the study is to specify internal shortages in the process sequence, to gather all possible information useful to design future solutions. The AS-IS model, i.e. the current description of activities and flow of information is necessary as the starting line for the next step: the design of the new processes inside the framework of the systemic view of the organization and the requirement of ISO Standards. Different hypotheses of change have to be investigated under the point of view of costs versus benefits.

In this phase a significant effort has to be dedicated to the process modelling, through which the sequence of activities can be described and symbolized. The consideration of the organization as a structure of processes requires a representation of the system with the aim of illustrating it, with subcomponents and interactions. The model of a process is important for its effective and efficient design, management and simulation. The model is the tool used to achieve an adequate level of understanding, useful to plan and execute the process, to control and to obtain improvements [1].
The AS-IS model is useful for understanding the behaviour of the current process, critical points and opportunities of improvement. This model must be abandoned and no longer used after the comprehension of the needed elements.
The following TO-BE model is a guide for the implementation, adjustment and continuous improvement of the process. This model hence requires more details and information.

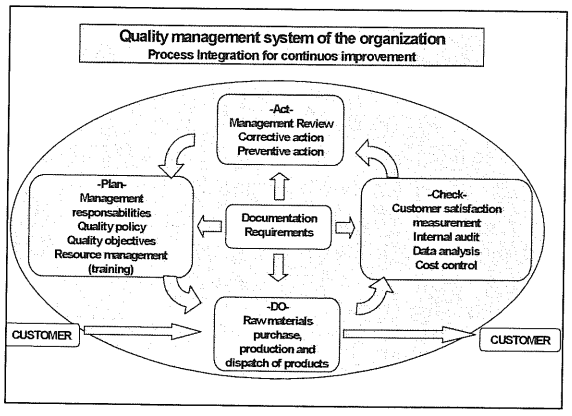

Figure 2: Model of the process-based quality management system

Figure 2 shows the model of the processed-based quality management system set up for the considered organization. The systemic view of the processes was modelled inside a PDCA dynamic cycle including the ISO 9001 requirements. Processes can be classified in two different types: i) main processes which justify the existence of the organization since they allow to achieve the objectives explained in the mission; ii) facilitating processes, needed by the organization in order to provide an added value to the main processes, thus making them able to attain expected targets in an effective and efficient way. In the analysed case, only one main process was defined, located in the "DO" box of the model of figure 2. It consists of a series of activities involving the product realization, from the purchase of raw materials (angora, silk, cashmere) to the dispatch of finished goods. The achievement of good results is affected by the facilitating processes, that involve control activities (analysis of data, nonconformities and complaints, internal audit, cost control), resource availability, planning and review.

A more thorough modeling technique was used afterwards in order to identify the elements of processes that needed attention during their definition. Modeling was also useful to link the ISO 9001 requirements to the process and build an optimised, efficient quality management system. As reported in the next paragraph, an applicable technique to schematize sequence of activities with related constraints is based on the $IDEF_0$ technology and examples of new processes are illustrated in figures 3, 4, 5.

The third phase of the roadmap involves the implementation of planned innovations. Inside the ISO context, the step implies procedures redaction or adjustment, training of people involved, resource management according with the practices previously established and defined in the quality manual. This phase is the most difficult to put into practice due to the resistance of people towards changes and its failure can easily bring the project to be abandoned.
After the implementation of the new solution, a long period is necessary for adjustment and a process of continual improvement has to start. Monitoring procedures must be put into practice in order to evaluate the performance of the introduced innovation and customer satisfaction. Appropriate tools made available by the ISO Standards (corrective and preventive action, management review) can be used to plan new interventions and achieve the dynamic cycle of continual improvement according with the scheme proposed in figure 2.

V. MODELING TECHNIQUE

The organization model was built starting from the definition of the main process, in this case the series of activities that transform customers' orders into finished products. Flow of materials and information have been identified inside the framework of the ISO 9001 standards; relevant links with the requirements have been pointed out in order to identify sub-processes or activities constrained by the ISO quality standards. A model is a representation of a set of components of a system. Different modeling approaches can be followed in order to schematise the organization activity. The choice of the best technique depends on the objectives that the model pursues. Models are developed for understanding, analyzing, improving or replacing the system.

Flowcharts are one of the best techniques to define activities, responsibilities, assign tasks and objectives. Flows of data, information and materials are evident for employees and workers. Matrix models (functions vs. activity), that guarantee ease of reading and immediate evidence of actions and interactions between activities and functions, have been built and used inside the organization, in the quality manual and procedures.

During the design phase, a different approach can be used in order to better define the system at all levels, consider links with resources, documentation, communication and provide a useful tool for analysts in order to communicate, exchange and compare ideas and proposals. At the end of '70s, the U.S. Air Force performed a project aimed at increasing manufacturing productivity through the systematic application of computer technology [7]. The project called ICAM (Integrated Computer Aided Manufacturing) identified the needs for better analysis and communication techniques for people involved in the field of reengineering. The result of the ICAM program was a series of techniques known as the IDEF (Integration Definition for Function Modeling). IDEF is a family of technologies developed to analyse processes of modern organizations. Some of them spread with the support of computer tools and are used by BPR designers. Among IDEF technologies, the $IDEF_0$ is the first born and most used by the technicians.

The $IDEF_0$ modelling technique is based on simple boxes or nodes (used to describe functions or activities) and arrows. Stringent rules on semantics must be followed during modelling activity. No less than three and up to six boxes are used in each diagram. Arrows represent flows of data and information or real objects between activities and can take on four different meanings: 1) arrows entering the left side of the box are inputs (I1, I2, ..) that will be transformed or consumed to produce outputs; 2) arrows entering the top are controls (C1, C2, ..) which specify the conditions required for the function to produce correct outputs; 3) arrows leaving the right side of the box are outputs (O1, O2, ..) produced by the activity and 4) arrows entering the bottom of the box are mechanisms (M1, M2, ..), i.e. a person or a device needed to complete the activity (used but not consumed resource). Diagrams have a hierarchy starting with the A-0 context diagram that identifies the scope and intent of the model. The top-level diagram is followed by a series of diagrams providing more details about the subject. The A0 diagram decomposes the A-0 into its main processes or functions which are described in the model. These processes can be further decomposed into different detailed levels by means of new diagrams (the activity A1, for example, can be divided into A11, A12, A13 activities in a new diagram and so on). As seen before, in the proposed systemic view of the considered organization, the main process, "fulfillment of the customer orders", (figure 3, A-0 diagrams) justifies the existence of the organization and allows to attain objectives described in the mission. It has been investigated and reengineered considering inputs, outputs, controls and mechanisms.

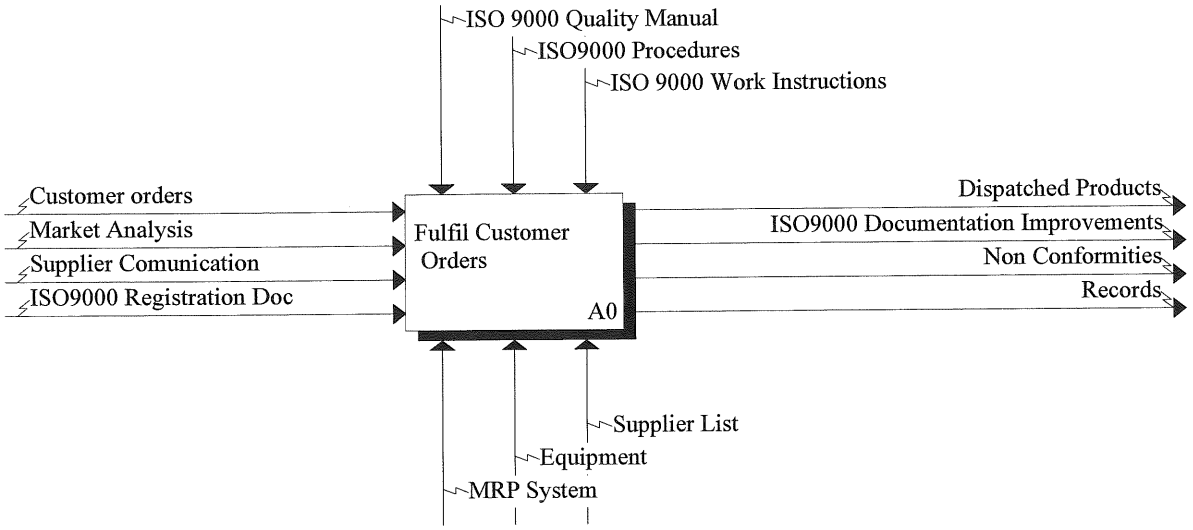

Figure 3: Main process (A-0) context diagram

The Fulfil-Customer-Order node was divided in five main activities as described in the A0 diagram (fig. 4). Links with documentation and ISO 9000 requirements are reported.

In this paper, special attention is given to the purchase of raw materials. This process is crucial for the company since the high value of handled materials, the difficulties to manage contacts with the suppliers and the links with the vision of the company. Since the natural variability of the features in this kind of raw materials, a supply in compliance with the specified requirements is essential for the good quality of the product, according with the mission expressed by the management. Furthermore, the high value of the purchased goods and the possible low reliability of suppliers pushed the introduction of a three-steps process control described in figure 5. The activities have been redesigned and stress was laid on controls, procedures, monitoring and responsibilities.

New detailed processes define controls on raw materials performed by the Chinese branch office during collecting and packing and, finally, performed at the Italian centre. Procedures, specifications and documents were generated in compliance with the ISO requirements to define activities and to record data and analyses

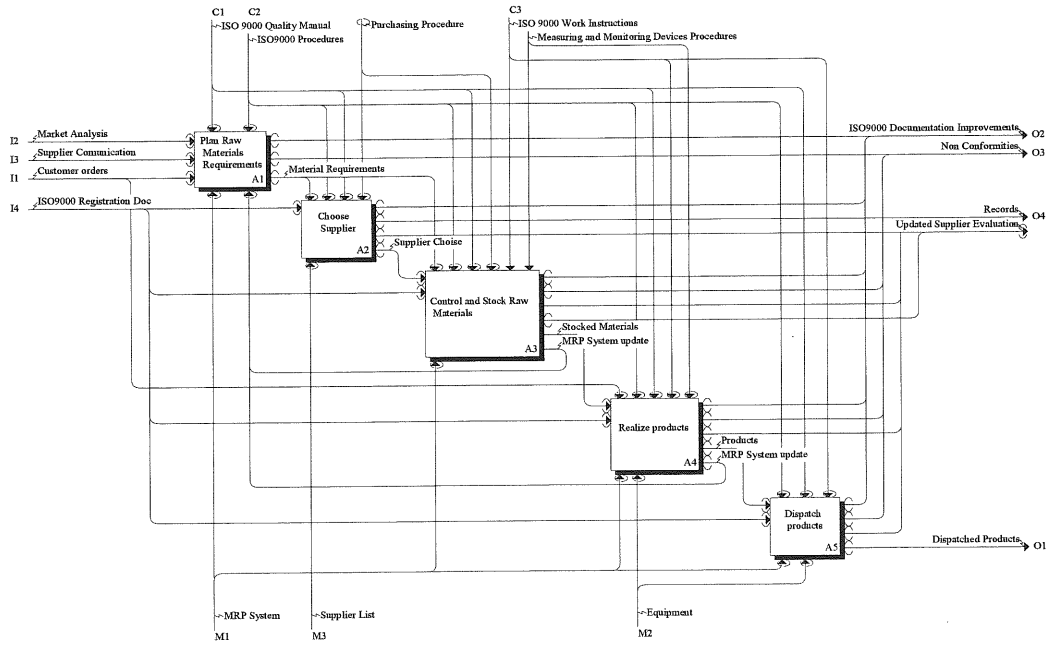

Figure 4: Activities of the main process (A0 diagram)

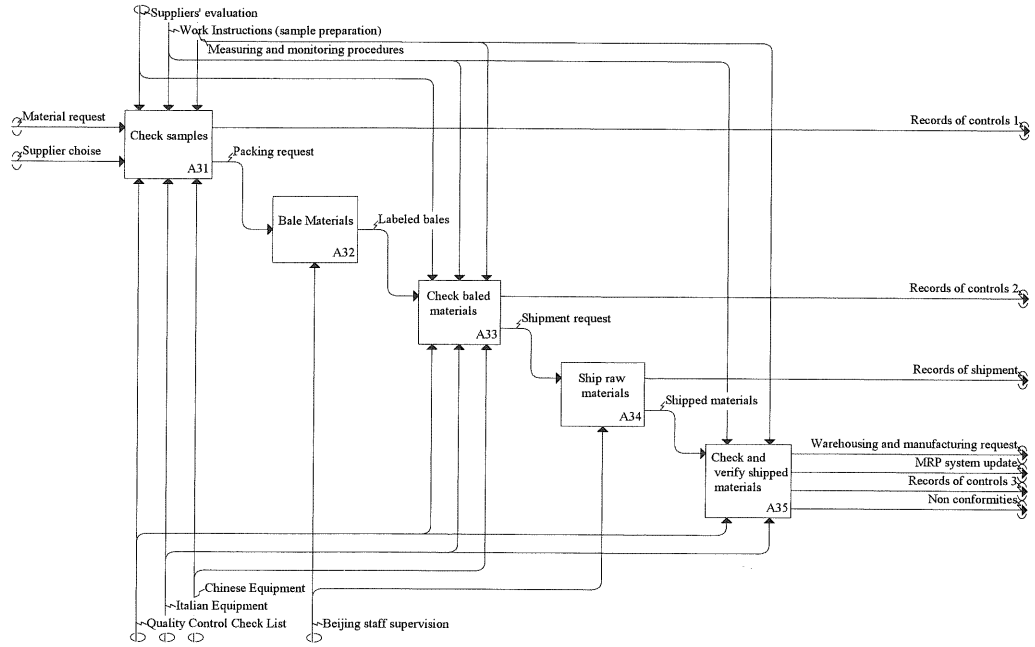

Figure 5: Activities of the A3 box

VI. CONCLUSION

In this work focus on the methodology of reengineering within the framework of ISO 9000 Standards has been pointed out and the modelling activity of processes has been illustrated. The application inside an industrial context of the roadmap of intervention is also presented and specific features highlighted.

The introduction of a quality management system prompted a new vision of the company and a greater awareness of the actual structure of the organization in the people employed.
The modeling technique was useful to highlight shortcomings with reference to the requirements of standards and to the effectiveness of the processes. A better coordination between functions has been achieved thanks to the definition of exact data and information required by the different nodes of the processes. Modelling experience showed its strong positive impact on management and a consequential actual ability to introduce and implement changes on the business process providing a consistent view of the functions and a communication vehicle to make choices and deliberations.
The processed-oriented approach of the ISO 9000 standards yielded evident improvements in the effectiveness and efficiency of the process. However, one of the main difficulties is to monitor the progress in a quantitative and detailed manner. The absence of a previous recording system does not allow a direct comparison between the current and the old system. On the basis of the performance indicators introduced in the processes, future improvements and analysis of cost-benefits can be better evaluated.
Following this consideration, a future development of the proposed roadmap of intervention should consider with more details a preliminary step regarding the assessment of the existing situation. On the basis of this evaluation, the organization could define with more confidence, based on factual data, the fields to invest resources in for improvement and to verify the attainment of planned objectives.

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BIOGRAPHY

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TQM PROCEDURES AND PROCESS MODELS TO IMPLEMENT PLM SYSTEMS

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Abstract: **Design and implementation of a PLM system (Product Lifecycle Management) requires an adequate analysis of the business processes to be supported by the PLM, and a complete model of the processes has to be drafted. In companies holding a Total Quality Management (TQM) system, there are procedures containing a complete description of the processes they regard. In this paper an experience is described, regarding the use of TQM procedures to integrate the process analysis.**

Index Terms: **Process Modeling, Process Simulation, Product Lifecycle Management, Total Quality Management.**

I. INTRODUCTION

Management of data, information and processes in the product development field is evolving from the EDM-PDM concept to the wider PLM (Product Lifecycle Management) paradigm. PLM involves the coordination of processes and information management environments of the engineering area with those of manufacturing-logistics area. Generally speaking, a PLM implementation process can be considered from two different points of view:

- Consider PLM as an extension of the engineering data and process management environment to cross the boundary with manufacturing and provide integration with this environment (namely ERP system);
- Consider PLM as an extension of the ERP environment to involve engineering documents and process management.

Anyway, the PLM concept requires interfacing and integrating information systems and processes pertaining to every element of the product development process. This requirement carries on two classes of issues:

- *information technology issues,* coming from the need to build very complex systems, and much often, to integrate heavily different legacy systems;
- *architectural and organizational issues*, arising from the need to integrate a variety of processes covering in scope the entire extended enterprise.

The integration of business areas means the integration of technological infrastructures and business solutions in order to correctly integrate the strategic

approach guiding each business area. From this point of view, a PLM implementation (like other complex business solutions based on new technologies) is related to an effort to introduce changes in the affected processes [1], [2]. To support such modifications a company needs to plan and introduce it in the right way. In many cases this is accomplished by using techniques developed for Business Process Re-Engineering (BPR). Namely, the design and implementation of a PLM system requires an adequate analysis of the business processes to be supported by the PLM. In fact, often, a PLM implementation is coupled with a Business Process Re-engineering to better deploy new technologies or methodologies.

BPR methodologies prescribe to start the analysis depicting the As-Is state of processes involved.

Companies holding a Total Quality Management system keep a repository of procedures, which describe its processes and the examination of those procedures can be a good starting point for process analysis.

This paper presents an industrial case, in which the process analysis phase of a PLM implementation has been carried out extracting information, either from TQM procedures or interviews with process owners.

II. Process Modeling

In BPR activities, one of the main tools is process modelling, used to understand:

- how the current process is working;
- how to exploit in it the innovation offered by the new technologies and methodologies.

In the case of a complex integration effort, like a PLM system implementation, it's important that the process modeling techniques employed permit to represent all business aspects both to provide a complete picture of the main process and to go deeper in detail where and when necessary.

A. A methodology for process analysis

The methodology developed by KAEMaRT group (University of Parma and Politecnico di Milano) [3] has been adopted for the present work. The methodology (Figure 1) provides a set of guidelines to fulfill BPR objectives. It mainly focuses the attention on modeling technique to describe *As-Is* and *To-Be* processes. As-Is model represents the process currently carried out within the company. During the definition of this model knowledge regarding both the product and the process, usually spread among the technicians and different company departments, is acquired and formalized. It permits to highlight process problems and area of possible improvements, and represents the term of comparison to evaluate quantitatively the effectiveness of innovative solutions. To-Be model constitutes the representation of the re-engineered process, derived from the analysis of the As-Is model.

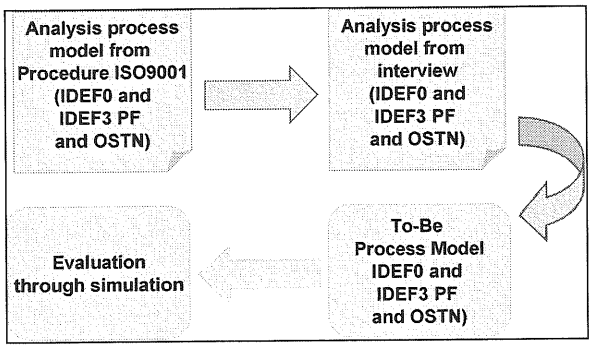

Figure 1: KAEMaRT Methodology

In literature, we can find different techniques for process modeling: ARIS (www.ids-sheer.de) [4], IDEF (www.idef.com), UML (www.omg.org/uml), etc.. IDEF techniques have been adopted for several reasons. IDEF Family is a set of modeling languages and methodologies, developed in the United States. During the 1970s, the U.S. Air Force Program for Integrated Computer Aided Manufacturing (ICAM) identified the need for better analysis and communication techniques for people involved in improving manufacturing productivity; as a result, the ICAM program developed a series of techniques known as the IDEF (ICAM Definition) techniques. They permit to represent process knowledge with graphic languages, simple and easy to be understood and used also by people without a technical background. This facilitates the communication among work teams with different competences, particularly important to validate the model with process experts and to ensure that collected information (process and/or product knowledge) has been correctly formalized

As-is and To-Be models are produced using three different IDEF techniques allowing representing different aspects of the processes:

- IDEF0 to represent activities and information flow;
- IDEF3 PF to represent activities execution flows;
- IDEF3 OSTN to describe Object states.

IDEF0 (Integration DEFinition language 0) [5] is a modeling technique based on graphic objects and text combination presented according to a strict syntax that permits an immediate understanding and supports the operation of analysis simplifying the representation of functions and resources and emphasizing process pro's and con's. It allows the definition of the functional model of the process, i.e., a structured representation of functions/activities (graphically represented by a box) and what is needed to perform these

activities (graphically represented by arrows) (Figure 2).

Figure 2 portrays an example of IDEF0 diagram related to the As-Is model.

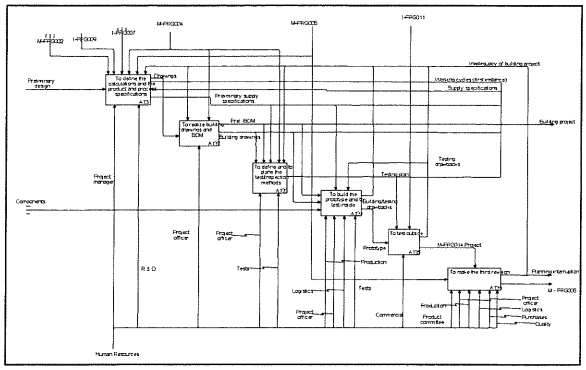

Figure 2: An IDEF0 diagram of the As-Is model

The IDEF3 Process Description Capture Method [6] was created to capture the description of activity sequences. Main purpose of this technique is to supply a structured method by which an expert analyst can represent the information to care of a special process or system.

The technique IDEF3 comprises two description languages:

- Process Flow (PF);
- Object State Transition Network (OSTN).

IDEF3 PF captures precedence and causality relations among activities. To drive the process flow, logical operator such as AND, OR and XOR are used. Figure 3 shows a snapshot of IDEF3 PF diagram.

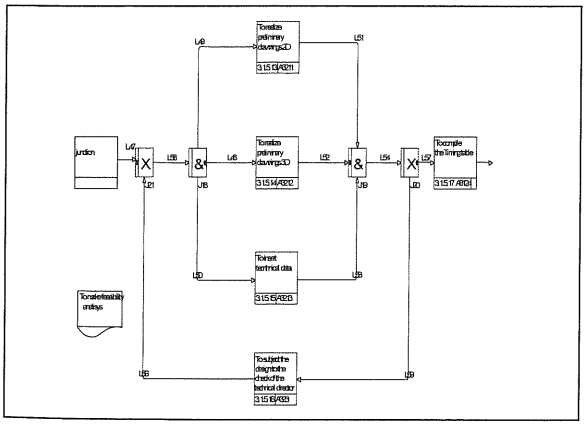

Figure 3: An IDEF3 PF diagram of the As-Is model

The Object State Transition Network (OSTN) diagram supplies a process view centered on the objects, representing their changes of state as transitions across an activity or a series of activities (Figure 4).

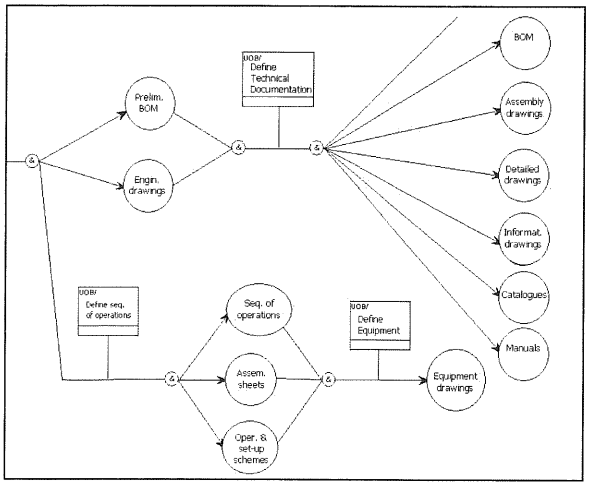

Figure 4: An IDEF3 OSTN diagram of the As-Is ISO9001 model

The methodology implies also the use of simulation techniques (by USING A commercial software) to obtain a quantitative data and compare As-Is and To-Be models.

B. Procedures as a tool to define process activities and documents flow

The ISO9000 is a family of standards that defines a set of requirements to guarantee the quality of a business system that produces goods or services. They permit to optimize the qualitative level of the processes and to maintain under control the costs of those aspects that affect the product quality. The procedures contain a complete description of the processes, but typically they are text-based and written using a business administration terminology, often not suitable for specifying information systems [4]. Therefore, a further analysis and refinement of the information contained in business procedures is needed, and the results are generally better depicted using semi-conceptual graphics method (such as, for example, flow charts, process diagrams and so on). Another advantage of graphics methods for process analysis is the commercial availability of software tools supporting modeling activities. They allow a better insight in the model storing a lot of information in many form (graphics, text, diagrams) and give the capability to generate detailed reports of the processes (e.g., documents-activity-resources relationships).

III. THE STUDY CASE

The research work has been carried out in collaboration with a company producing hydraulic systems.

The case study describes the outcomes of modelling activity related to a design process whose main goal was to extract the "As-Is" process model from ISO9001 procedures of a company holding Total Quality Management to be used for the implementa-

tion of a PDM system. The main objective of the PDM implementation was a better coordination and data exchange among engineering, manufacturing and test labs in order to facilitate testing and prototype activities and to improve the product development lead-time. The company's documents and information flow was evolving from a 2D drawing-based system to a 3D model-based system. Basically, this means that instead of circulating only electronic files representing 2D technical drawing, 3D CAD models will be exchanged and used, where possible, directly for all the activities downstream the engineering department. Therefore, the introduction of a PDM system was planned to start with the implementation of engineering documents and workflow management. For this reason, the first step of the analysis consisted in the definition of the process model to map the document flow and the processes/activities, which will use and manage the engineering documents.

IV. Process Modelling and Simulation

Process models described in this paper, are made of a static model (IDEF0, IDEF3 PF and IDEF3 OSTN) and of a dynamic model built using a discrete event simulation system.

The objectives of the process modeling activities were mainly [7]:

- Build an "As-Is" model of the product development process;
- Build a "To-Be" model of a product development process in which PDM capabilities are deployed to enhance the document sharing;
- Evaluate the use of TQM procedures combined with interviews to gather information;
- Evaluate the suitability and effectiveness of IDEF tools to be used in Total Quality Management environments to improve dissemination and understanding of procedures.

A. As-Is Models

Two different As-Is models (in the following *ISO9001 As-Is* and *As-Is*) have been realized with the purpose to compare different data acquisition methods: from the procedure ISO9001 "Development and check of the planning" and from interviews with personal employees. Main objectives of the ISO9001 As-Is have been:

- to evaluate the possibility to extract all necessary information (activity, necessary resources, development times, information flows, ...) for process model definition directly from ISO9000 procedures;
- to study the possibility to use a semantic processor to extract automatically the modeling concepts from the ISO9001 procedures text
- to verify the use of IDEF techniques to spread inside the company quality procedures also thanks to web site where the user can navigate and easily recover data process from a database.

In order to have a complete overview of the entire design process, we considered all design process typologies described in the ISO9001 procedures. Each type of design process is subdivided into four main phases:

- Concept generation;
- Preliminary design;
- Detailed design;
- Product engineering.

The *As-Is* model (Figure 2) has been built gathering information only from interviews with design process owners in order to compare and to evaluate which method is more suitable to extract each kind of information.

The two models clearly show significant differences, particularly as far as concerns activity flow and synchronization aspects. This is mainly due to the fact that procedures review task has been accomplished by people aseptic from the process. They interpreted the procedures literally, and so introduced in the resulting process model many checkpoints and gates that are not present in the real life processes. This is also depends on the language used to write the procedures, typically a business language suitable for good interpretation by people with experience and insight in the process, but which can give ambiguous responses to software experts reading it with the purpose to extract a workflow suitable to automation.

Another finding is a slight difference between the process actually carried out and ISO procedures. This is caused by the dynamics of innovation inside the process; namely, the transition from 2D-drawing-based information to 3D model-based information exchange was already started in the company. Therefore, in many cases the process is no more the drawing based flow described in procedures, but an hybrid process using partially the 2D drawing based flow and starting to deploy the advantages of 3D CAD model exchange. This is not due to a scarce maintenance or respect of ISO procedures, but instead it relies on different dynamics of the process and procedures evolution. This is particularly true for small and medium-sized companies where the steps for changing the process are not so well planned to allow their correct inclusion in the procedure from the first stage. They are often introducing new solutions, testing and

fitting them in the current process making runtime the adjustments to make things work correctly, and then writing the procedures.

B. *To-Be model*

The following phase was a gap analysis using the two "As-Is" models in order to harmonize what perceived by the analysts and to study which aspects of the process could be modified and improved introducing a PDM system. A re-engineered process, described by the To-Be model, has been designed. It forecasts:

- The introduction of CAE tools, already in use in the R&D area, to assist designer and involve the technological experts during identification of possible problems for the feeder head drive points;
- The introduction of rapid prototyping systems;
- The implementation of a PDM system (Figure 5) to improve information flow, documents production and recovery making them more secure and rapid.

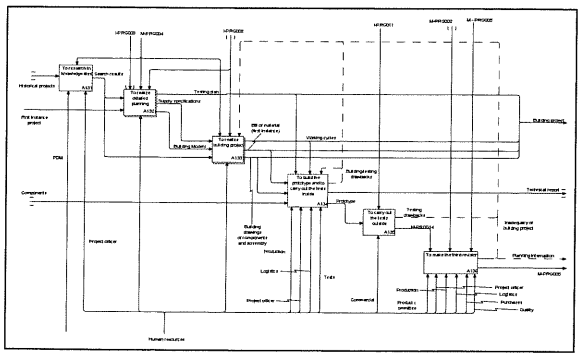

Figure 5: An IDEF0 diagram of the To-Be model.

C. *Simulation results*

To compare the two different process assets simulations were carried out by using a discrete events simulator. It permitted to obtain quantitative data about two meaningful aspects: the development design time and project manager utilization.

Comparing results obtained simulating the As-Is and To-Be processes, it has been estimated a reduction of about 35 % (Figure 6) for the development time and a reduction of 31,9% (Figure 7) for the project manager utilization.

V. CONCLUSIONS

As previously stated, procedures are often not suitable for specifying information systems. To build a process model it is necessary to gather more information, interviewing people and using other information sources (such as, for example, project management systems to collect historical data on activity duration). Nevertheless, procedures give a lot of useful information, and allow speeding up the process analysis activities.

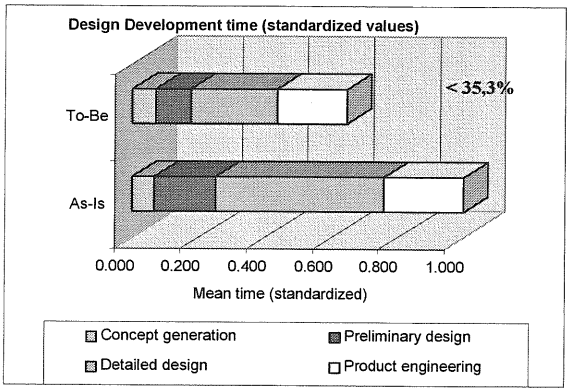

Figure 6: Development time

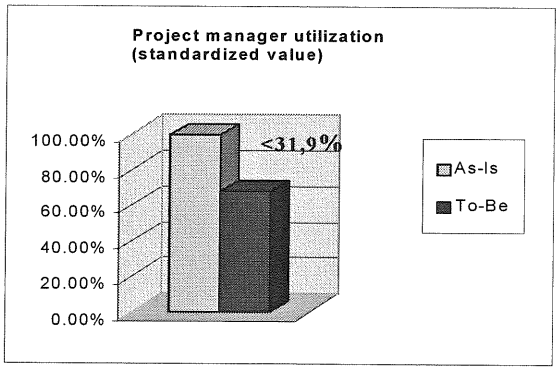

Figure 7: Project manager utilization.

IDEF (and in general graphic modelling languages) are useful to support procedures comprehension, especially thanks to the capability of the modelling software tools, enabling to make information available in a graphic model published in web based and hyperlinked form, to facilitate the navigation through the entire process, identification and use of the information needed in a single activity.

State-of-the-art strategies require quality management concepts that are consistently focused on business processes [4], and also requires business processes integration and management aligned with the new paradigm, using business solutions based on Information technology [8]. Further work will be based on the evaluation of suitability of some business modelling frameworks to represent all the aspect needed to keep up to date procedures and supporting IT Process oriented do PLM implementation systems; the first candidate frameworks to be evaluated are ARIS [4], and Zachman framework [9].

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BIOGRAPHY

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FUZZY ENHANCED PROCESS MANAGEMENT FOR THE INDUSTRIAL ORDER HANDLING

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Abstract: **Business Process Management Systems have proven their positive effects in well-structured procedures. In practice business processes depend on implicit knowledge as well as experience and require decisions based on unclear objectives. This vagueness of real-world problems is not appropriately supported by modelling methods and process automation systems so far. Today the fuzzy set theory is used successfully in systems that provide sophisticated control mechanisms with a small set of simple rules. This concept has not been adopted yet to the non-technical or production area in industrial enterprises. In this paper a holistic and integrated advance for the integration of the fuzzy set theory into BPM from modelling methods to workflow automation is proposed.**

Index Terms: **Business Process Management, Event-driven Process Chain, Fuzzy Set Theory, Process Knowledge, weak-structured Business Processes, Workflow Management.**

I. VAGUENESS IN BUSINESS PROCESS AUTOMATION

Business Process Management systems have positive effects on time- and cost-effectiveness in well-structured procedures. Especially standardized workflows that are repeated very often and which have a simple composition are suited for automation systems. Thus comprehensive software products are available that can support thousands of transactions a day. This business process automation is generally preceded by a business process reengineering project to identify appropriate procedures and to improve their quality and efficiency. Therefore the introduction of a workflow management system must be embedded into a holistic business process management concept from requirements analysis via business process modelling and the conceptual design to implementation and maintenance [1]. A lot of methods have been developed in order to model procedures from various perspectives [2]. Only a few of them are generally accepted. One example for structured methods are Petri-Nets [3] that are often used in the context of workflow control [4] whilst Event-driven Process Chains (EPC) [5] are a semi-structured modelling method used on the conceptual level. These different fields of application result from the intuitive usage of EPCs for employees in contrast to the unambiguity of Petri-Nets that corresponds to the clearness that computers need as an input.

In practice business processes depend on implicit knowledge and require decisions based on unclear objectives [6], [7]. Decisions based on vague or qualitative information belong to the class of the decisions under uncertainty extending the classical view of deterministic and stochastic models [8]. In this contribution vagueness is understood as the uncertainty regarding data and their interdependences. A more detailed view on this term can be delivered by the identification of different kinds of vagueness referring to their origin [9; 10].

The complexity of the environment and the perception limits of human beings cause informational vagueness. Business processes contain information from various sources or data with a short life-span and therefore at a fixed time only one part of the whole system can be analysed, so that data become obsolete during the collection of other partial aspects. Human preference profiles are not determinable. Thus the objective "substantial reduction of the processing time" cannot directly be transferred into actions as the extent of the desired change is unclear. Furthermore, interdependences with other goals are not specified.

Natural language descriptions of real world facts contain inherent (also: linguistic) fuzziness. Both the creation of linguistic models and the context sensitivity of linguistic statements contribute to the

emergence of this vagueness. Closely connected is the inaccuracy in linguistic comparisons. The statement "this object value is much higher than x" can serve as example for this vagueness.
Similarly it is a human characteristic to categorize perceived facts. E. g. a customer order is classified as high, medium and low. The boundaries cannot be determined exactly.
These complex scenarios aren't appropriately supported by IT so far. This weakness derives from the difficulties to translate the vagueness and ambiguity of natural language and human thinking into business models and formal mathematical models for workflow automation. Imprecise or tentative data have been treated as hard facts and sophisticated interdependencies have been reduced to a few relations as substitutes. Thus the transformation of real-world uncertainty, imprecision, and vagueness into information technology controls that are based on propositional logic imply a loss of relevant information. The use of vague data is favourable whenever appropriate measuring methods are missing or are too expensive, the environment is characterised by high dynamics or is not determinable.
The whole business process management approach must be able to treat vagueness and fuzziness as shown in figure 1.

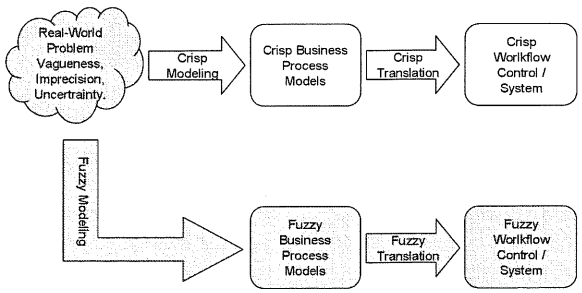

Figure 1: Fuzzy BPM approach

II. Fuzzy Set Theory

In 1965 Lotfi A. Zadeh proposed an extension of the traditional crisp set theory [11] that admits not only true or false as logical values but also membership values between 0 and 1 and is able to tolerate a certain amount of vagueness [12; 13]. With fuzzy sets linguistic variables can be formulated. These linguistic variables link fuzzy sets to linguistic expressions like "the value of this object is high".
Figure 2 shows the linguistic variables "object value" and "absence". The membership functions μ_{low} and μ_{high} express how much a specified value is member in the set of being low or high respectively. The object value 26,000 € belongs with a degree of 0,82 to the fuzzy set "low" and with 0,47 to the fuzzy set "high". This mapping of crisp values on fuzzy sets is called fuzzification. In a crisp context boundaries must be fixed. E.g. an object value starting from 26.000 € would be considered as "high" whilst 25,999 € would already be considered as "low". Similarly the availability of a employee can be rated as good or bad corresponding to his or her absence given his or her capacity.

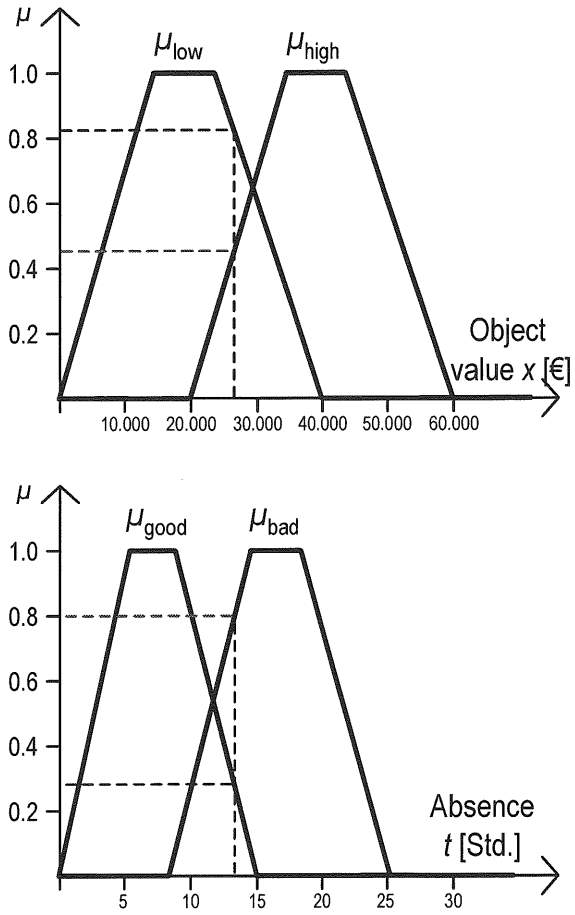

Figure 2: Membership functions

A fuzzy system consists of input and output variables, whose respective attributes are expressed by rules, consisting of condition and conclusion part; e.g., "IF object value = low THEN priority = average". The input variables are transformed into output variables by inference mechanisms. For a executable action, e. g. "assign employee to customer order", a crisp value of the output variable is needed. A suitable defuzzifying method delivers this crisp value.
Today the fuzzy set theory is used successfully in many products from home appliances to industrial manufacturing. Fuzzy logic controllers optimise the functionalities of these devices by applying the three basic steps of fuzzification, fuzzy inference with a fuzzy rule set, and defuzzification to control decisions [14; 15]. The outstanding advantage of these systems is the sophisticated control mechanism, which is achieved by only a small set of very simple rules [16]. This concept has already been adapted for the technical field of production planning and control. However its adoption within the business level domain of workflow systems hasn't been realized yet from an integrated perspective.

III. Existing approaches for fuzzy-extended business process modelling

In the field of enterprise modelling some traditional methods have already been extended by Fuzzy Set Theory concepts. Zvieli and Chen [17] describe a fuzzy extension of the Entity Relationship Model (ERM) [18]. Entity types, relation types and attributes are interpreted as fuzzy values. The use of these fuzzified data in business process automation ensures the uncertain and vague information being treated appropriately. Particularly Production Planning and Control (PPS) can benefit from provisional data that represent preliminary information or estimations about customer orders [19].

Besides others Petri Nets are used for modelling workflows. The bivalent behaviour of places and transitions in Petri Nets is not suited for knowledge intensive and weakly structured processes. In order to represent procedures with vague conditions or incomplete information Petri Nets were extended by fuzzy concepts. The Fuzzy Petri Net results from the projection of several crisp Petri Nets [20]. Petri Nets are a formal modelling method based on mathematical precision. In contrast business process modelling with Event-driven Process Chains is semi-structured and thus intended to be more user-friendly. EPCs are widely used in practice [21]. Especially their intuitive practicability and comprehensive tool support have contributed to their relevance. EPCs are integrated in the ARIS Toolset of the IDS Scheer AG [22] and the Business engineering and customizing of the SAP R/3-System [23].

IV. Fuzzy-extended EPCs

Becker, Rehfeldt and Turowski [24] introduce provisional data into EPCs. Preliminary customer orders are used as information objects in EPCs. They are marked as shaded elements.

As a next step Thomas, Hüsselmann and Adam [25] extend the EPC semantically. To reach this extensions entities that are able to represent linguistic variables and fuzzy rule sets have been added to the meta-model of the EPC as shown in figure 3.

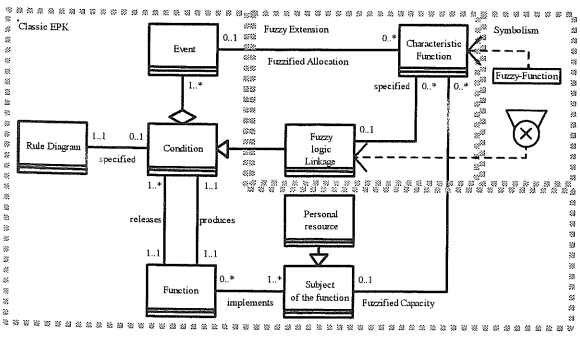

Figure 3: Extended meta-model of the EPC and symbolism

With this supplement current problems in modelling can be solved [26]. E. g. the following business process can be adequately illustrated: In an industrial enterprise with a make-to-order production concept a manager is responsible for the staffing of the project teams. Who is assigned to a specific project depends on

- a computed object value for the order, summarizing customer equity, size of the order etc. and
- the availability of a specialised engineering team (EP).

The latter circumstance represents a bottleneck, which can lead to delays.

The availability of any Standard Project Team (SP) is considered as given inherently. The way of treating the order and thus the implemented functions differs depending upon the organizational unit assigned to the activity. This structure with multiple conditions is even more complex as the manager decides based on soft boundaries, implicit knowledge and experience. In figure 4 the corresponding crisp business process model is shown.

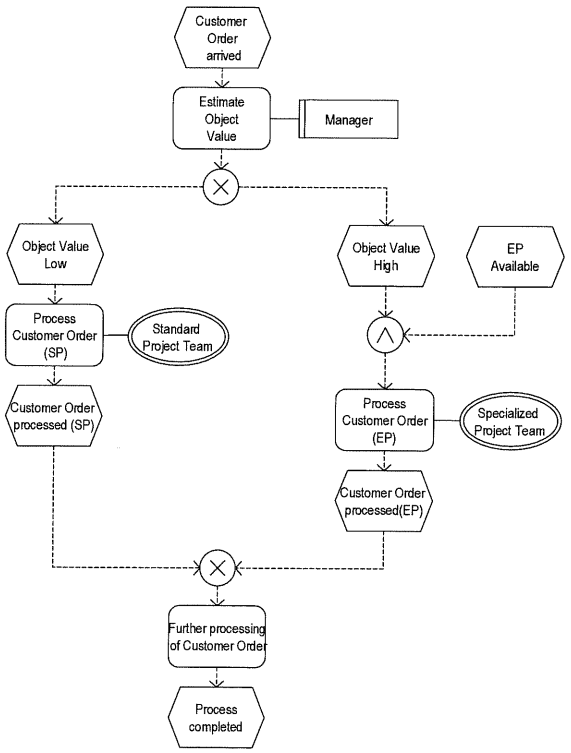

Figure 4: Crisp EPC

Traditionally the vague conditions would be translated into crisp decision rules to be executable within workflow systems, if this process were supported by workflow automation at all. The intervals would be limited by exact boundaries and a more or less comprehensive mathematical model would substitute the experience of the manager. There relevant information is lost and the IT supported decision is worse than the original one.

Using the introduced fuzzy-extension of EPCs the workflow management can be improved. Decision rules are now implemented with the help of the lin-

guistic variables "object value" and "availability". As linguistic terms "low" and "high" for the object value as well as "good" and "bad" for the EP availability are defined, a reduced rule-set can be given with:

(1) IF "object value" = low OR "EP availability" = bad THEN SP processes customer order

(2) IF "object value" = high AND "EP availability"= good THEN EP processes customer order

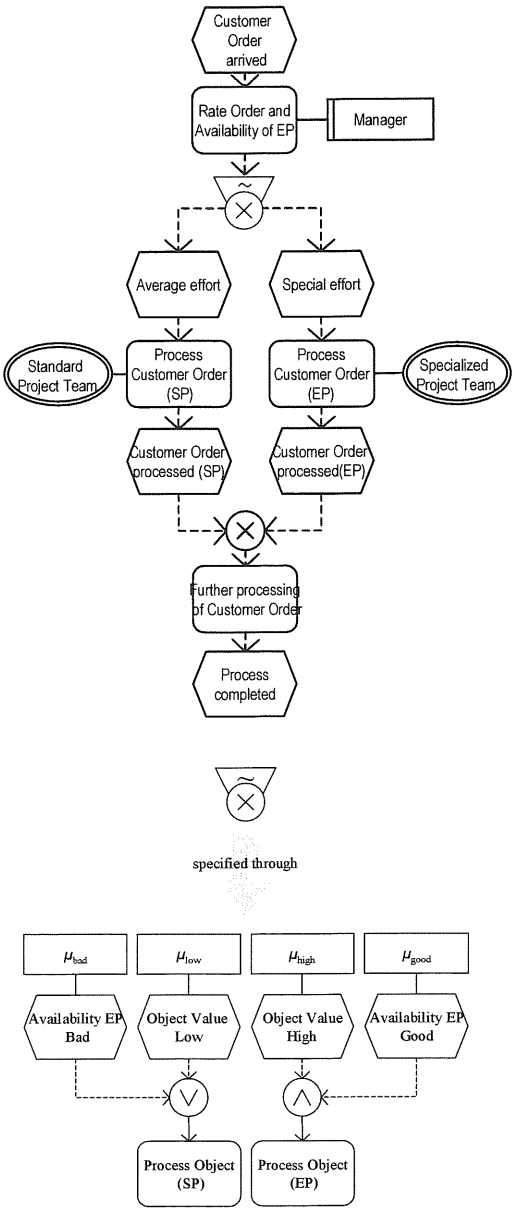

Figure 5: Fuzzy-extended EPC with connector specification

The relevant membership functions μ_{low}, μ_{high}, μ_{bad} and μ_{good} have already been presented in Figure 1. In the example a representation as simple as possible is chosen. The extended EPC is shown in Figure 5 using the newly introduced fuzzy operator "⊛". As can be seen from the figure only a marginal change of the graphical representation is necessary. At the same time the EPC becomes more intuitive as the core of the procedures is shown whilst the control logic is displayed only if required.

The used membership functions of the linguistic terms are attributed to the connector. Intentionally the membership functions are not modelled within the graph as they would overload it for the user.

The activitites are considered as internally crisp so that only one can be active at the same time. Thus the functions *Process Customer Order (SP)* and *Process Customer Order (EP)* are singletons determining the resulting output variable (see figure 6).

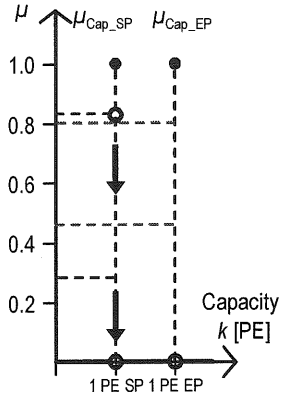

Figure 6: Output variable as singletons

The min-max method is chosen as inference mechanism for the example. After computing the fuzzified values, the inference results and the defuzzification value the Standard Project Team would treat this order as can be seen in figures 2 and 6.

V. FUZZY-EXTENDED BUSINESS PROCESS MANAGEMENT

The flexible control logic is taken out of the model so that only the business knowledge is represented in the EPC. Thus any employee can use it directly without major efforts in training. The necessary control knowledge to transfer the business model into workflow controls is attributed. Thereby the models can be easily adapted to similar cases or can instantly be used as reference models expressing best local practice. The natural way of human thinking is directly applicable in the design and administration of model-based workflow systems. The user can change the easily understandable rule sets at run-time and hence is able to influence the execution of the business process straightforwardly.

In figure 7 a prototype for a business process management tool is shown in a screenshot. A standard BPM tool can be extended to include fuzzy components. The user can work in easy mode where only the traditional left hand side window is displayed containing business content. On the right hand corner additional components are available to define or fine tune membership functions with a wizard and to intuitively enter the rule base. The usage of existing standards as often as possible and the support of the user through wizards ensures the acceptance of the new concepts in practice.

In order to transfer the fuzzy-extended concepts into workflow control and process automation systems two ways can be taken. First the applications can be fuzzified internally whilst the workflow management system itself is not affected. This solution has already been implemented several times e. g. within a project of the firm FUZZY!INFORMATIK with BMW Bank rating customers in loan granting. The main problem herein is the loss of relevant information after the specific activity is completed and the unavailability of relevant information for the workflow system and for consecutive activities.

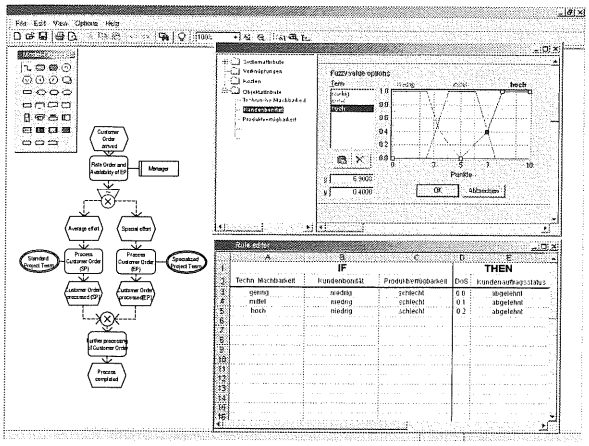

Figure 7: Screenshot of modelling tool

The second and better way is the direct extension of workflow systems. The inclusion of fuzzy control mechanisms can be based on existing implementations of fuzzy controllers that are available in many programming languages from C++ to Java. The most difficult part will be the extension of workflow definition languages. A first study on extending WFMCs Workflow Process Definition Language (WPDL) [27] showed that only data structures have to be changed or added. The concept itself is not affected. With the new XPDL [28] that is based on XML-Technology the extension will be even more easy.

The workflow system OPENFLOW [29] has its origin in a scientific context but is also used in production systems. The system relies quite strictly on WFMC specifications. As a proof-of-concept it has been extended with the proposed fuzzy concepts on the level of non-graphical process definition and instance execution.

VI. CONCLUSIONS

As shown current business process management concepts mostly disregard vagueness and uncertainty in business statements. Especially when a business process is supported by workflow management systems imprecise or vague data and interdependencies are translated into crisp mathematical models. This loss of relevant information and flexibility produces significant inefficiencies. The long existing Fuzzy Set Theory can be used to integrate this kind of uncertainty into BPM.

A Fuzzy Workflow Management System can be defined as an IT-system that relies on fuzzy-extended business process management methods. It mainly consists of Fuzzy Workflow Controllers that use fuzzy inference mechanisms and fuzzy rule sets to proactively route the flow of data and documents within a group of users. Thus the traditional benefits of IT-supported workflows are strengthened and can even be achieved in the field of unstructured and imprecise business processes. Additional value is generated as uncertain and tentative information can be modelled and implemented.

The authors propose two directions for the further work. In the research area business processes in different domains should be extended systematically. Here the whole spectrum of fuzzy concepts should be used. Beyond the extension of core control logic, resource assignments and information flow objects can be treated as fuzzy entities. Concerning fuzzy-enabled BPM software tools and workflow systems, implementations with a large scope of functionalities should be addressed and in consequence first product-near prototypes will be realized. To promote dissemination of this idea XML-schemas capable of fuzzy data should be developed and published.

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BIOGRAPHY

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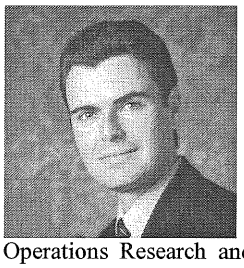

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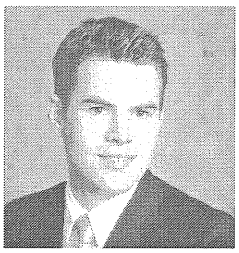

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SIMULATION MODELS FOR THE FEASIBILITY AND REWORKING STUDY OF AIRCRAFTS

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Abstract: **In this paper Authors describe a methodology to project the production flow of the reworking activities for a twin turbo-engine aircraft and to evaluate its feasibility and efficacy by a simulation model built to improve the characteristics of the reworking.**

The company described in this work, Piaggio Aero Industries, specialises in executive class airplanes. The product object of this study, called P166, used by the italian army for search and rescue, is the result of complex manufacturing processes. The reworking procedure has a strategic meaning for the company Piaggio Aero-Industries because of the foreseen need to rework the whole fleet of flying P166 in a near future.

The maintenance of aircraft it's a very important phase both for safety reason as for it's complexity and higher costs. The main goal of this study is to combine customer needed and company necessity. Obviously a maintenance process requires a great attention and control from the deliveries time and the quality point of view. The paper shows the different phases in which the study was developed.

Authors describe the use of simulation in addressing interrelated issues such as final product due date determination, supply requirements, suppliers relationship management, work centre loading and work-in-process control.

Index Terms: **Reworking processes, discrete event simulation, planning and scheduling.**

I. INTRODUCTION

The study is divided into three different steps. The first was the certification and configuration control of three aircraft used as prototypes. The modifications regarded the main on-board systems, avionics, structural reinforcements related to new operational requirements and the substitutions of the engines [11].

The second step was about the project of the production flow suitable to achieve the complete reworking of four different aircraft per year. The project defined the human, mechanical and operational resources required during the second phase of the study. In this phase it was necessary a detailed analysis of the operations cycle in order to well identifies the milestone and to define the capability of the existing system.

Finally the third step has been realized in order to better analyse the efficacy of the projected flow; Authors developed a simulation model suitable to verify planned production flows in a stochastic state. The model was implemented using the MODSIM III programming language and runs using data obtained during the first and second phase. This choice was decided after a comparison between different simulation tools.

The stability and adherence of simulation results to the simulated reality was then statistically analysed.

In a simulation-based scenario, such a proposed flexible flow shop case study, several dispatching rules are used to make a decision when a resource becomes available. Simulation-based approaches are restricted mostly to a scheduling capability and are able to represent the details of scheduling situations, communicating the specific details to various levels of personnel because of the visual aids (e.g. animation) offered by simulation.

Since each rework involves the overhaul of a great number of parts and the 60% of them are provided by external suppliers, the outsourcing plays a crucial role for the whole production process and, in particular, at the final assembly time. The outsourcing process introduction in Piaggio Aero Industries followed seven fundamental steps:

1. strategic analysis;

2. needs and objective expectations from the outsourcing point of view;
3. potential suppliers identification;
4. suppliers selection;
5. effective transfer of management operations;
6. supply chain requirements identification;
7. suppliers relationship management.

The challenge of the proposed simulation study is to verify the feasibility of the reworking operations, taking into account the intrinsic stochastic nature of a reworking process. The proposed approach is able to satisfy the delivering of products with respect to the existing resources, the minimization of the work-in-process and the maximization of the personnel and the equipment utilization by establishing routine operating policies such as customized supply agreements, predefined shift patterns rather than overtime.
At the beginning of the simulation project, these goals are determined at management-level meetings. After goals were determined, data collection and transformation of goals into measurable criteria began.
The remainder of the paper is organized as follow: after a brief explanation of the studied case, the proposed approach is followed up and the processing routines and the simulation shell are described; then the contribute of the stochastic approach is highlighted and the conclusions are drawn.

II. SIMULATION OF THE REWORKING PROCESS

The aim of the proposed work is to face a production where the major stochastic source is represented by the deliveries of sub-items and material along the reworking process.
The rework of each aircraft can be divided into six macro operations:

- disassembly of the interested parts;
- structural modifies; new landing gear, new fuel tanks, new reinforced wings tips, new balance tabs
- the maintenance, control or substitution of all on board systems;
- the reassembly;
- ground tests;
- flight final tests.

At the beginning of the simulation study, a preliminary data analysis showed that the supply items could be divided into three major classes and that A class materials play a crucial role at the final assembly process. Nevertheless due to the high number of A class suppliers (107), involving the 90.6% of the total supply costs, and items (786), it has been necessary to build classes both for suppliers and for items according to the following table:

Table 1: Suppliers and items modeled classification

Supplier class	Class A PN	Class B PN	Class C PN	Total PN
Aa	84	121	175	**380**
Ab	38	55	97	**190**
Ac	1	44	171	**216**

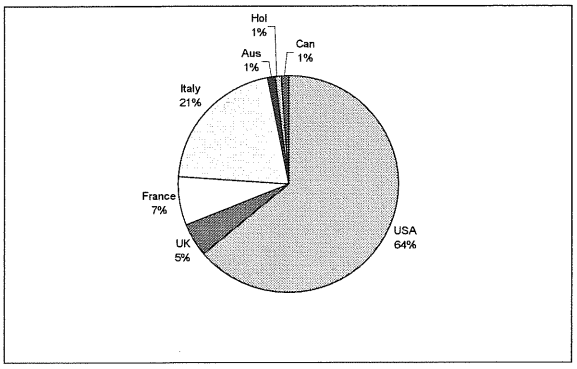

Figure 1: Suppliers geographic location

Referring to the class A suppliers localization it is interesting to outline that the 64% of them are sited in the United States while only the 21% are in Italy, as figure 1 shows. For each of the aforementioned items sub-classes routings were identified and developed using spreadsheets, as figure 2 shows. Engineering and production personnel verified these routings. While this activity was taking place, modelling started.

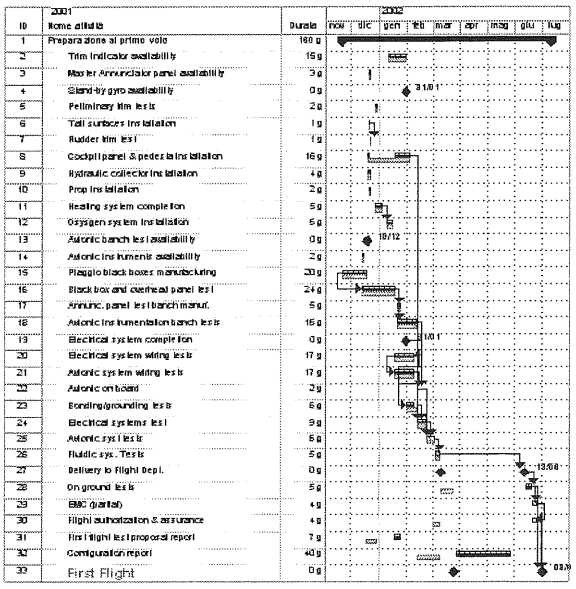

Figure 2: P166 reworking phase

III. IMPLEMENTATION ISSUES

The second phase of the simulation study has been focused on the necessity to verify which tools were able to model the reworking and supply process. Through the development of several dummy models a

preliminary analysis has been performed and two different simulation tools were used: Simul8 (Visual Thinking International), and OSIRIS (developed by DIP - University of Genoa).
These models, implemented at a first stage using deterministic data derived from the aforementioned routings, have been also implemented using stochastic data; the models run over a simulation horizon equal to 10 years, showed analogous behaviors, as MSpE (Mean Square Pure Errors) graphs outline.

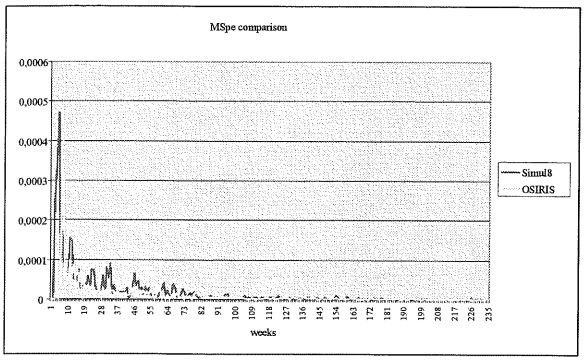

Figure 3: MSpE comparison

Both simulation environments provided correct models of the production system to be investigated. Furthermore, referring to Simul8 tool, reliability was ensured by a commercial support.

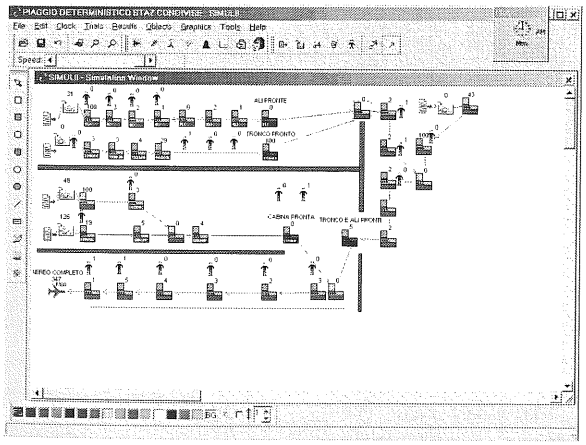

Figure 4: Simul8 environment

Nevertheless, according to the particular purposes, the final choice was to develop an ad-hoc software able to interface easily the existing enterprise information system, using customized procedures. The developed environment has been derived from a previous study, made under a national granted projects, named WILD (Web Integrated Logistics Designer) [5], [6].

IV. IMPLEMENTATION, VERIFICATION AND VALIDATION

The proposed simulation environment, has been developed by extending some of the basic functionalities of the WILDNESS (Web Integrated Logistic Design Network Scheduler and Simulator) prototype and by adding objects and methods necessary to the reworking system managing, planning and control cycle. Authors paid particular attention to the supply procedures providing a powerful interface to the users in order to define supply requirements complying with the master production schedule [7].

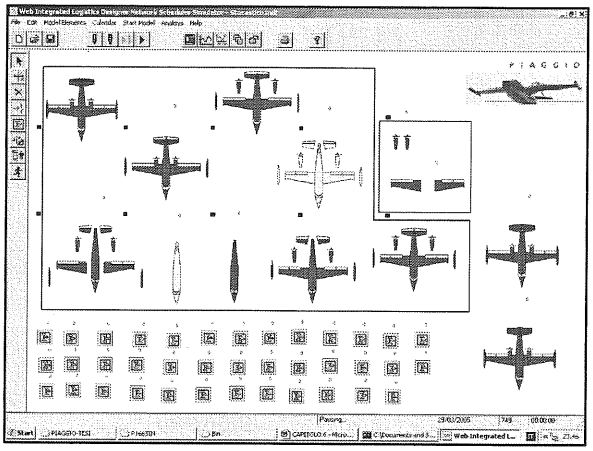

Figure 5: – WILDNESS environment

The simulation model is able to include the following components, which are found in most simulation models [2], [8]:

1. production system objects;
2. production system gates (items);
3. items;
4. inter-operational buffers;
5. human resources;
6. mechanical resources or workstations;
7. processes and tasks;
8. learning curves;
9. statistical generators;
10. suppliers features.

After the data collection data phase user has to enter several input in order to run the model:

1. plant calendar;
2. planning horizon;
3. suppliers reliability;
4. learning curves;
5. warehouses state;
6. in-process orders;
7. arrival items list.

The developed model is able to produce the following information during simulation:

- graphic animation;

- warehouse level and WIP;
- event and message trace;

The following results can be displayed at the end:

- resources utilization;
- critical path of each production PERT;
- delays list;
- general statistics.

From the simulation point of view, the model is considered as a queuing network where a reworking process may require several different operations by different workstations or workplaces, and may have to wait in several different queues [2].
Activity processing times have been described through probability distributions calculated from the historical data collected during the last five years.
While the plane flows over the different workplaces or reworking/assembly stations several parts are replaced; an operation on a station can be performed only if machines, personnel, equipment and materials are available in the right quantity at the right time. So several stations, which represent a constraint in terms of physical space and equipment devoted to the support of the reworked airplane, have been added in order to execute the necessary tasks in successive time and to continue with the reworking process of other aircrafts; others, instead, can be only of serial type and are a critical capacity constraint. This flexibility, introduced through the adoption of parallel workstations, even if is useful in order to reduce the impact of completion delays, on the other side implies increased costs; in fact, the non-planned use of these parallel workstations is computed like an extra-cost. The external reworking of particular items as well as their replacement are the critical point of the entire process, bringing to cumulative delays which can be approximately close to 1/3 of the total reworking time. Moreover, the whole reworking process can be seen like a PERT and it is possible to identify a critical path on which each station delay reflects directly on the completion due date.
In order to obtain a valid model of the reality to be investigated, during the modeling phase the parallelism of the critical workstations has been maintained and delays collected.
After verification, the model was run in order to compare planned operations with planned reworking due dates, as the following figures show:

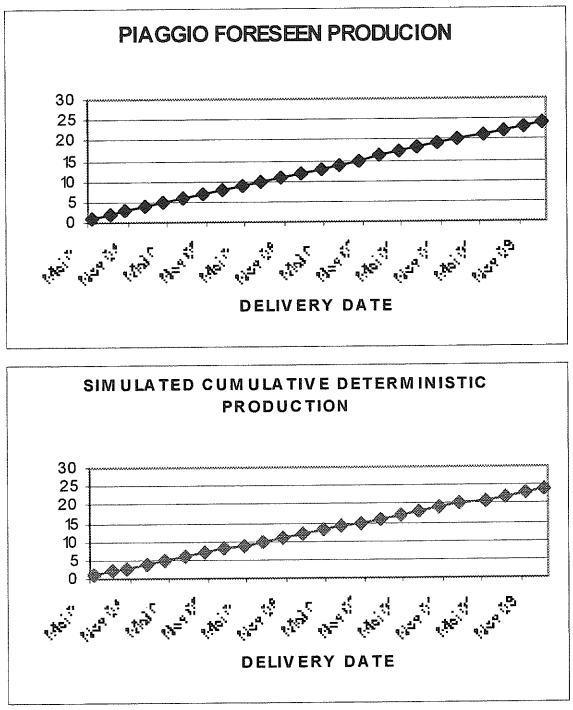

Figure 6: Cumulative production curves

Validation of the pilot model was finalized at a top-level management meeting. In this phase, project's goals were summarized, along with the model assumptions, and a "results versus reality" discussion took place. In particular the criteria required for the success of the project were defined as listed below:

- the model ability to predict the number of reworked airplanes for the 2004 and following years;
- the model ability to show the key information referred to supply requirements, reworking times, equipment and personnel utilizations (i.e. shifts).

The reworking system re-design represented, in fact, a new reality from which, by considering the uncertainty state, new parts supply and old parts maintenance contracts had to be derived and personnel number calculated, evaluating if such an assignments were complying with the resources capacity, cash flow constraints and obviously reworked airplanes due dates.

V. THE REWORKING PROCESS SIMULATION

The reworking flow design was divided into two phases. In the first one, Authors collaborated with the managers of all areas involved into the reworking program. During these meetings all problems were faced, human and mechanical resources, as well as locations, were considered. Furthermore in this phase the technical, security and the belonging relationships of all operations was considered. By using classical management methodologies the first PERT diagram was drawn. In this phase , the Authors pay particular

attention to the planning of the structural modification activity. This aspect is critic for the complexity of the operations, their duration near to six moth, and the great number of people and sub-items involved. A low level of standardization reduces the possibility of estimate necessary times, mechanical and human resources. Another important aspect was to plan the right flow to verify the necessary certifications for the rework. Only in this way in fact, Piaggio will be authorized by "National aircraft certification agency", to rework all P166 fleet

The first step finished with the formalization of the preliminary reworking flow and the implementation in the simulation model. After a performance test of the proposed planning, the simulator was used to evaluate the impact of the stochastic aspects, related to the process, with respect to the deterministic reworking plans. In this phase was outlined all contradictions related to the deterministic planning.

The system was stressed and experiments made, changing critical parameters, like operational times, available resources, and so on, to understand their importance into the reworking process. The position of some operation and the required resources were changed. Every time, the importance of the supply process emerged, more than the process or technical aspects themselves.

The results of this second step was the final reworking flow including of all the indications in order to increase or reduce the production capacity. Other important results were:

- the real capacity related to the reworking plan;
- several parametric indicators useful to rank the most critical operations of the process;
- a support in order to define the reworking program at manager level.

VI. RESULTS

Experimentation included many simulation runs considering different suppliers reliability coefficients, safety stocks, multiple workstations at critical stages and alternate routings for reworking activities as well as different material arrivals. Authors chose a simulation length of 6 year. Instead of a warm-up period, a realistic work-in-process status in the shop was used. Results outlined several important problems:

1. it is not possible to rework 4 airplanes per year since the resource allocation was made by using deterministic data;
2. by considering the stochastic data, like suppliers parameters, material arrivals and the preset safety stocks levels, the production system is able to rework only 3,45 airplanes;
3. the actual situation corresponds to a system in which suppliers have an average reliability of 75% on deliveries;

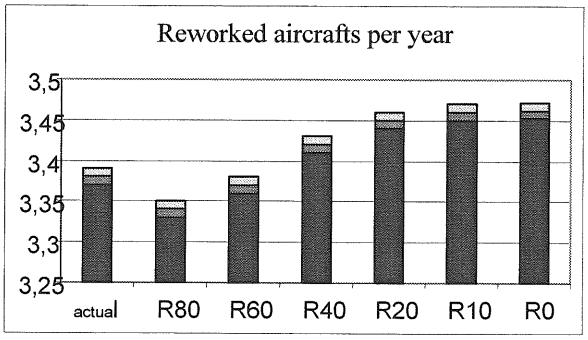

Figure 7: Annual production scenarios

4. delays showed higher values in the first reworking stages and decrease along the assembly process;
5. the use coefficient of workstations is low and increase in the final stages of the reworking process in order to recover collected delays;
6. new policies of configuration control are necessary to reduce delays;

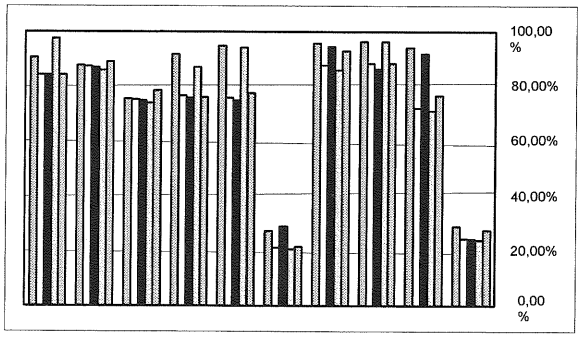

Figure 8: Workstation use coefficients

7. structural modifications are the most important and critical phase of the rework;
8. there is a scenario for which it is possible to rework about 4 airplanes with double shift in some stages of the reworking process.

This latter point can be obtained only by changing the supply requirements and agreements, using an higher number of parallel workstations at the most critical production stages and defining different safety stock policies and personnel number.

The effects of expediting, in order to improve the supplier punctuality, showed to be useful in this type of reworking process.

VII. CONCLUSIONS

This work, finished in March 2003, and its results will be used by Piaggio Aero Industries' managers to

plan the new reworking program for the next six years.
Looking at the provided forecast accuracy, nowadays, Piaggio Aero Industries is interested in a more appropriate and detailed implementation of the planning model since results showed which are advantages of a methodology based on simulative approach both in the case deterministic and stochastic data are used to build the model.

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BIOGRAPHY

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USING SIMULATION METHODS FOR MODELLING THE PRODUCTION OF THE CASTINGS OF ENGINE BLOCKS

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Abstract: **The contribution focuses on using simulation methods to test and increase the throughput of orders in the production process. The aim of the simulation study was identifying bottlenecks in the production process and taking such measures that would ensure maximum increasing of the throughput of orders at minimum costs. In the paper we describe the procedure of a case study solution and we present an example of a simulation model, as well as the case study results.**

Index Terms: **discrete simulation, shift model, manufacturing system, foundry industry**

I. INTRODUCTION

If a company specializes in piece production and each product has a different technological procedure, then the optimisation of the production process is difficult to implement. In case of small- and large-scale serial production or even mass production, the question of optimisation is becoming more and more important. It means providing solutions to the flow of material through the workshop and proposing adequate production and human resources in the workshop.

It often happens that the workshop does not reach the required production volumes. During the actual production process there is often a delay of some operations. Mutual influence of such delays causes the planned production is not achieved. An important role is played by the common production resources, e.g. various instruments, interoperation transport, workers operating more machines at one time, etc. It is evident that there are many influences affecting the production process and therefore it is difficult to set up the entire production process in the optimal way.

This contribution concentrates on the situation analysis and on proposing measures for increasing the throughput of engine block castings using simulation methods.

II. CASE STUDY

In the production originally oriented on casting big steel and cast-iron pieces, a new solution has been sought for to realize small production series (up to hundreds of castings per year). This new situation required particular measures to cover the production of the planned number of orders cost-effectively.

For this production the common technical "equipment" such as models for castings, moulding frames, storage areas and other resources are used. It is necessary to coordinate the transport of some of these instruments within the workplaces during different phases of the production process and use them most effectively.

This project was concerned with finding bottlenecks and eliminating them cost-effectively. A considerable problem was the fact there were no clear and guaranteed production procedures at our disposal. Therefore, it was necessary to make the following factors more precise:

- technological procedures
- timing of technological operations at workplaces
- interoperation times
- numbers of workplaces – their interchangeability
- operating personnel – shifts.

For the above reasons solutions using MRP or APS were not acceptable, and a method of verification using simulation study was applied. The task was to optimise the production of castings by maximizing the throughput and minimizing the investments and time necessary for implementing these changes.

A. Data for simulation

In the first phase, the simulation project focused on data acquisition needed for creating the simulation model. Therefore the task was divided into two areas of activities carried out by two working groups. The first one collected the data for more accurate technological procedures and for the correct operational times. The second group focused on the building of simulation models and on realization and evaluation of simulation experiments.

B. Analysis of orders

The analysed orders consisted of several types of castings. For all these types the analysis of technological procedures and times was carried out and consequently the basic representatives of all types of castings were selected.

C. Simulation model

On the basis of completed analysis, the simulation model for all the three types of castings was created. The functions of the developed simulation model were validated using the method of animation assisted by specialists from workshop who had to confirm if, according to their experience, the functions of the model were correct. These specialists evaluated the production times, the movement of castings and the allocations of workplaces during the production and also allocation of particular resources. This validation was carried out for all the three representatives of castings.

D. Animation

A very important step during the simulation runs is the simple animation - see Fig. 1. This animation was used either for validation of the simulation model or for presentation of the preliminary and final results. This animation is psychologically very important for the industrial enterprises managers. It helps to change their cautious attitude to simulation results and thus it facilitates implementation of the recommended measures.

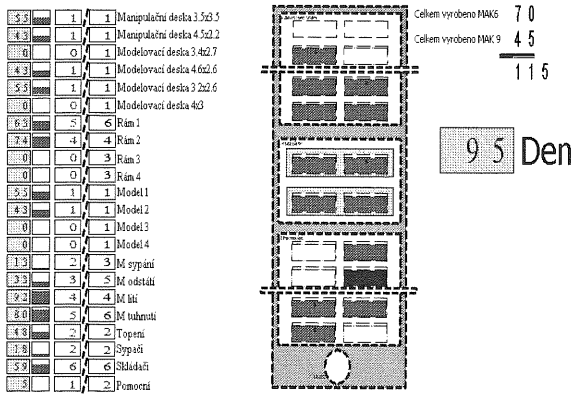

Figure 1: Example of simple animation

If we take a look at Fig. 1, we can see a simulation model animation that combines two types of castings at a given ratio. Here it shows utilization of individual resources (workers, tools, workplaces etc.) - both numerically and in diagrams. In addition, also the number of resources being used at a given interval is shown, as well as the number of free resources being at disposal. Moreover the time and the number of finished products are displayed. The central part of the picture is reserved for the scheme of the workshop layout including particular workplaces for castings. The colours are used to distinguish the different stages of the product. The red colour indicates that the casting is still in the production process. The blue colour is used when the product is ready for the next technological operation.

E. Software used for evaluation of the experiments

Every simulation experiment is necessary to be evaluated according to different outputs. Standardized output statistics from the simulation tool ARENA were used to evaluate these experiments. To display the other important results, we used Microsoft Excel and we programmed the application also in Microsoft Visual Basic.

Fig. 2 represents one of the Excel output statistics we used. The figure comprehensively illustrates the utilization of the resources.

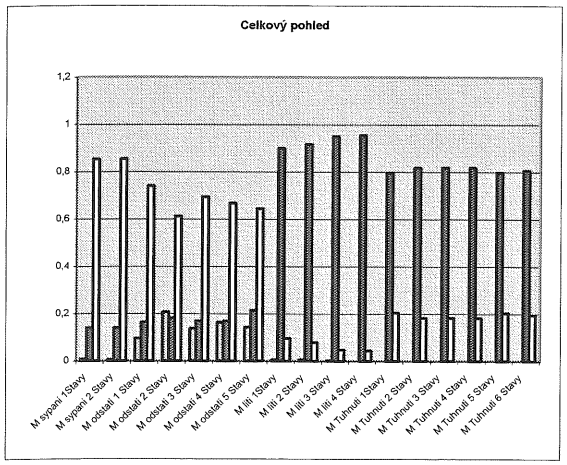

Figure 2: Output statistics in Excel

Another example of some more output data is in Fig. 3. It is evident here how a given type of resource is being used during the simulation interval. This diagram shows the uniformity of resource utilisation.

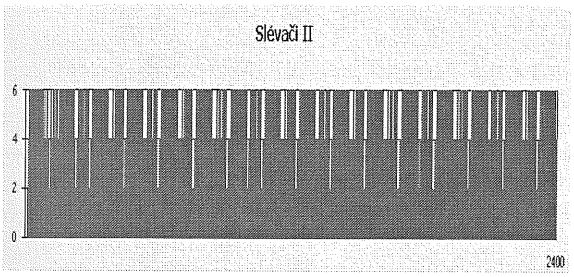

Figure 3: Resource utilization in given interval

F. Experiments

All experiments were carried out in close collaboration with specialists from the company. In this way only such experiments were validated, which are feasible in the company. Also the question of safety norms for foundry industry had to be considered.

During the experiments various combinations of products were tested and bottlenecks were identified. On the basis of the realised experiments we succeeded in proposing several convenient variants how to increase the throughput of orders at different investment costs.

For each type of castings different bottlenecks were identified. On the basis of the experiments carried out, it was possible to double the production throughput at minimum costs (about several ten thousand in Czech crowns).

III. Conclusion

Using simulation models enables to validate the impact of different management decisions on the whole production process and to recommend its more suitable adjustment. E.g. we can determine the common production resources (various instruments, interoperation transport, workers operating more machines at one time, etc.) for the most economical way of producing the required number of products of a particular structure.

During the development of the case study some particular recommendations were put into practice in the workshop where the throughput of orders has gradually increased.

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Biography

Vaclav Votava had worked as a researcher at SKODA company in Pilsen (since 1964 in the field of the automatic control, measurements, information systems, software development). From 1991 he has been Associate Professor in the Department of Industrial Engineering and Management at the University of West Bohemia in Pilsen. Current activities are focused on education (present and on-line form), simulation of the discrete systems, information systems analysis, multimedia approach, internet information systems.

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CAPE APPLICATIONS IN SPECIAL WOOD FRAMES MANUFACTURING

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Abstract: **It is common knowledge that CAPE applications (Computer Aided Production Engineering) are the most innovative tools to plan, model and simulate manufacturing processes in view of the fact that factories need to cut down time to market and to optimise the resources to be employed. The present work outlines the results achieved by means of the application eM-Plant used to define planning of items production upon order.**

After the preliminary analysis - aiming at pointing out the resources to be employed and the quality and quantity of the lots to be produced - thanks to simulation techniques, we were able to find out optimal plant configurations and operational sequences able to cut down production times and costs.

Index Terms: **Computer Simulation, Computer Aided Production Engineering, Digital Factory.**

I. PRELIMINARY ANALYSIS

The final market of the factory under consideration is extremely differentiated as far as type of the product and final customers are concerned.

The items produced – door and window frames and furnishings – due to their fine materials and the nature of the output process, are characterised by high quality standards.

The impossibility of planning production in advance and the fact that some manufacturing phases are handicraft, often cause undesired interoperative accumulation, poor balance of processing phases, low efficiency and, as a consequence, delay of delivery times.

As already said, in order to remove these problems, the production process has been planned and simulated by means of the application CAPE eM-Plant by Tecnomatix Technologies Ltd.

Working phases have been classified as follows:

- process analysis and data collection,
- production cycle modelling and implementation,
- simulation and validation of the virtual model,
- evaluation and comparison among process index,
- resource optimisation.

In particular, the processing surface has been divided into functional areas and operative sections as indicated in Figure 1.

Due to timber seasoning, there is no initial storeroom but a separate, air-conditioned area.

The planimetric layout used, harmonises the operating phases of the classical model of step-by-step organisation. The planning of different production cycles implies different materials handling among the various shops, thereby putting into practice the concept of flexibility, which is typical of working on order.

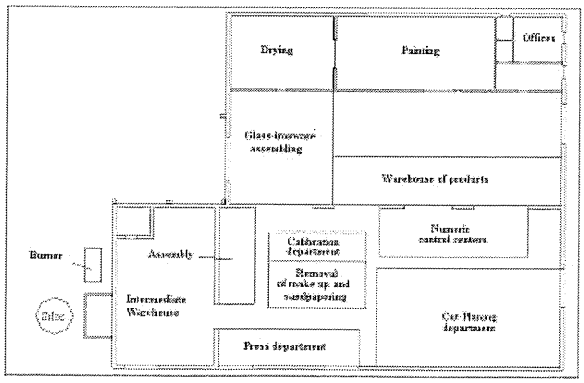

Figure 1: Plant lay-out

In order to reach set targets, system analysis focussed on products much in demand.

The Figures schematize the processing phases necessary for products output.

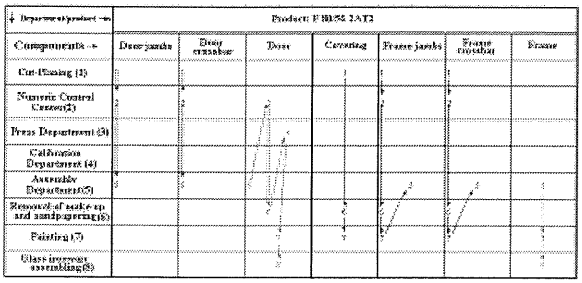

Figure 2a: Product F 80/56 2AT2

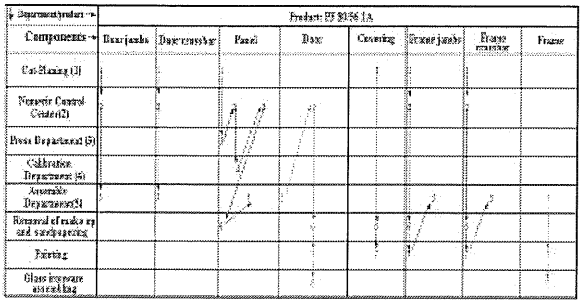

Figure 2b: Product PF 80/56 2A

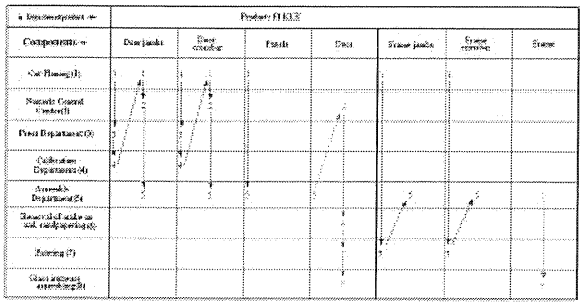

Figure 2c: Product PIKKK

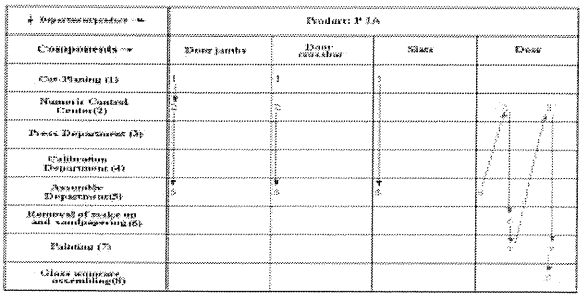

Figure 2d: Product P1A

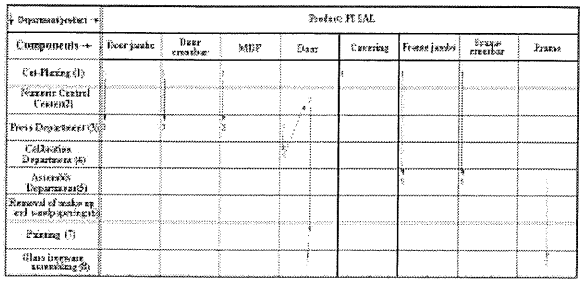

Figure 2e: Product PI 1AL

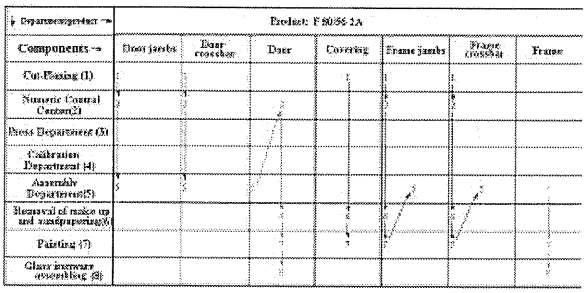

Figure 2f: Product F 80/56 2A

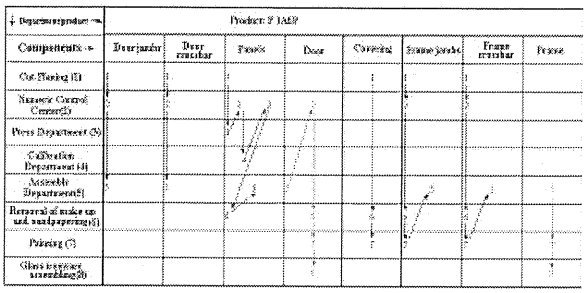

Figure 2g: Product P 1A6P

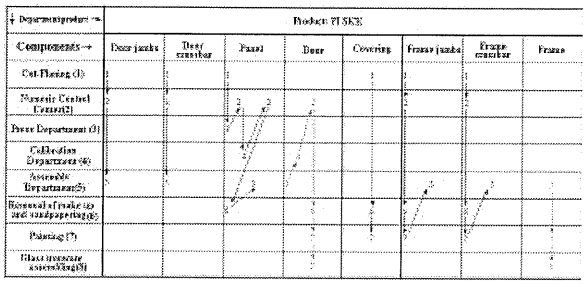

Figure 2h: Product PI SKK

II. SYSTEM MODELLING AND MODEL VALIDATION

eM Plant application uses a graphics interface with different dialogue windows enabling the access to support libraries from which different tools can be selected in order to:

- define plant layout,
- create work places,
- modelling of equipment used for materials handling,
- define monitoring and control tools for process parameters,
- monitor main, intermediate and final warehouses.

It is useless to underline that the correct use of the software is subsequent to an accurate initial evaluation of plant components and activities.

It is therefore of prior importance to organize technical documents for gathering and organising information concerning:

- machinery equipping times,
- processing times,

- accessibility/non accessibility times,
- processing parameters,
- production capacity,
- statistical evaluation of rejects,
- planned maintenance interventions,
- control modes, entity and frequency,
- materials collection and transportation modes,
- handling space and time,
- stock management policies.

Once processed, the data acquired enable to arrange and simulate the production cycle in virtual reality.

In the present case, the implementation of above mentioned phases defines an initial virtual model, which is indicated in Figure 3, where different images indicate the resources employed (production shops, raw material main, intermediate and final warehouses, tools for production control and resource optimisation).

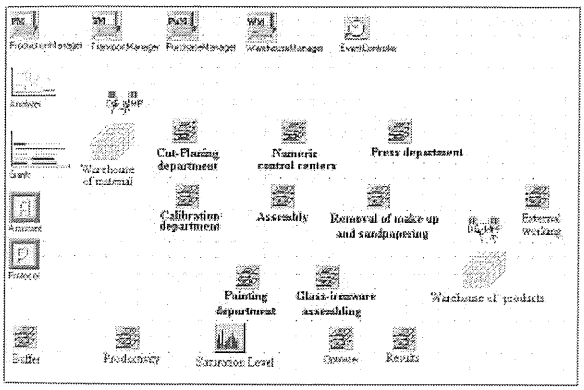

Figure 3: Virtual lay-out

Simulation carried out in this first phase aims at validating the model by checking obtained results.

In the present context, a complex simulation program was used, taking into consideration orders processed by the firm in the year 2002.

The results obtained are indicated in Table 1.

In particular, it is important to highlight that the difference between actual and simulated time does not exceed 6%.

Table 1: Validation of the simulation model

Products	Quantity	Quantity	Quantity	Quantity	Quantity
P 1A	10	21	5	2	1
P 1A6P	10	10	15	4	1
P1 SKK	10	60	15	5	1
P 80/56 2A	10	197	30	8	1
PF 80/56 2A	10	10	30	8	1
P 80/56 2AT2	10	66	15	8	1
P1 KKK	10	28	5	3	1
P1 1AL	10	430	15	7	1
Simulated production time	12 days	155 days	22 days	8 days	5 days
Real production time	11 days	147 days	24 days	8 days	5 days
Difference %	5.88%	2.91%	8.35%	0%	0%

Once tested the effectiveness of the model, further analysis was carried out to define plant layout and management procedures to employ resources more rationally.

It is obvious that the simulation model under application must be a tool able to mime the performance of the real system, which could evaluate the results when changing production.

In the model proposed – in order to evaluate system performance when changing input parameters – a specific tool called optimiser (see Figure 4) was devised. It possesses a graphics interface in three sections aiming at:

- optimising the sequence of production orders by means of genetic algorithms,
- testing the sequence proposed,
- monitoring firm productivity, the quantity of interoperational stock and machinery use coefficients in real time.

It is important to highlight the nature and entity of problems which must be solved by the optimizer and, of course, understand how it works.

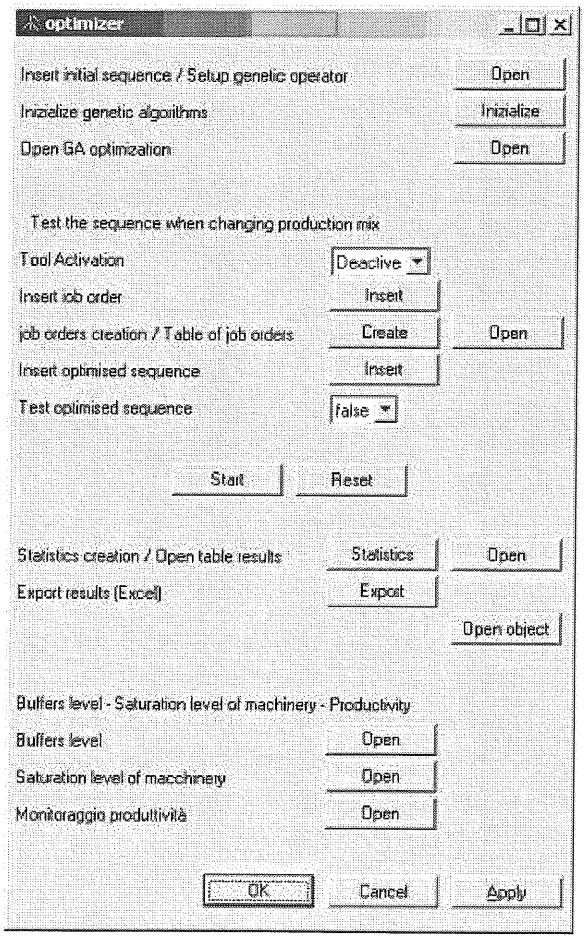

Figure 4: Optimizer

The most frequent problems when working upon order are the following:

- correct scheduling of production orders,
- optimal buffers size,
- balance among production lines,
- downtime cutting,
- system productivity.

It is also important to point out that problems concerning the scheduling of production orders cannot be solved only by means of simulation tools.

In fact, after establishing a certain sequence of order processing, the simulation can find out:

- long times for orders processing,
- considerable unbalance among shops,
- excessive wait times.

By varying the processing sequence, the initial solution can be improved or worsened.

To systematize the sequence it is therefore necessary to use optimisation algorithms which, thanks to an interface with the simulation model, find out the most suitable solution.

Optimisation algorithms must find out acceptable solutions, while the simulation model must test, validate and choose the best solutions.

Within eM-Plant genetic algorithms suitable for sequence optimisation are already implemented.

The interface between the simulation model and genetic algorithms was created through the programming and application of specific sub-routines, written in SimTalk.

The use of algorithms goes through three fundamental steps:

- initial sequence setting in and setting of genetic operators,
- algorithms initialization,
- optimisation.

The best sequence which can be obtained for processing production orders by means of genetic algorithms can be suitable for the order under consideration, but it can turn out not to be suitable for others.

It is therefore necessary to test the chosen sequence when changing production mix.

This can be done through the second optimisation phase. For this phase it is necessary to:

- activate the tool,
- input orders characteristics and generate the production mix,
- create orders and visualize their results,
- input the optimal sequence, (output of genetic algorithms),
- choose the sequence to be tested, (non optimal or optimal),
- start simulation.

Once the simulation is over, the following results are visualised:

- production times for the same orders with different order sequence,
- percentage of orders for which the sequence was optimal,
- mean improvement in terms of total production times,
- intermediate buffers monitoring, (in real time during simulation),
- machinery use degree,
- mean production monitoring.

III. Optimal configuration research

Initially, various simulations were necessary on the data concerning the orders processed in 2002 in order to generate optimal sequence for the management of production orders by means of genetic algorithms.

By analysing the results obtained, it was noticed that the best improvement in total production time can be achieved by adopting the following sequencing criteria:

- carrying out of orders concerning products with external veneering,
- carrying out of orders concerning products easy to produce,
- carrying out of orders concerning more complex products.

For these phases a complex simulation program was used to analyse and test plant performance with reference to the processing of 100 orders generated as indicated in Table 2.

Table 2: Job order

	Orders 0 - 100		**Orders 101 – 200**	
	0 – 50	51 –100	101 – 150	151 – 200
Average	8	6	5	2
Standard deviation	4	2	2	1

	Orders 201 – 300		**Orders 301 – 400**	
	201 – 250	251 – 300	201 – 250	251 – 300
Average	50	25	50	25
Standard deviation	15	8	15	8

	Orders 401 - 500		**Orders 501 – 600**	
	401 – 450	451 –500	401 – 450	451 –500

Average	100	30	100	30
Standard deviation	50	5	50	5

	Orders 601 – 700		**Orders 701 – 800**	
	601 – 650	651 – 700	601 – 650	651 – 700
Average	180	100	180	100
Standard deviation	25	20	25	20

	Orders 801 - 900		**Orders 901 – 1000**	
	801 – 850	851 –900	901 – 950	951– 1000
Average	8	5	75	125
Standard deviation	4	2	35	10

The results obtained in terms of *improvement/worsening* of total production time are summed up in Table 3 and reported in Figure 5.

Table 3: Improvement/worsening of total production time

	Orders 0-100	**Orders 101–200**
% Optimised orders	88	91
% Non optimised orders	12	9
Mean improvement	~ 26 hours	~ 11 hours
Mean worsening	~ 21 hours	~ 11 hours

	Orders 201– 300	**Orders 301-400**
% Optimised orders	89	86
% Non optimised orders	11	14
Mean improvement	~ 147 hours	~ 48 hours
Mean worsening	~ 52 hours	~ 22 hours

	Orders 401-500	**Orders 501-600**
% Optimised orders	87	97
% Non optimised orders	13	3
Mean improvement	~ 273 hours	~ 279 hours
Mean worsening	~ 83 hours	~ 172 hours

	Orders 601- 700	**Orders 701-800**
% Optimised orders	97	83
% Non optimised orders	3	17
Mean improvement	~ 491 hours	~ 151 hours
Mean worsening	~ 96 hours	~ 61 hours

	Orders 801-900	**Orders 901-1000**
% Optimised orders	76	96
% Non optimised or-	24	4
Mean improvement	~ 26 hours	~ 398 hours
Mean worsening	~ 15 hours	~ 92 hours

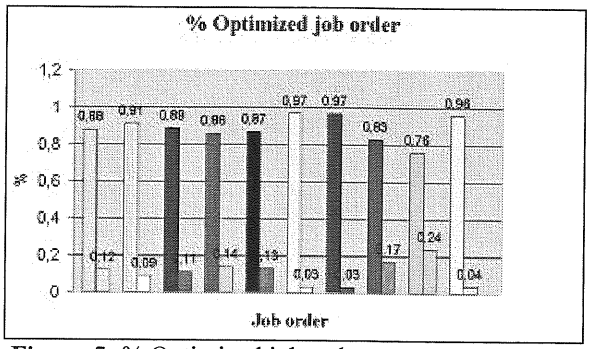

Figure 5: % Optimized job order

By processing the data contained in Table 3, the evaluations contained in Table 4 were obtained, where the improvement of total production time (in %) refers to a single order.

Table 4: Optimised orders and time improvement (in %)

Optimised orders	89%
Time improvement	12%
Non optimised orders	11%
Time worsening	5%

During simulation, further analysis focussed on machinery performance and buffers filling levels. Figure 6 highlights equipment use mean coefficients. The diagram indicates that most used machinery concern the processes of cutting and painting.

Initially, it was supposed to duplicate most used machinery in order to uniform use coefficients and reach a better balance.

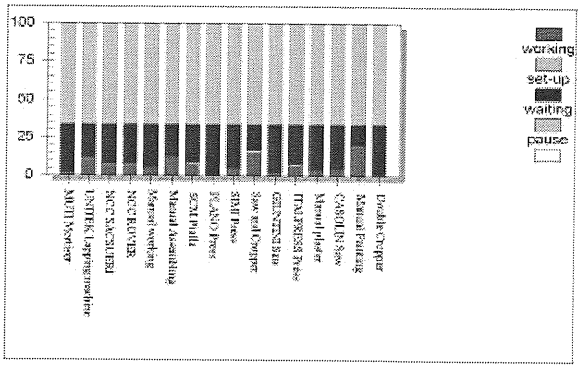

Figure 6: Mean saturation level of machinery

The simulations carried out by means of this configuration reduced production time by 13% and increased productivity by 18%.

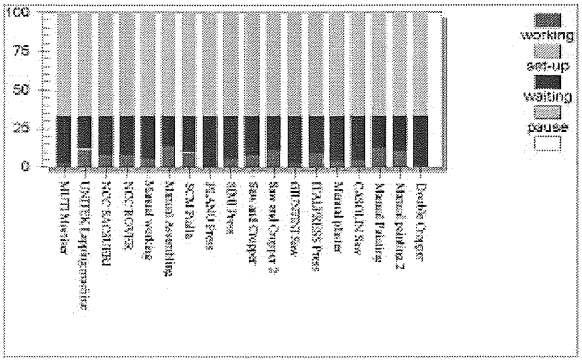

Figure 7: Optimised mean saturation level of machinery

According to the results obtained, further analysis must be carried out to establish if the solution proposed is cost effective.

The simulation model, adjusted according to examined orders and sequence criteria proposed, caused a mean reduction of half-processed products accumulation of 23%, and, as a consequence, a redefinition of the materials handling and accumulation areas.

IV. Conclusion

The validity and efficacy of the applications employed is no doubt of great importance and they are consolidated by the results obtained in other case previously considered.

What must be stressed is its flexibility which enabled to simulate the performance of the production cycle in real time and to plan tools suitable for optimising employed resources.

Solutions found can be filed as tools to be used in other cases and/or simulation models.

With reference to the results of the system analysed, it is necessary to point out that the solutions proposed, besides offering configuration hypotheses in a real configuration, could be compared with other optimisation criteria to find other possible structural hypotheses which are technically- and cost efficient.

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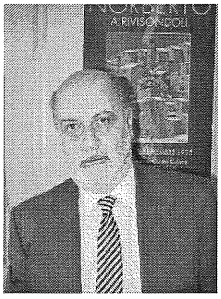

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INTEGRATED VIEW ON PRODUCTS AND SERVICES – PRODUCT-SERVICE SYSTEMS

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Abstract: **This paper gives a general survey of the field of integrated development of products and services, describes the corresponding problems and shows a first approach towards a new design methodology.**

Index Terms: **Design Methodology, Property Driven Development/Design, Product Development, Service Engineering.**

I. INTRODUCTION

Although it is considered as a future research domain, the integrated view on material products and services is treated in the most cases from a marketing point of view. Development approaches are hardly drawn into consideration. This paper gives a general survey on the field of integrated development of products and services. It also describes the corresponding problems handling an output, which consists of components with completely different structures and formal representations. Starting from this discussion the paper shows a first approach towards a new design methodology which considers both material and service aspects.

II. PROBLEM DESCRIPTION

To achieve an effective competitive advantage, it becomes increasingly important to give up the restriction of the term "product" in reference to a material artefact and instead to develop an integrated concept of products that besides material also have non-material components ("service components"). [1]-[6]

This can be understood easier, if the focus is set on the need or the problem of the customer, which has to be solved. A solution for a complex problem is, at the beginning of a development process, a black box which can be realized by a material product, a service or a combination of both. Seen from this perspective, it becomes obvious that already today certain required properties of a product can only be achieved by services, which complement or even replace the material product. As an example, the safety of an aircraft can not be ensured only by the selection of materials and the dimensioning of the (material) components, but additionally needs maintenance, i.e. non-material components. It has become obvious, that a separate view on material products and service is obsolete [3]. The importance of an integrated view on material products and services is increasing [4], [7].

For this type of integrated business offers, the term "Product-Service Systems" [4] is used in up-to-date publications in engineering science to distinguish them from the traditional concept of material-related products. In the field of business administration the term "hybrid product" [7] is used for a very similar concept. In engineering sciences, however, this term is often used to describe so-called mechatronic products (which remain entirely material products).

The core problem considering Product-Service Systems is, that there is no common approach that deals with material products and services equally and integrated. Both in the field of (material) product development and in the field of service engineering, which deals with the systematic development of services and is, in fact, a research topic in economics, not in classical engineering, there are existing methods in different levels of abstraction to develop products or services, respectively, based on systematic procedures. But until now, there has not been an attempt to combine these approaches from a development point of view.

On the field of engineering science, there are existing well developed methods to generate products in a systematic way, like VDI-2221 [8] or the methodology of Pahl and Beitz [9] or Roth [10]. All these methods are very strongly orientated on the functional structure of a product. But it is obvious, that certain requirements of a Product-Service System and even of a material product or a single service cannot be mapped in a functional structure. An example for this could be a web-based music player which offers any type of known music. The requirement on the music library to be up to date can hardly be matched in a functional structure. This problem occurs at material products, services and even stronger at Product-Service Systems.

Another unsolved problem concerning the classical design methodologies from the field of engineering sciences is the transformation from the description of a product as a functional structure to the level of principle solutions. There are lots of means like catalogues for transforming a function into a principle solution. But this only means support for the transformation into a material solutions. There is no approach to support the transformation of the functional structure into a principle solution of services. It is arguable, if this transformation is possible. These weak points of existing engineering design methodologies make them unsuitable for the support of a systematic development of Product-Service Systems.

III. PRODUCT-SERVICE SYSTEMS AND THEIR IMPACT ON THE DEVELOPMENT PROCESS

A. *Integrated View*

The use of methods in product engineering is an established way to get from an abstract idea to a highly elaborated product. Design methodologies and product models are in use in many enterprises. On the opposite, the development of services by a set of methods and a structured methodology is at the beginning of scientific consideration. There exist simplistic process models which show the important steps towards a new service [11]-[15]. Apart from that, in definitions of the term „service“ there exists a certain fuzziness in the scientific literature. The approach which is considered the most useful is the constitutive approach of definitions which includes three dimensions: potential oriented, process oriented and results oriented. More detailed information about these approaches is described in [16]. The reason why these dimensions are important for a further look at Product-Service Systems is, that these dimensions are the base for according kinds of models which can be developed: resource models (dimension of potentials), process models (process dimension) and product models (dimension of results) [17]. Product models describe the results of a service, process models describe the act of supplying a service and resource models describe the required (enterprise) resources to supply a service.

B. *Objectives of a research approach*

Considering Product-Service Systems there must be some objectives which help to understand this phenomenon. The existing marketing view should be integrated with a development view – or better – the marketing view should evolve from the development view. This means that the fact to have a bundle of products and services cannot be seen as given per se. This bundle must be seen as on object of development which is demanded by the clients. Concerning this demand, it is not clear in advance which demanded product property is fulfilled by a service component and which one is fulfilled by a material component. The system of objectives which must be drawn into consideration is the following:

- Product engineering is characterized by a large use of product models as backbone of the life cycle. Such possibilities concerning several concepts for an integrated view on Product-Service Systems are postulated, but there only exist first approaches. To have such product models for services and – further on – for Product-Service Systems, there is a need of formal description by means of characteristics or properties of services. After that an integrated model can be developed.
- The basis of development are more or less structured requirements of a solution provided by an enterprise or a network of enterprises. These requirements must be transferred into required properties which eventually lead to a possible solution. As a basis of this transfer there must exist a classification and characterization of Product-Service Systems which leads to a possibility for a representation model of a Product-Service System.

- A process model has to be developed, which describes the process from given requirements to a detailed structure of a Product-Service System. This model can – together with a product model – show, which requirements are realized by which characteristic, and which product or service components influence which property in which degree.

IV. Existing Approaches

The phenomenon of Product-Service Systems must be seen on the interface between traditional engineering and economics. Studying the scientific literature from both sides, there are some first approaches which can help to understand the modeling of Product-Service Systems. Shostack [18] for example visualizes bundles of products and services from a marketing point of view as a connected system of components and emphasizes their relations. This molecular model leads to the problem of a structured development of this bundle. It assumes the components of a Product-Service Systems as given. Hermsen [19] shows the process of development of product-related services by the adaption of existing bundles of products and services. He develops a data model which shows the connections between a service and corresponding organizational, informational, cost and product aspects. This approach refers to adaption processes. The required properties of the solution for an individual problem must be given. Other approaches for an integrated development of Product-Service Systems like [20] refer to the norm VDI 2221 [8] and describe the problem of a parallel development. The question, how given requirements can be transferred into characteristics of a Product-Service System is not answered.

V. Property Driven Development as an Approach for the Development of Product-Service Systems

A possible solution for the problem of representing Product-Service Systems in a systematic way and to structure the development process of a Product-Service System can be the approach of Property-Driven Development/Design (PDD) [21].

The core of the PDD is the clear distinction between characteristics which define the product's structure/design and can be directly determined by the designer, and properties, which define the product's behaviour and can not directly determined by the designer [22]. Examples for characteristics of material products can be shapes, dimensions, materials etc., examples for properties are function, safety, aesthetics etc. The specific difficulties of product development are due to the complex interdependencies between characteristics and properties (among the characteristics as well as between characteristics and properties). These interdependencies can be particularly well displayed in the PDD approach and the focus on them is its actual novelty. In figure 1 the descriptive/analytical view of the PDD is shown.

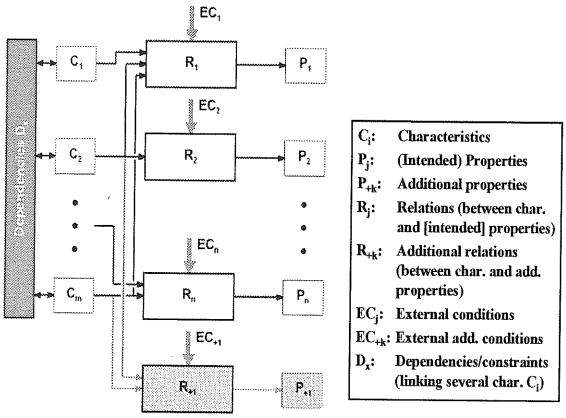

Figure 1: PDD analytical view

The characteristics ($C_{1...m}$) of a product resp. of a Product-Service System are connected with the properties ($P_{1...n}$) by certain Relations ($R_{1...n}$). These relations can not only be mathematical functions; every coherence, that predicts the behaviour of the product can be a possible relation. For instance, this could be guesswork, estimation, experiments, computer tools etc. The dependencies D_x represent possible relations between the Characteristics like certain geometric dependencies, the external conditions ($EC_{1...n}$) can be influences like environmental conditions, the kind of means of manufacturing etc.

Besides this, a process model for product development can be derived, supporting all steps of the development process. This can give the opportunity for the application and further development of computer-based supporting tools. In figure 2, this synthetical view is described.

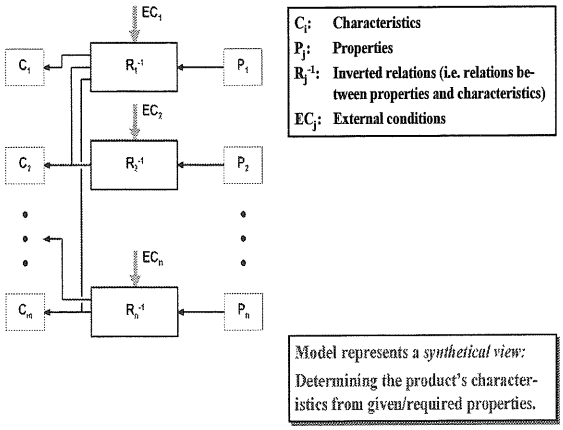

Figure 2: PDD synthetical view

The core problem of the synthetical view is the "inversion" of the relations ($R_{1...n-1}$) which is (mathematically) only possible in exceptional cases. The way from the (required) properties to the characteristics, that define the product resp. the Product-Service System can be realised by methods/tools like association, experience, catalogue solutions, collection of rules, inverted calculations, computer tools etc.. Even classical design methodologies like VDI-2221 can be used as inverted Relation, if the required property is a functional property, while other requirements (e.g. requirements, that can be fulfilled by a service component of the Product-Service System) have to be dealt with other methods, like shown in figure 3.

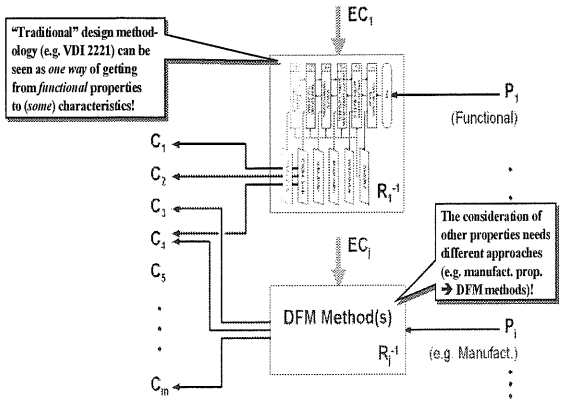

Figure 3: Integration of different methods in PDD

The development process of a Product-Service System starts by listing and structuring all required properties. After that, all known characteristics have to be listed together with the properties, they bring along . The next step will be the beginning of the actual design process by picking one property, that is not yet fulfilled to satisfaction and determining/assigning characteristics of the solution by using suitable methods for a product synthesis (step I). After this, the influence of all characteristics already assigned on all properties has to be analysed. This leads to the so-called "Ist-Properties" which means the actual properties (step II). These Ist-Properties have to be compared with the desired Properties ("Soll-Properties"). This step shows the deficits of the current solutions and gives hints for the next process steps (synthesis) or directs to a modification of the Soll-Properties (step III). The steps I-III have to be repeated, until the termination conditions are fulfilled, which means, that the Ist-Properties are close enough to the Soll-Properties of the Product-Service System. A detailed presentation of the PDD approach can be found in [21].

Recapitulating, PDD can be used as a model to describe a certain product as well as a model for a product development process and we suppose that PDD is a very promising approach to deal with the very special requirements of Product-Service Systems due to its open constitution as well as its flexibility, which allow the integration of many different methods and tools. It can be easily adjusted to particular applications by specialising the characteristics and/or the properties. A possible representation of a Product-Service Systems according to the PDD structure is given in figure 4.

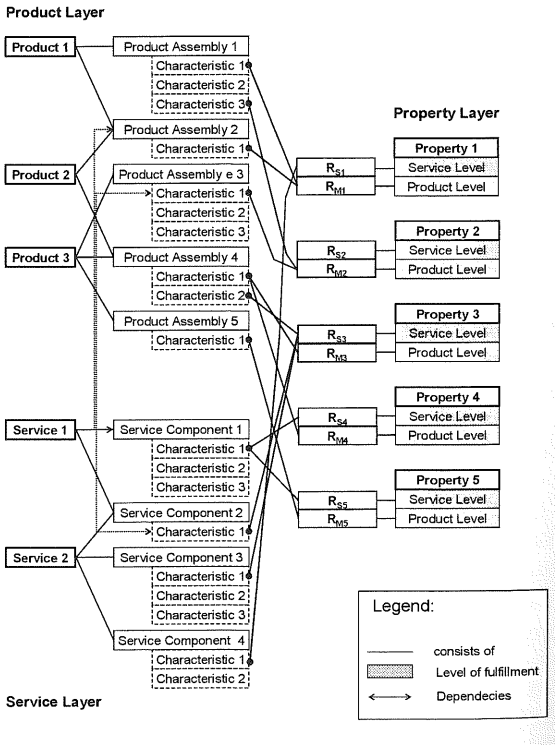

Figure 4: Possible Representation of a Product-Service System

VI. Conclusion

Even if this paper represents a first approach to the integrated development and modeling of Prod-

uct-Service Systems, there are still some unanswered questions concerning Product-Service Systems in connection with the PDD. Regarding material products, the subdivision in certain classes of properties and characteristics is well examined and established [21]. To represent Product-Service Systems in the PDD structure, it is necessary to know, what kind of characteristics and properties of services are existing and if it is reasonable to make this kind of subdivision with services. This needs some further research activities. The PDD could be an approach for coherent models of Product-Service Systems and their development process.

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DECISION SUPPORT SYSTEM: A CUSTOM APPLICATION FOR MANUFACTURING SME TO PLAN AND CONTROL THE PRODUCTION

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Abstract: **In the field of precision mechanical activity a transition phase is in act. During this phase the reduction of importance of human activity means that the manual works are substitute from the use of special equipment with higher precision, fact that induce to search for people with different skills.**

Today the enterprises requires technical people with the capacity to plan and control the work centre with high complexity and not simple labourer.

This is the reason why also the small enterprise, where the human ability was in the recent past very important, actually are almost completely automated. Consequence of this fact is the necessity of specific management toll able to guarantee the best result from the realised economic investments.

A lot of commercial tools exist to manage and plan the production activity, but often they are to much expensive and characterised from a low flexibility in order to correctly match with the operative procedure of each enterprise.

In this context special attention is needed for the SME (Small Medium Enterprises) because they usually require a long time to renovate all equipment and, for this reason, they can not modify all their operative cycle in order to fit the requirements of the commercial tools.

In this paper the Authors present the development of a scheduling tool with an high level of customisation to fit in the best way the needed of a SME. This tool is not only customised on the operative activity of the SME, but it is also developed in order to manage the production cycle during the transition phase to renew all the equipment from manual control to automatic work centre.

Index Terms: **Sequencing and scheduling, optimal production planning and control, production on order, decision support system.**

I. INTRODUCTION

With the purpose to manage a complex industrial reality, as in this case study, the developed Decision Support System (DSS) has been articulated in a detailed way according to the characteristics of the production site.

Facility of use and maintenance has been reached by developing custom modules, using object-oriented approach; this feature allows an easier and continuous updating of the system. By considering technological constrains, handling a great number of different jobs, the scheduling problem quickly becomes too complex to be managed without computer assistance. The use of the computer and the development of operations research techniques, have been able to optimise the scheduling problem under limited settings.

Exact mathematical approaches have been replaced by heuristic approaches. This approach is not guaranteed to find the optimal solution for a problem, but it is able to find a good solutions using limited computational time. Several constrains have been relaxed and a set of rules has been developed to dispatch production orders.

This proposed industrial case is represented by a manufacturing firm of hydraulic pumps, with an on order production, called Euro Press Pack S.r.l. All its production is realised in a big plant site in the east of Liguria.

The aim of the present study is the introduction of an alternative management system in terms of customer' satisfaction, order deliveries, workstation loads, in order to determine a sequence of job referring to some meaningful parameter.

The proposed system implemented on Microsoft Windows™ platform and developed in Microsoft Visual Basic™, linked to the business informative system through interface ADO (ActiveX Data Object), is able to:

- codify information related to the customers, the workstation state, the product specifications and the order deliveries;
- report encoded information organised in a database to which can be applied rules of integrity, if necessary;
- extract the necessary information to perform statistic analysis whose results, for instance the necessary time to produce a defined lot, are useful to the goals of a short and middle period planning;
- schedule the orders by using a mix of heuristic (EDD or CR criteria) in order to produce a MPS;
- simulate the proposed master production schedule (MPS) in order to allocate resources by performing a capacity verification and, during the optimising phase, allow to make changes appraising the consequent impact.

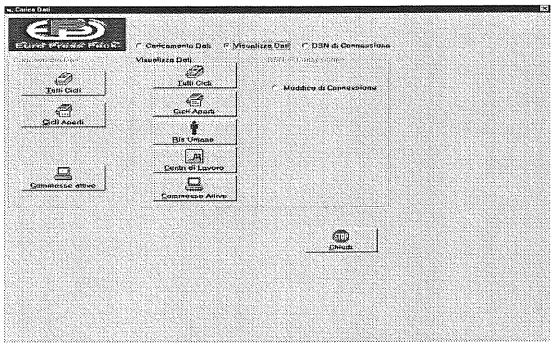

Figure 1: Informative System tool's interface

Great attention has finally turned to the graphic analysis of the tabular data in order to evidence tendencies or singleness hardly makes otherwise.
The efficiency of the system to manage the work in process is closely connected with the phase of data update, operation that must be carried out with continuity from the E.P.P. operative staff.

II. DECISION SUPPORT SYSTEM

The proposed system is articulated on different independent modules. The system architecture is representative of the productive cycle and includes all the management logic.
The system is realised referring to the theory of Planning Production, discipline that groups all the activity that, starting from a list order or from a sale forecast, allow:

- the generation of the production orders;
- the allocation of orders to the different productive units;
- the planning of requirements (for example the raw materials);
- the sequencing of activity on each work centre.

The production planning is characterise from three different levels, in relation of the time interval it consider:

- Long period planning;
- Medium period programming;
- Short period programming;
- Control.

During the developments of this tool main attention is dedicated on the last two points.
First step to realise the model that best fit the EPP operative system has been the definition of hypothesis able to explain in a easy way the problems and, at the same time, to guarantee the adhesion to the real system. This is the only way to obtain good results.
Usually the commercial tools consider only one critical resource (equipment), while only the complex and expensive tools are able to consider the presence of two different critic resources (men and equipment), but often the high number of simplification required reduce the capability of them to represent complex industrial process.
In the case study presented the AA do not introduce simplification on the real system except for the hypothesis that each equipment can't work more that one task at the same time.
Before to start with the realisation of the tool a preliminary phase of data organisation and rationalisation was realised. This phase carried out the definition of some lists:

- Item to realise;
- Item's technological cycle;
- Lot number;
- Due date;
- Resources list and available day time.

Special attention was given to the knowledge of the exact item's technological cycle, this because the sequence of operations for each of them allow to know the real capacity of the plant, connected with the information before mentioned.

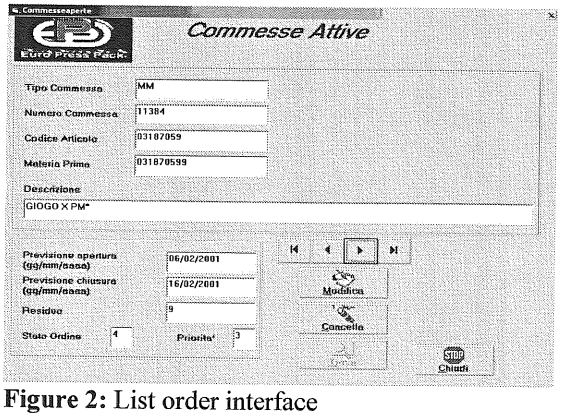

Figure 2: List order interface

The possible models to use for the operative programming activity are classified in relation to three different profiles:

1. production system;
2. objective of the programming activity;
3. resolution technique used.

More attention was focused on the first profile.
Different typology of production system exist, from the more simple model with only one equipment to complex system with a lot of different equipment.
The developed tool, that used heuristic theory, was based on the substitution of the primary objective with others. This operation is realised to simplify the relation between the system input variables, but this operation guarantee that the main final object will be not different from the real one.

III. MODEL ARCHITECTURE

A simple, but effective architecture derived by the application of well known techniques to the direct needs of the SMEs, has been developed (scheduling heuristics).
The proposed scheduling process is a base-rule approach. From statistical evidence it is known that some algorithm works better than others do so, after a period of experimentation, several rules have been implemented in order to produce quickly and easily good production plans.
The rules used during the activities of operative programming are based on heuristic algorithms that allow to generate the items list that must be worked on each different equipment, if they are available. This list is generated calculating different coefficients for each activity, coefficients that should be based, for example, on the process time (work time or set-up time), on the due date or on economic parameters.
The sequence is obtained giving higher priority to higher coefficient. The used heuristic are:

1. Earlier Due Date (E.D.D.): where task are sorted according to the due date and considering customer priority;
2. Critical Ratio (C.R.): where the priority coefficient is based on mathematics operation that mix due date, work time and customer priority, all related with the real available time.

These two heuristics are simple to apply and give good results. The choice between the different rules must be realised from the user.

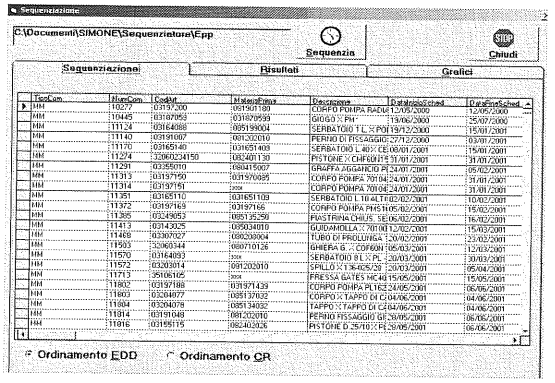

Figure 3: Initial order list

To develop the presented tool it was necessary to translate the logic of these heuristics in a software, operation that was not simple because it was very important that the system was, at the same time, fast and efficient. To combine these two objectives it was necessary, for the AA, to introduce in the tool some control operations of the input data and also some procedures in order to modify the real data and to translate them in a simple way to be used from the model.
First step is the control of all the input table where are stored the information coming from the MIS (Management Information System) in order to verify that the local database do not have empty space.
Particular attention is dedicated, moreover, to the table "CICLI APERTI" where the technological cycles of all items realised are contained, this in order to verify that the set-up and the work time must not be both equal to zero. This activity is absolutely necessary because the use of tables without data or with incorrect data during the scheduling process can generate a not useful process results or, worse, shut down the computational process. The system can proceed only after the upper mentioned positive controls.
If the control results are negative the process stop and, before to restart, it's necessary to correct the tables.

Figure 4: "Cicli Aperti" table's interface

Second step is the data loading in the system memory, using a matrix system, in order to speed up the process.
The memorised data are contained in the tables:

- "COM_SEQ": list of jobs to be worked and correlated work time;
- "ST JOB"; job condition. A job should be: available(D); busy (B); waiting between two work step (I); finished (F);
- "ST MACCHINA": single equipment's condition. An equipment should be: available (D); busy (B); out of work (F);

In the table "ST JOB" to each job is assigned an unique progressive number utilised to easily identify the item during all the logic sequencing process.
The table "ST MACCHINA" is structured to contain the complete list of equipment, in particular every element can appear more times in relation with the number of the same equipment that are present in the enterprise cycle. To each equipment is associated the daily work time.
The more important information to be loaded for the sequencing process are: equipment required for each work phase; work time; set-up time; raw material; lot number.
The use of matrix increase the process speed because the data are allocated in the computer memory, this means that during the elaboration it is not necessary to read and write from the hard disk and so to open and close tables.
The risk using the matrix is related to the quantity of data to be loaded, in fact if they are to much it must be considered the possibility to use all the RAM memory, event that should generate problems during the elaboration process. A previous analysis was realised from the AA in order to verify the absence of this risk.
After the previous described phase the tool provide to order the table "COM_SEQ" respecting the rules of the selected heuristic and, consequently, to order the "ST JOB" table.
Other parameters are also considered to find the "best sequence", they are raw material and order/customer priority. The first one was introduced with the purpose to reduce the set-up time between two job, this reducing the change time of work equipment.
The job priority is divided in three level (A,B,C); the first one is dedicated to the work in process (they must be worked first), the others are correlated usually to the customer and should be changed, by the user, for operational reason.
After these operations the tool has all the necessary data to proceed with the sequencing process of each single task.
During the sequencing process the tool verify the resources availability (human resource and equipment). It's important to underline that the tool has different processes if the requested equipment is a generic equipment or an external operation or a control operation.
In the second and third case the system use default times given by the expert people from the E.P.P. company, otherwise, for the internal equipment, the system checks other important aspects. First of all the system checks the type of equipment, in particular it checks if the human resource is requires to support the operation for all the work time (traditional equipment) or only for the set up time (numeric control equipment).
If equipment and human resources are both available the task is allocated.
When all controls are realised on the complete "Job" list the toll realises the time advances. In general it can proceed respecting two different method:

- continuous advance;
- discrete advance.

In the first case it's taken a system's photo for each time instant while in the second case the events are recorded to previous define instant time.
The tool use a technique mixed between the continuous and discrete advance. The time advance is realised in a similar discrete way, moving the time until the first event (operation) finish; this time is indicated from the lower time present in process table (work time and/or set up time). This method allows to not jump any event and to simulate a continuous time advance.
The resource release is different if the finished operation is a set up in a numeric control equipment (release of human resource) or in a traditional equipment (no release), and if it is a work operation (release of equipment, human resource and "Job").
The complete cycle is repeated until all the "Job" are realised. In figure 5 it is showed the sequencing algorithm.

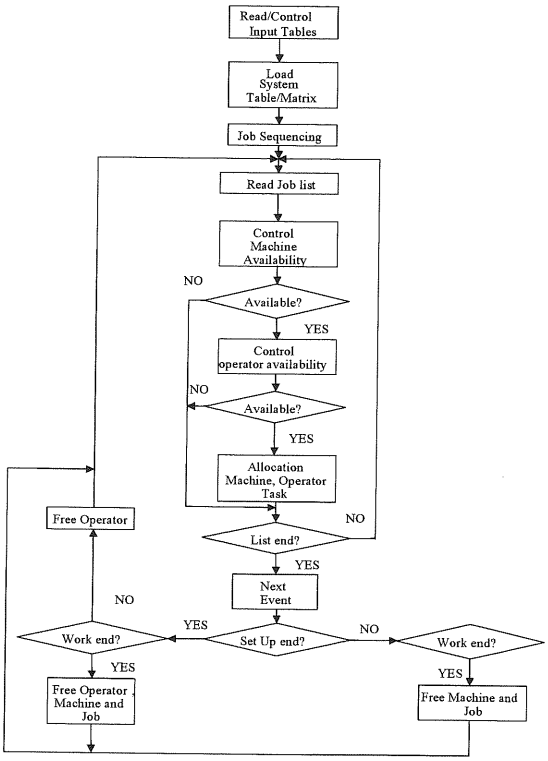

Figure 5: Sequencing algorithm

Output of the process is the table MPS2 where are stored all the information necessary to elaborate the Master Production Schedule (M.P.S.).

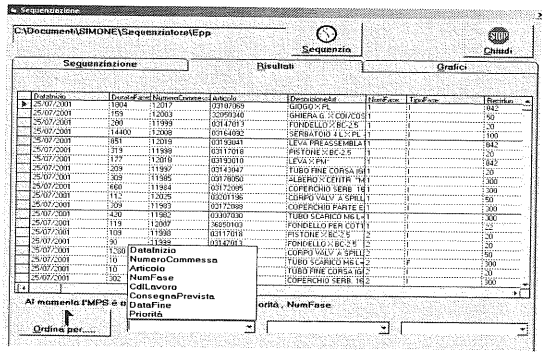

Figure 6: Master Production Schedule

The MPS generation is obtained using also information present in the matrixes loaded in the PC memory.
The final output contains the MPS complete of start and finish data and time, the required equipment and the set up and work time.
The time codification is realised using a special process that allow to consider the different work time of each equipment.

IV. RESULTS

The possibility to manipulate, by using the Visual Basic™ environment, the database engine has allowed to perform both simple and crossed queries on the fields of one or more linked tabs. The produced matrix can be read by a specific Visual Basic™ control called MSChart; it is able to plot automatically bar or line diagrams.
The organisation, in a statistic context of the production data, allowed to analyse, by using five different typologies of diagram, the entire production process:

- Real time to produce each lot and related delay;

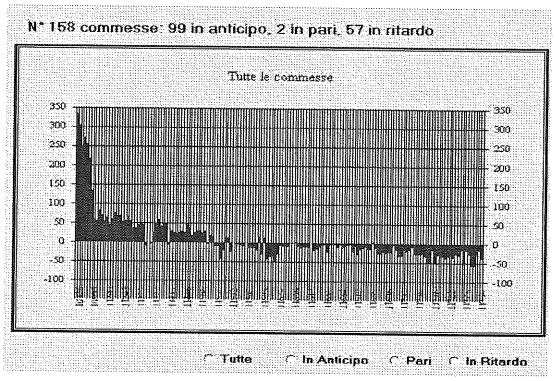

Figure 7: Production time diagram

- Customer orders situation of a specified period;

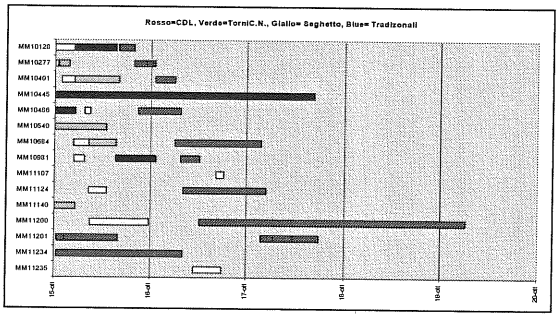

Figure 8: Customer GANTT diagram

- Human resources use;

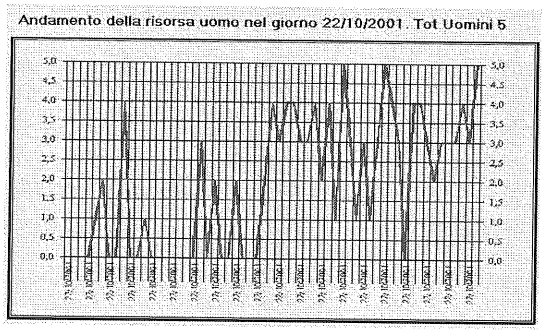

Figure 9: Human resources diagram

- Single Resource uses;

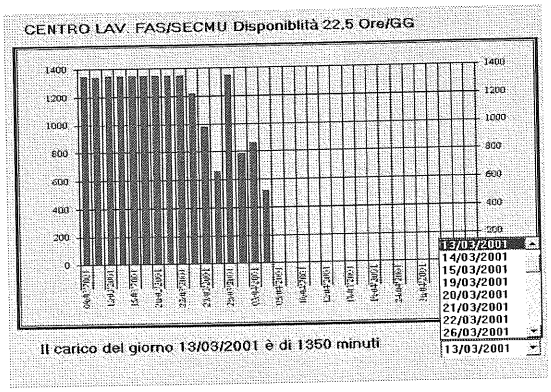

Figure 10: Resource daily diagram

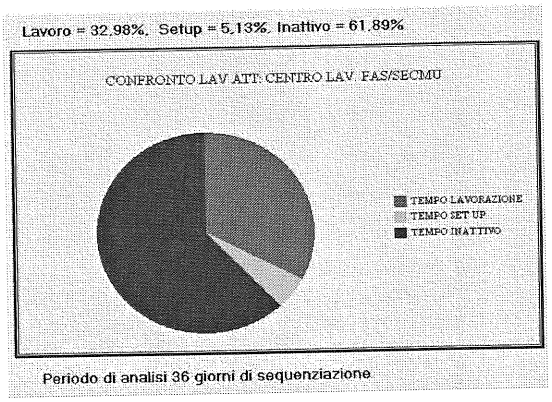

Figure 11: Resource global diagram

V. CONCLUSIONS

Final tests have underlined that the developed decision support system allows a production planning more rational and a greater use of the productive capacity. At the same time it increase the customer service level. Besides the proposed system allows to unify the previous fragmentary vision of the productive and managerial process allowing a sharing of the global objectives inside the firm in terms of commercial strategies and operational control. The planning processes, usually made by hand, have been totally replaced by using an interconnections between the DSS and the main informative system. This semi-automatic interactive process allows to evaluate the system efficiency and to determine the optimal configuration according to the objective function. Finally the decision support system plays a main role in the threshold identification of the production capacity. By considering the obtained results, the General Administration can evaluate plant updating or resources increasing in order to face the production demand.

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BIOGRAPHY

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AN HYBRID MULTI AGENT APPROACH FOR DYNAMIC SCHEDULING

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Abstract: **The evolution of the international competition pushes more and more manufacturing systems toward increasing levels of competitiveness and innovation of product and process. This leads to a time-to-market strong reduction and requires more sophisticated and accurate tools for planning and scheduling.**

This article illustrates a model of scheduling, realized within a national research project (called WILD – Web Integrated Logistic Designer), for highly uncertain and unstable manufacturing environments. Such model, based on a Multi Agent System (MAS) algorithm of control, reaches the fixed objectives maximizing resource utilization and minimizing setup times and delays on job due dates.

Index Terms: **Scheduling, Hybrid MAS.**

I. INTRODUCTION

In the last ten years the efficiency of manufacturing systems has become the object of increasing interest for the academic and industrial research. A lot of the most significant innovations realized in these years in the field of planning and management of manufacturing systems was orientated to increase the efficiency in productive field, and to give back the system more flexible to the changes [1].

Nowadays, manufacturing systems work within changeable environments, furthermore the difficulties of the development system management are often due to: unforeseen events, non-linearity of management operations and to a great number of interactions noticed during the shop floor activities development [2].

Consequently, the complexity and the inconstancy of the whole systems restrict the conventional approaches efficacy, usually used to solve problems of the executive scheduling and control [3].

There is an answer to the research of the procedures to manage productive systems that result able to satisfy these requirements [4]. The solution consist in an distributed approach across the employment of "Multi Agent System" (MAS). In fact these systems offer the possibility to find the right compromise between flexibility and operating efficiency, at the same time the MAS assure the hardiness of the shop floor, where the productive activities, identified through different modules, become competitors establishing a "cooperative competition" among themselves [5].

This work has the purpose to propose a system to schedule using autonomous agents which, working in a cooperative way, allow an highly flexible and dynamic executive scheduling. This system, that was implemented through the employment of structures well-know in literature [6][7][8] has been characterised by specifically computational algorithms to permit an effective resources assignation aimed to the optimization of different and conflicting global objectives.

II. PROBLEM DEFINITION

Scheduling has the objective to convert production requests in effective work orders and it can be seen as a process, conceptually separated in 3 phases:

- Allocation of job operations on the available resources;
- Temporal allocation of job operations;

- Sequencing of the jobs on machines.

These phases, even if separated, are tightly correlated and interdependent; therefore, they involve a notable increase of optimisation problem complexity. If we also consider variability and numerousness of data affecting the scheduling, daily changes on MPS, resources break-downs, human factors, etc., it is comprehensible the ineffectiveness of planning techniques based on previously fixed lead times, in medium time horizons.

The machines saturation, the respect of the duedate, the setup times minimization, are only a few objectives of a productive planning. Sometimes these objectives are different and often they are conflictual and complementary, such the planner has to adapt every time the weight of each one to the contingent situation [3].

The productive environment that was considered in this work, can be formally defined by the characteristics which mark the jobs and the work-center.

Let $J=\{J_1,J_2,\ldots,J_{nj}\}$ the group of the job order existing inside the system, each of them is characterized by the following attributes:

- The manufacturing cycle (CL_i) is formed by a variable number of phases (n_f), each of them have a specifically typology of manufacturing (L_{ij}) and a "normal duration" for each manufacturing (D_{ij}) (realized in a work-center with medium performances). Symbolically we will have:

$$CL_i = f\left(L_{ij}, D_{ij}\right),\ \forall j = 1\ldots n_f \tag{2.1}$$

- The "due date" (DD_i) represents the days allowed for the order completion, it is fixed by the customer at the moment of order confirmation and, sometimes, it can change in relation to the greater or smaller urgency that the customer has attributed to the product.
- The "penalty" (PN_i) represent the cost of delays from the date of delivery promised to the customer, for each period of delay from this date the vendor has to pay to the costumers the cost of negotiated penalty.

Therefore, each job order is a function of

$$J_i\left(CL_i, DD_i, PN_i\right) \tag{2.2}$$

The resources group, instead, can be defined as $R=\{R_1,R_2,\ldots,R_{nR}\}$ where each resource is characterized by:

- S_k: is the setup matrix for each resource, in this matrix every element s^k_{rs} represents the setup-time requested to pass from the manufacturing of the job r to the job s on the machine k.
- P_k: is the performance offered by the work-center in relation to the job operation to do on the machine k.

$$P_k = \left\{p_{k1}, p_{k2}, \ldots, p_{kn_L}\right\} \tag{2.3}$$

where p_{ks} is a corrective factor of the "manufacturing normal time" (D_{ij}), that it allows, by the formula (2.4), to determine the duration of the effective operation s on the machine k of the job i which is situated on the phase j.

$$De^s_{ijk} = k_{ks} \cdot D_{ij} \tag{2.4}$$

- Q_k: time queue of the jobs which are just inside buffer of the machine k.

$$Q_k = \sum_{i^*=1}^{n_q}\left[De^s_{i^*jk} + \left(s^k_{rs}\right)_{i^*}\right] \tag{2.5}$$

i^* represent each of n_q job into the queue of the machine and $(s^k_{rs})_{i^*}$ is the setup-time defined for the job i^* related to the job i^*-1 that precedes it.

So each resource is defined, for each instant, by this type of function:

$$R_k = f\left(S_k, P_k, Q_k\right) \tag{2.6}$$

the lead time of the specified operation is achieved adding the effective duration, the setup time and the time queue:

$$LT^s_{ijk} = De^s_{ijk} + s^k_{rs} + Q_k \tag{2.7}$$

the research of the optimal solution is opposed by a lot of objective function which each time we have to maximize at the same time. For example:

- The minimization of the job that are late and the minimization of the penalties;
- The minimization of setup-times;
- The maximization of annual level of the production.

The conflict of objectives pushes towards the search for flexible scheduling systems and heuristic algorithms of management that, acting at the local level, can adapt the system behaviour to different conditions, producing optimal solutions in most of the circumstances. This kind of problem can be solved, in efficient way, by a non-hierarchical approach. It eliminates all hierarchies, modelling the productive system as a set of autonomous control units, distributed and cooperating.

Through the employments of elementary modules called "agents", this method permit to decompose the whole problem in a lot of local under-problems easier to manage and orientated to the achievement of the system global objective.

The classical methodology described by Lin and Solberg [7] and others is often used to define the structure of the system control and the architecture of the coordination mechanism. It consists in a negotiable discussion between the entities of two different classes (part agents and resource agents) that leads to the stipulation of a contract between the manager of a resource and a contracting buyer of the part (the manager of the job), for the execution of particular task (Figure 1)[9], [10], [11].

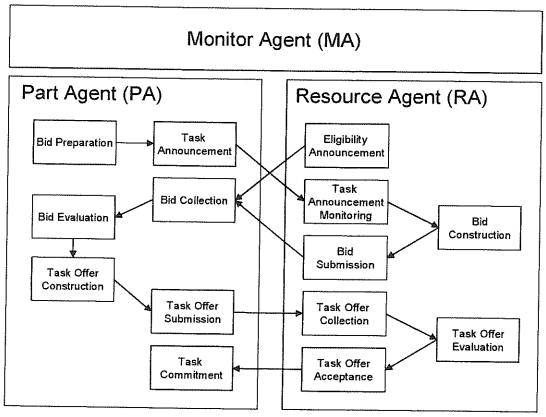

Figure 1: phases of the negotiation (Lin, Solberg 92)

III. THE PROPOSED MODEL

The coordination mechanism, as seen in figure 1, contemplates the possibility of a negotiation of type both "part initiated" and whether "resource initiated". Therefore the resource can analyse the received offers and, if necessary, it can decide to refuse them. Contrarily, the mechanism proposed includes only the transactions "part initiated" and the valuation ability of the offers simply inside the "part agents". This choice has been made because, in the most of cases, the jobs require services near the machines that are usually employed in other processing. Therefore it was decided not to contemplate the second opportunity of beginning negotiations because it would be used very few in the reality.

Instead, the valuation ability was transferred completely inside the "part agents" pushing towards the changes of the model of Lin and Solberg , as we can see in figure 2. in this way the mechanism become more rapid and easy to manage through the manipulation of a singular parametric algorithm. This solution has permitted a foreseen of agents behaviour more immediate and an easier regulation of shop floor dynamics.

In this optic, we have developed a scheduling model based on an multi agents architecture that is characterized by a scheme of productive capacity negotiation (Contract Net Protocol [12] opportunely modified) that takes back the methodology typically used for autonomous agents architecture described by Lin and Solberg. That model was developed using the methodology just present in literature[13], [14], [15], [16]. In this work, we transform the "Resource Agent" in "Monitor Resource Agent" (MRA), assigning them the control of the behaviour of resources and the faculty to communicate the lead time necessary for manufacturing to the "Part Agent" (PA), without performing any type of negotiation. Moreover, we move entirely the ability of evaluation into the PA, modifying in this way the Lin and Solberg architecture.

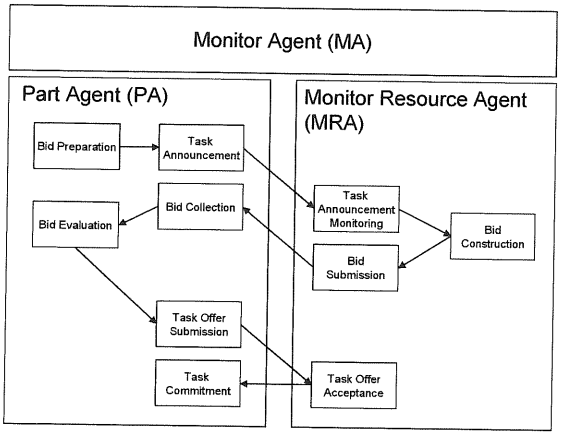

Figure 2: phases of negotiation of the proposed model

The algorithms that control the behaviour of the system differ in function of the agent typology. Each one of them essentially develop functionalities of:

- "Monitor Agent" (MA) initialisation;
- "Monitor Resource Agent" (MRA) bid construction;
- "Part Agent" (PA) bid evaluation.

These three agents operate to every phase of working cycle. This has been done in order to make the system data as much as possible correspondent to the production reality, with a continuous updating of the local information.

The PA, after its initialisation through the MA, which gives him all the information about the current state of the resources, communicate to MRA the type of working that the job needs and, after a phase of capacity checking, the MRA communicate to the PA their offers. These proposal have to be selected by the PA which chooses the resource able to offer him a time of process compatible with his "local" objectives.

These objectives are defined "local" because they are applied to every job, but especially, they are valid only for a particular instant of time (instant of

negotiation phase) and probably it would change in the next phase.

During this work we will illustrate all the functionalities of the single agent.

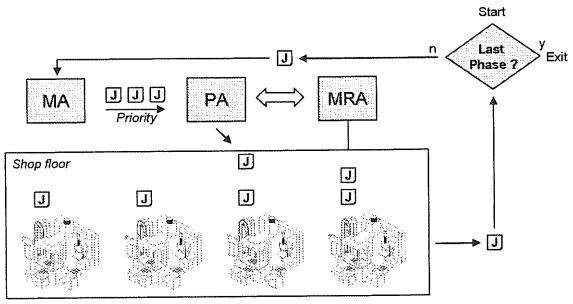

Figure 3: model structure.

A. The Monitor Agent

MA result indispensable for the architecture coordinate functioning, in fact it provides global information about the system to the other agents which utilise them to aim their own behaviour. During the initialisation, the MA acquires information about penalty values and state of productive resources. Thanks to these, it furnishes indications to the PA for a correct positioning of the jobs that are going to gain access to the negotiation phase. Furthermore, it provides an evaluation of the production lead time for all remaining manufacturing phases. In such way it is possible to know potential delay on the promised due date with a great advance and, therefore, it is possible to drive more effectively the scheduling activities.

The number of negotiations for each job is the same number of the manufacturing phases, so at the end of every production phase that would be followed by another phase, the job enters again in the system to announce a new task. In this phase it will come sent to a new admission queue and it will come subordinated to a new initialisation which will produce different results as consequences of different task's characteristic and different state of the system. During the initialisation, MA assigns to the entrance job the *priority*, the *esteemed time* and the *exceeding time* that will have to be used for the proposal evaluations.

Priority

The priority p_i represents the "weight" of the penalty applied to the job number i and it results from the function described in (3.1).

$$p_i = \frac{PN_i}{\max\_penalty} \tag{3.1}$$

where "max_penalty" indicates the max value that the factory is ready to pay to any customer.

Observing the (3.1), we see that $0 < p_i < 1$, so the job with a great penalty will be favourites between a group of jobs with the same advance.

Esteemed Time

The "esteemed" time (EST) assigned to the job indicates the time that the job has for the wait phase in a queue, the eventual setup phase (it depends on the setup configuration that the machine has at any moment) and the process time. This time is assigned in relation to the particular conditions of the productive environment at any moment, the "normal times" (see the formula 2.3) and the type of working that at the request of the PA. Therefore the esteemed time assigned to the job is given by the sum of three components:

Medium setup time T_{ms} it is calculated like a state function of the system in a certain moment and it is obtained by the arithmetical mean of setup times necessary to the chosen machines to execute the current working. In fact, whenever the job i arrives to the system, the working to execute (or rather the particular setup configuration requested) is analysed and, using a table in a local database memorised for each machines able to do the particular manufacturing requested, the passing time from the current setup configuration to the requested one is calculated by the expression:

$$T_{ms}^{i} = \frac{1}{m}\sum_{k=1}^{m} S_{rs}^{k} \tag{3.2}$$

where m represent the number of machines able to do the working that the job requests. Whenever there is a wait queue at the enter into machine, the necessary setup time to calculate the local setup time of the incoming job, is taken as the setup time that machine needs to change from working type of last job into the queue to the incoming one.

Medium wait time in queue T_q is function of the system state and it is calculated like the arithmetical mean of the wait times for each queue. It results from the expression:

$$T_q^i = \frac{\sum_{k=1}^{m} Q_k}{m} \tag{3.3}$$

The esteemed process time of the whole lot i (T^i_L), remembering the (2.1), is indicated with:

$$T_L^i = D_{in_c} \tag{3.4}$$

where n_c represent the current phase of work. It is an estimate of necessary time for the working, and it has not to be confused with the effective process time promised to the job that will communicate through the task offer by the respective MRA. Fi-

nally, the "esteemed time" for each job will be done by the formula:

$$EST^i = T^i_{ms} + T^i_q + T^i_L \qquad (3.5)$$

Exceeding Time

The "exceeding time" (*EXT*) defines the advance of the job on completion date and it is calculated in this way:

$$EXT^i = DD_i - Tnow - \sum_{i=n_c}^{n_f} T^i_L - n_R \cdot \left(T^i_q + T^i_{ms}\right) \qquad (3.6)$$

where T_{now} expresses the current time of the job inside the system and T^i_L is the total of the standard time of the job working from the current phase (n_c) to the final phase (n_f). Observe that *EXT* is directly proportional to the slack time of the job. Moreover *EXT* is calculated taking in consideration the inevitable wait time into the queue and the medium setup times, also for the following working phases.

It's advisable to observe that the activities characterising the initialisation phase are repeated for each phase of the working cycle, in this way the system is continuously updated; the *EST* and the *EXT* are actualised and referred to the working expected by the PA to avoid that possible jobs more urgent than the others will undergo useless delays waiting for the end of the working cycle.

B. *Il Monitor Resource Agent*

The MRA manages production capacity of the resources and constructs bids with reference to PA requests. The formulation of the offer is made considering the time that the job requires on the machine for the production phase. For the construction of such offer the MRA has to perform an evaluation of each machine state (queue, setup and working time) and then it can formulate the price for its performance. The price of the offer proposed to the PA represents the necessary time to realize the requested task by each resource. Since the resource objective is the maximization of the saturation and the limitation of setup times, the price will be determinate weighing time to realize setup $T_{S,real}$, added to the effective wait time into the queue $T_{Q,real}$ and to the working technical time $T_{W,real}$ that the machine requires. These time information are extracted from MRA in this way:

- $T_{S,real}$ is drawn from the table included in the agent informative module containing the setup time for each possible configuration change expected (see the section 2).
- $T_{Q,real}$ is obtained adding run time and setup times of all the jobs which are present in the queue (see the formula 2.5).
- $T_{W,real}$ is the process time and it is the product of the "specificity" coefficient concerning the requested working, with the "standard time" indicated by PA for the job currently processed (see formula 2.4).

The offer price is expressed in this way:

$$T_{T,real} = T_{S,real} + T_{Q,real} + T_{W,real} \qquad (3.7)$$

We want to underline that, differently from the *EST* formulation, these addends are characterized by the notation "real" that indicates that the addends are not the result of a medium evaluation on the whole system, but they are the product of a local computation in relation to the real condition of the resource just before the bid construction.

Obviously, at the end of the working phase, $T_{T,real}$ value will be different from the effective value of the crossing lead time, because this one is affected by all the wastes of time that are impossible to estimate.

C. *Il Part Agent*

The PA is able to conduct the respective jobs inside the system to guarantee both the respect of delivery dates and the availability of resource capacity eventually necessary for other more urgent productions. The PA takes its decisions using an heuristic algorithm that has been conceived to realise different objectives depending on the local state of the job.

The objective of PA is to drive the job in the working process to guarantee production times compatible with expiration dates. Therefore, the PA can distinguish situations in which it is necessary to accelerate, even "paying" expensive setup, from situations in which it can stay in a queue avoiding setup and leaving the most efficient resources to more urgent jobs.

The PA, appraising the completion time of every phase, the exceeding time on the due date and the priority (function of penalty), guides the jobs toward the resources that offer processing time, queue time and setup time the most satisfactory. In such way the objectives of the jobs become a function of their priority; in particular, the less urgent job, able to stay in the system for a longer time, pursues the common interest of the system, driving itself toward resources that guarantee shorter setup time but longer lead time. Vice versa, the jobs that have little time available and high penalties, are driven to the resources that guarantee total lead time shorter in comparison to the others. In synthesis, without penalties and close expiration dates, it schedules backward, reducing the setup time; in the contrary case, it schedules forward.

PA take his decisions utilising the algorithm illustrated in the Figure 4.

We can observe in the algorithm the presence of conditionals expressions like these:

- *EXT / EST > a*: it measures the advance time in comparison of the duedate related to the further phases that could be done on the lot in examination;

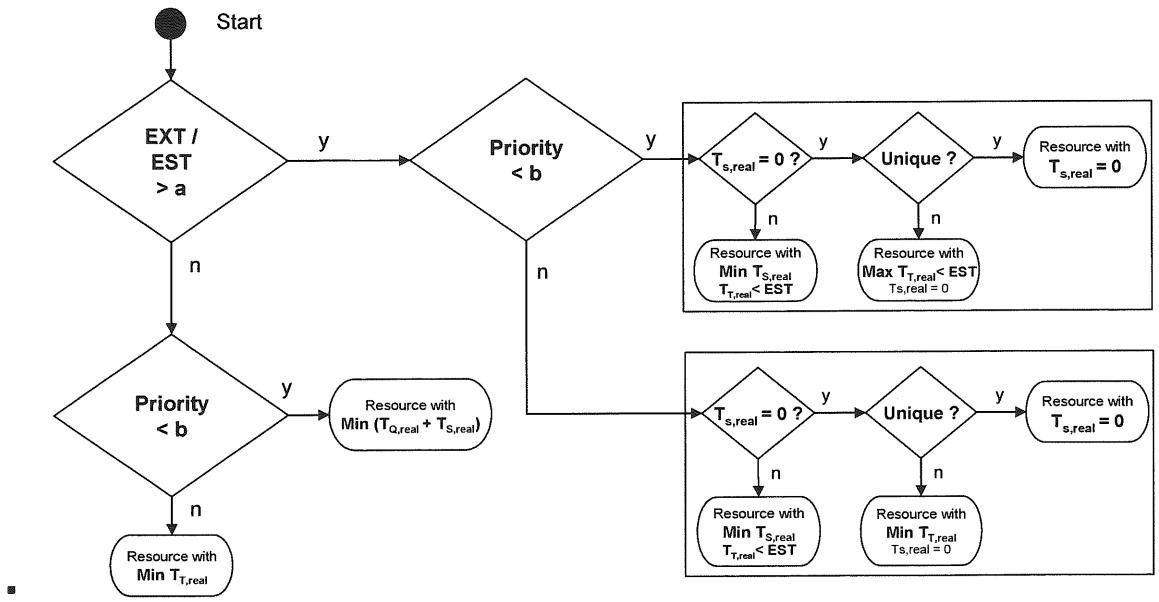

Figure 4: Offer selection algorithm

- *Priority < b*: it measures the job urgency in relation to the entity of the penalty.

These expressions are very important to guarantee the correct functioning of the algorithm and the choose of *a* and *b* factors influences a lot the performances of the whole system. If we change the parameters, the system can take two different extremes typology of behaviour that are:

1. *If* $a \rightarrow +\infty$ *and* $b \rightarrow 0$ the system takes a behaviour belonging to the SPT (Short Processing Time) where the jobs are guided towards the resources that promises less working total time;

2. *If* $a \rightarrow -\infty$ *e* $b \rightarrow 1$ the system takes a behaviour belonging to the SST (Short Setup Time) where the jobs are guided towards the resources with the lowest setup time.

These two extremes behaviours will be taken respectively in the case of jobs with an elevate delay risk and expensive penalties, otherwise in the case of a long time available and low penalties. Through the opportune calibration of the parameters, the behaviour of the whole system leads to an optimal scheduling that results also very flexible in relation to the change of the operative conditions.

IV. Conclusion

The proposed model of scheduling offers the possibility, using a non-hierarchical architecture based on agents, of realizing the cooperative scheduling using in function of the local environment (jobs and shop floor units) pushing towards the global optimisation of the system

Furthermore, the proposed model of scheduling offers the possibility to manage in an optimal way whatever unforeseen event in the "shop floor", as, for instance, urgent order arrivals, changing in due dates, reprocessing phases, unavailability of resources, etc., without the necessity of rescheduling the entire production. This system has been conceived to manage the resource assignment in production system with high saturation, where the number of work centres is lower than the possible typologies of manufacturing phases and the production operative plans are often modified. In fact the system conforms and adapt itself postponing or accelerating the workings, respecting always the fixed global objectives which have the tendency to restrict as more as possible the setup and to respect as far as possible the duedate in function of the penalties weight.

Next step of our research will consist in an exhaustive test of the system to realize characteristic curves of functioning in relation of the parameters that regulate the algorithm behaviour. After this, we'll re-

search the best and more lasting configuration in relation to the change of the interference factors as the variability of the production times, demand times and variability of setup times in comparison to the esteemed times.

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HOLISTIC INFORMATION EXCHANGE IN THE BUILDING AND CONSTRUCTION INDUSTRY

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Abstract: **In the building and construction industry a change can be determined from a sub structured to a more holistic enterprise-spreading information exchange. Co-operation between companies, consultants, and authorities by digital information ex-change becomes a strategic success factor. Solutions, which cover all stages of the value creation chain, such as e-tendering, cost estimation, calculation, and produc-tion must be anytime accessible and hardware independent. While the basic conditions of IT-infrastructure (digital networks) are today fully sufficient, the compatibility between the systems and the information to be exchanged represent the largest problem. The main problem is in the range of different systems and various information domains. Transformations and adjustments of the exchanged information still cost nearly 40 % of engineering time. Efficient information exchanges require an universal exchange format, which makes the existing systems compatible. This paper describes the German approach for a holistic information exchange in the building and construction industry.**

I. INTRODUCTION

The construction industry has a very heterogeneous IT landscape, which makes an economical integration of software systems more difficult. The integration is pre-vented by the existence of different software systems and their proprietary data standards. Therefore the necessity of a standard for information exchange within the construction processes is ever more obvious. These construction processes begin for example, with the first request for bids by the project owner that could end with the distribution of construction material and elements from the supplier to the contractor. Between the construction processes there usually lies a multiplicity of individual activities, which must be accomplished frequently by different project participants by means of different software systems. According to these fragmented processes often a complex information exchange with multiple data input follows, which increases information errors and time delays [1].

The infrastructure of the internet is an ideal platform for the integration of project in-formation in the construction industry where heterogeneous partners are working together. By the possibilities of an online co-operation tool in the tendering and bidding procedure, and material procurement, a large cost-reduction potential is achievable. Using a comprehensive information exchange the transparency and the quality of the construction processes increases. Simultaneously the costs decreases.

Generally the tendering and bidding procedure is divided into three business do-mains: planning, execution and supplying (see fig. 1). Furthermore there are two main sectors within the tendering and bidding procedure: e-commerce and project communication. On one hand the task of the GAEB project was to develop an efficient method of collaboration. On the other hand it would also develop an enterprise wide exchange of information within the tendering and bidding procedure [2].

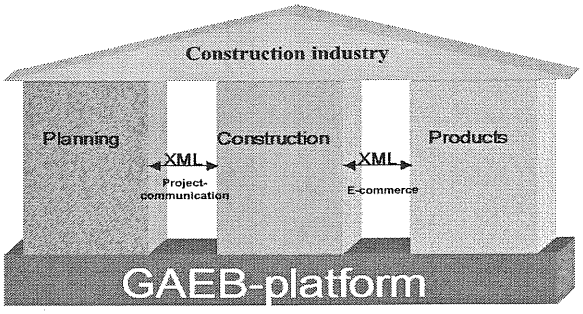

Figure 1: XML Integration in the Domains of the Construction Industry

II. GAEB (JOINT COMMITTEE FOR IT IN THE CONSTRUCTION INDUSTRY)

A holistic solution for the purpose of information exchange is offered by the German group GAEB (Joint Committee on IT in the Construction Industry) [3]. GAEB offers a distributed approach, which makes the information exchange by a common standard on basis of XML technology possible and helps to solve existing communication problems. The developed standard and information structure defines the holistic information exchange format and is based on the XML technology. The following three points describe the decision of using XML as an overall standard: [4]

- separation of structure, content, and layout in the documents,
- compatibility, flexibility and internationality (UNICODE) and
- platform independence

In the following the overall holistic information exchange format will be presented.

The Joint Committee on Information Technology in the Construction Industry (GAEB) promotes the use of data processing in building and construction. Public and private owners, architects, engineers, the construction business, suppliers, research institutions, and construction software companies are all represented by their own federa-tions or professional associations in the GAEB. The GAEB establishes the precondi-tions necessary for the use of integrated information exchange in the execution of construction work and supports all partners involved in the building and construction process to use this open standard, which serves as a specification for the creation of different interface software.

The current GAEB standard is called: GAEB DA2000-xml. The main objective of the GAEB DA2000-xml project is to support the building and construction industry to co-operate faster, cheaper, and more effective, by using the new xml-based technology, that is specifically tailored to the needs of the building and construction (BC) industry. Although internet capabilities form the ideal low-cost communication platform for the BC industry. In BC practice internet is currently only used in a very limited way. The most important reasons for the limited internet use in BC are: insufficient security, low bandwidth, unsatisfying possibilities for structuring specific information. The current internet language XHTML is too simple, and too insufficient. It is also unstructured to support BC communication requirements, due to the fact, that only limited data ex-change is supported. GAEB has developed a specific eXtensible Mark-up Language (GAEB DA2000-xml), that covers all needs mentioned above by providing the right information infrastructure for this industry.

A. Overview of Information Exchange for Bid Call, Award and Billing Processes

The bid call, award and billing (BAB) process is an important part of the construction process, which for example regulate the first request for bids by the project owner. It ends with the distribution of construction material and elements from the supplier to the contractor and the billing of the services. For a holistic and economical information exchange in the BAB process, the various BC partners using heterogeneous software systems must be integrated based on the above mentioned standard. This is the most important requirement for an optimal communication and value creation in the building and construction industry. The BAB process for construction tasks also requires that a common set of rules are defined and are available for free. It is required that the generated information (specification, bill of quantities/materials, product descriptions, bills etc.) must be exchanged in a digital way and therefore they must be well classified, and well structured [5].

Such a course of action has following advantages:

- It makes information available and reusable on a digital basis.
- It reduces working time managing the information.
- It optimizes workflow processes.
- It reduces input errors because there is no need to reenter the data.

The diagram below illustrates the parties involved in BAB processes.

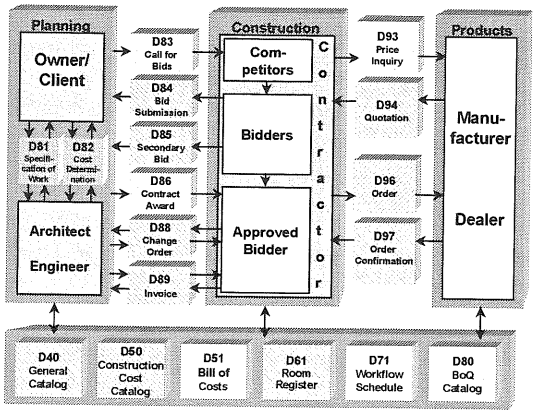

Figure 2: Partners involved in the BAB process

B. *Information flow using GAEB-XML*

The GAEB specifies different document types to cover the communication needs between the different partners. Each document is assigned to a so called data ex-change phase, e.g. the data exchange phase D83 represents the call for bids (see fig. 3). During each of this phases additional information like the description of work items, prices etc., are incorporated into the data structure. The specific information must be available in the assigned construction sequence. Therefore the construction sequences form the basis for the data exchange phases, which contain logical objects in which elements comprising keywords and their values are embedded. It makes no difference whether the information is exchanged between sophisticated cost estimating systems, or cost calculation systems, or is used for viewing purposes on site. The following figure demonstrates all partners and specified document types (data exchange phases). The figure shows all possible scenarios of information ex-change between the BC partners. The partners have to use for each data exchange phase the specific document type for co-operation. This is based on public building law. The most important data exchange documents in the GAEB standard are de-fined in the so called 80's and 90's phases. The phases D80-D89 are responsible for the co-operation on basis of bills of quantities/materials and the phases D90-D99 for procuring processes (e.g. ordering products). All these documents are specified with the platform independent and programming language independent XML technology. The XML technology makes the implementation of BAB software systems easy and economical. For the definition of different document types the newest XML schema technology is used, which enables on a much better way the definition of data ranges, exceptions etc.

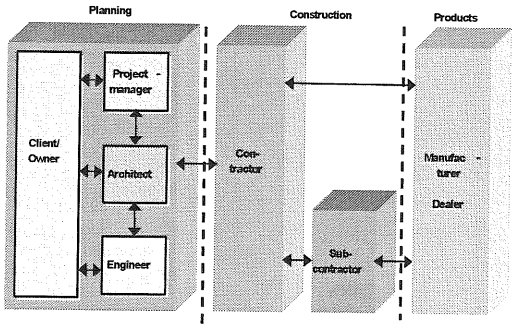

Figure 3: Holistic Information Flow in the GAEB DA2000-XML Standard

C. *Explanation of the GAEB-XML procedure for Inquir-ies/Orders*

The standardization of digital data exchange between contractors and suppliers based on XML plays a very important role in the upcoming B2B environment. Project information like bill of quantities/materials are used for data exchange between construction companies and manufacturer/dealer/supplier. When preparing a bid, the contractor sends the bill of quantities/materials to the manufacturer/dealer/supplier as a price inquiry. The manufacturer/dealer/supplier then sends a quotation to the con-tractor. This information is modified by the construction company, and finally incorporated in the contractor's estimate and used in the bid. The definition of a standard for material procurement in the building and construction industry is one of the most important parts in this project, because all stages of the procurement process must be considered. Therefore different xml schemas are adopted like classified schemas and product catalog schemas.

These standardization is essential, because only then BAB systems can exchange successfully digital information covering the distinguish aspects. The standard has also to consider various hardware and software platforms and has to provide a common language for construction information exchange. However, the real problem is the heterogeneity and openness of the exchanged content as is the case of bills of quantities/materials. There are at least two levels at which this heterogeneity arises:

- at the level of product catalogs structures
- at the level of product classifications.

Structuring and standardizing the product descriptions is a significant challenge for BAB processes. It helps customers to find efficiently the products they are looking for. There are different schemas and standards for product classifications and product catalogs, that are important for the BC industry. In the following are the most important standardizations addressed.[10]

III. Standards for Product Classifications and Product Catalogs

A. The BMEcat Format

The BMEcat-format [6] was developed with the objective of standardizing and simplifying the exchange of product data catalogs, that are used between suppliers and purchasing organizations. In the basic model, a supplier compiles a catalogue in electronic form which complies to the BMEcat standard. The Bundesverband Materialwirtschaft, Einkauf und Logistik e. V. (BME) [Federal Association for Material Management, Purchasing and Logistics] in Frankfurt/Main is responsible for the BMEcat standard. Many renowned companies have taken a very active part in this initiative. These include Alcatel, American Express, Audi, Bayer, BMW, C@Content, DaimlerChrysler, Deutsche Bahn, Deutsche Telekom, DLR, e-pro solutions, Frankfurt Intern. Airport, GZS, InfraServ Höchst, Lufthansa, Mannesmann, Philips, PreussenElektra, Ruhrgas, Siemens, VEBA and VISA [6].

B. The eCl@ss Standard

Each supplier may use different structures and vocabularies to describe their products. This may not cause a problem for a one-to-one relationship where the buyer may get use to the private terminology of his supplier. BAB market places that enable n-m commerce cannot rely on such an assumption. They must classify all products according to a standard classification schema that help buyers and suppliers in communicating their product information. eCl@ss is a widely used classification schema [7].

The following picture shows the necessary steps for the specification of information exchange during the material order in GAEB. There are 3 steps within three different domains:

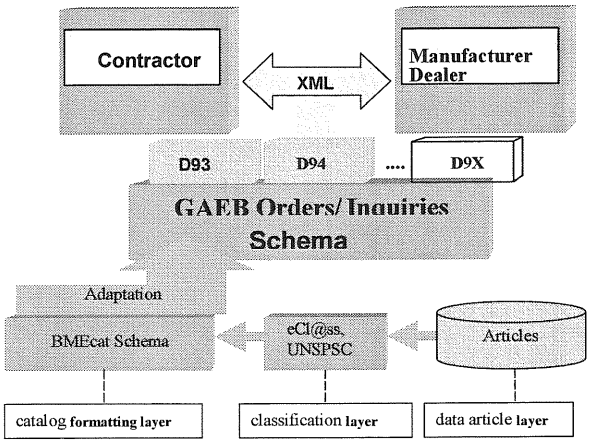

Figure 4: Necessary Steps for Ordering Processes in GAEB

- physical data layer
- categorization layer
- cataloging layer

IV. Internet based BAB Processes using GAEB-XML

Internet and Web technologies starts to penetrate many aspects of our daily life. Its importance as a medium for business transactions will grow during the next years. B2B market places provide furthermore new kinds of services in the construction industry. Construction projects become ever more complex. It also exists a large number on project participants, which are at different places and have to co-operate with one another. This requires a new methodology of collaboration that particularly applies to the execution of BAB-processes. BAB-processes are to be controlled economically and supervised in time. Therefore the use of modern and intelligent collaboration platforms is necessary. These must offer a holistic and process orientated information management. A system for BAB-processes essentially consists of the ranges: cooperation, communication, and management of projects.[9]

There are software companies which support parts of the BAB-process via internet. These distinguish BAB platforms have different goals, technologies, and usabilities. The media discontinuity is a substantial lack according to existing BAB-platforms. Therefore such systems could achieve only a limited spreading. Only a holistic sys-tem could lead to success. In future, the internet will become the information ex-change platform and XML will become the language independent data description format for the building and construction industry. These are the substantial conditions for the intelligent control and monitoring of projects in the area of BAB. The describ-ing of an information exchange using the neutral XML technology for the construction industry will enable tendering, planning, procurement, regulation, invoicing, and other business processes to be conducted online. [11]

A BAB-platform which considers the advantages mentioned before is the e-tendering platform of the German government [8]. This Initiative is called e-government "Bund Online 2005" and defines technical specifications to allow electronic communication between public sector bodies in Germany and private suppliers. It is core to the government's aim of making all public sector services available online by 2005. This system uses the advantages of the internet on the one hand and on the other hand permits an entire document exchange on the basis of the language neutral data exchange format XML.

V. Conclusions and Further Work

The definition of a holistic information exchange format and system for the construction industry increases dominantly the efficiency of planning and construction tasks. The development of a Web-based system becomes possible by the linkage of al-ready existing, isolated software units (web services).

The web service technology makes the transition from a pure document-oriented to a service-oriented business possible. This innovative family of technologies opens an enormous potential for the software development of the future in the construction industry.

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Biography

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IMPLEMENTING ELECTRONIC COMMERCE IN SMALL AND MEDIUM-SIZED ENTERPRISES

ELECTRONIC COMMERCE CONSULTING SERVICES OF THE COMPETENCE CENTRE OF ELECTRONIC COMMERCE

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Abstract: **Electronic Commerce stands for all business processes that are supported by new information and communication techniques. Especially for small and medium-sized enterprises, Electronic Commerce is a chance to increase efficiency, to lower costs and to improve business processes both with business partners and internally. The Competence Centre of Electronic Commerce is an initiative supporting small and medium-sized enterprises in the introduction and use of modern information and communication technologies.**

Index Terms: **Electronic Commerce, Electronic Business, small and medium-sized enterprises, Consulting, Competence Centre, reference concept, virtual delivery company, Best Practice.**

I. INTRODUCTION

Companies that integrate processes of Electronic Commerce into their organisations, improve their competitiveness because they speed up and shorten their business processes, offer better customer service and improve their cooperation with suppliers. Electronic Commerce reduces costs in the long run, improves services and accelerates durable business processes. To stay successful, medium-sized enterprises must not fail to catch that train.

However, numerous enterprises especially small and medium-sized (SME) lack the required information and know-how to appreciate the benefits of information technologies for their businesses, and therefore are not able to tell, what kind of scenarios would be reasonable for their own business and what value the Internet might add.

Initiatives like Saarland's Competence centre of Electronic Commerce (KEG Saar) illustrate, what potentials and advantages Internet and Electronic Commerce can offer and how small and medium-sized enterprises can step by step prepare and implement their way into the Internet.

II. ELECTRONIC COMMERCE IN THE CONTEXT OF SMALL AND MEDIUM-SIZED ENTERPRISES

A. Definition of Electronic Commerce

The constant technological progress of new information and communication systems enables the evolution of business models and strategies and affects the economy as well as enterprises themselves. Various new courses of actions for enterprises arise as a result of these changes in telecommunication, media and information technology and the globalisation of the competition as a consequence thereof. [1] Electronic commerce applications are the transmitter transferring the technological innovation into the organizational implementation.

Electronic Commerce stands for all business processes which are supported by new information and communication techniques. [2] Next to terms like Electronic Commerce exist several others that are broader conceptualised (Electronic Business) or even more specialised (Online Catalogue, Online Shop or Electronic Market). The term Electronic Business extends on quite common organisational and process-related trade relations between as well as inside organisations whereas Electronic Commerce comprises

more the negotiation phase and especially the pricing. To simplify matters, Electronic Commerce and Electronic Business are used as synonyms in this article.

B. *Small and medium-sized enterprises*

As for SME, the EU Commission recommends the following definition, which is in use since 1996: A medium-sized enterprise is an enterprise, which has

(a) fewer than 250 occupied persons and

(b) has either an annual turnover not exceeding 50 million euro, or an annual balance sheet total not exceeding 43 million euro, and

(c) either does not belong to a group of linked enterprises, or it belongs to a group of linked enterprises that fulfils the conditions laid down in (a) and (b) above.

Lately the Commission adopted a new recommendation regarding its SME definition replacing the recommendation of 1996. The revision takes account of the economic developments since 1996 and the application of the definition. It will be applied as of 1 January 2005.[3]

Micro, small and medium-sized enterprises are socially and economically important, as they represent 99 % of all EU enterprises, employ more than 74 million people and are an essential source for entrepreneurial spirit and innovation. Furthermore, SME represent the characteristical strength in the German economy. In the year 2000 there existed more than 3,3 Millions of middleclass enterprises with around 20,1 Millions of employees, that is up to 99% of all liable to tax on sales enterprises.[4]

Coping with the changes on the markets - caused by more internationalised and unstable market and competition conditions - requires a high degree on manoeuvrability. The monolithic structures of the traditional large-scale enterprises are not up to this. However, manoeuvrability is a core competence of SME. These are characterised by more specific, more specialised and less diversified products and services, which is often a logical consequence of the limited availability of resources.

The middle class is considered as a „germ cell for growth of economy, a pulse generator for innovations, a stimulator for the competition and a supporter of hope for the labour market".[5] Its strength lies especially in the distinctive proximity to customers and high flexibility through homogenous and therefore quick decision-making and unbureaucratic management. In medium-sized enterprises, a very close connection exists between the enterprise and the entrepreneur, who often is the owner of the business. He is the main information and decision centre thus SME are encumbered with relative low internal coordination expense.

The most common strategy of SME is specialisation - based on finding a gap in the market to offer specialized products to a limited number of customers. SME often operate on local markets. But the mentioned specialisation requires a wide range of potential customers in order to reach a critical mass for their specialized products. Therefore, an expansion into supraregional or international markets seems necessary. Appropriate information and communication technologies are the tools to support this expansion.

Because of the limited availability of resources, lack of know-how and high staff requirements, medium-sized enterprises need to be supported in order to stay competitive on the international markets by using the Internet, new telecommunication systems and further electronic commerce applications.

III. Relevance of Electronic Commerce for SME

The driving factors and potentials of Electronic Commerce are improved services, cost reduction and image growth.

Next to a website as a cost-effective way to present and advertise products and services to a wide range of public, a big potential of Electronic Commerce for SME is the rapid and cost-effective communication and interaction with business partners as well as inside their own business itself. Electronic information can be passed on to other business partners by e-mail or the required information is available in a database where it can be interrogated. Through the effective use of Electronic Commerce SME can build cooperation with other businesses that dispose complementary resources to strengthen their competitiveness.

Advantages of Electronic Commerce consist not only in improved business processes but also in the opening of alternative sales channels that lead to new customers and markets. Furthermore, the Internet allows a local independency whereby regional disadvantages can be removed. Therefore SME get a chance to participate in the global market and competition. E. g. the size of an enterprise cannot be made out on the basis of a webpage.

IV. Difficulties of SME in implementing Electronic Commerce

Enterprises have to adapt faster and more focused to their economic surroundings to stay competitive in the present day and age. A change in the demands of a customer and rising competitive pressure require higher flexibility and efficiency. SME are affected by these developments in particular. On the one hand –

due to their size - they are dependant of small market segments and therefore have to act quickly and innovatively. On the other hand, they are often integrated in the value chain as a direct supplier together with large-scale enterprises and therefore take up a weaker bargaining position. To meet these requirements SME can focus their energy through cooperations and strategic alliances. The strengths of SME, e.g. high flexibility as well as accessibility to customers, survive and at the same time disadvantages affected by their size are reduced. They have to network their resources with other business partners through cooperation. Modern information and communications technologies are used to integrate partners, support the cooperation process and compensate the existing weaknesses of medium-sized enterprises.

The Internet is a significantly increasing instrument for enterprises doing business. However, what kind of internet-based application is suitable depends on the individual requirements and on the business vision of the individual entrepreneur. It is of crucial importance that the application matches that individual enterprise strategy.

According to a survey of MR&S Market Research & Services GmbH there has been little implementation efforts of Electronic commerce applications in SME so far. The three major reasons for this are:[6]

- Difficulties in the adaptation of the enterprise culture,
- deficits in qualification and know how of the employees,
- little market transparency on the provider side.

In the meantime companies have identified that the introduction of Electronic Commerce affects all processes and cultural structures of the enterprise. In order to accomplish these major changes, the effects on the internal structures and processes have to be described and methods of resolutions have to be developed. Because of the company's deficits in e-business know how, consulting services were initiated which will be described in the following section.

V. The Competence Centre for Electronic Commerce

To facilitate SME with the possibility to access Electronic Commerce, a network of regional Competence Centres was build up in Germany. The Centres focus on their respective regional areas and support enterprises in all matters of Electronic Commerce. The partners who form the support team within a centre include both academic and practically orientated institutions. The regional Competence Centre for Electronic Commerce (KEG) Saar, which is responsible for the Saar-Lor-Lux-region, is managed by the Institute for Information Systems (IWi) at the German Research Centre for Artificial Intelligence (DFKI) and the Centre for Productivity and Technology Saar e. V. (ZPT). It is supported by the Chamber of Industry and Commerce (IHK). KEG Saar is one of 22 nationwide regional Competence Centres that have been sponsored by the Federal Ministry of Economics and Labour (BMWA) over the last five years. It is part of the Federal Government's "Information Society Germany" action programme.

In order to increase their competitiveness, KEG Saar supports all industrial and commercial companies as well as service and craft businesses in the introduction and use of modern information and communication technologies. The team of KEG Saar covers a complete lifecycle, from analysis and consulting to a complete concept definition, implementation and continuous improvement. Thus it helps SME to find a most suitable IT strategy and to implement a tailor-made solutions for their special business and requirements Building on the three areas of information, consulting and qualification, KEG has developed numerous activities which are intended to increase regional companies' awareness for the benefit of the Internet and Electronic Commerce. These include up-to-date information about all fields of electronic commerce applications live events (e. g. presentations of best practice examples) and a series of publications like booklets, handbooks or checklists.

Furthermore, KEG Saar offers independent consulting in all questions concerning electronic commerce as well as qualification trainings like seminars, specialist courses and workshops. The consulting service differs between consulting for enterprises that are new to online trading, enterprises that use Electronic Commerce already and those that need deeper information and subject-specific consulting. Figure 1 illustrates the intensity of consulting in different stages of experiences.

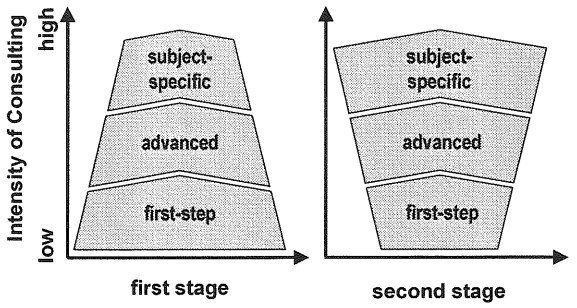

Figure 1: Intensity of Consulting

The different types of consulting offered by KEG Saar build up on each other whereas the intensity of consulting increases. The lowest phase represents a first-step consulting. First basic information is given

in terms of counselling interviews, booklets or checklists. This first phase serves as a jump-start for problem solving during the planning phase and until the implementation and use of the Electronic Commerce application. The next consulting step addresses enterprises that already use Electronic Commerce and need further information. In the last step, subject-specific consulting is given to specialised problems.

When the Competence Centre started its activities, a majority of the consulted enterprises needed fundamental information about Electronic Commerce and internet-based information technologies. The entrepreneurs were interested in topics like what kind of information and communication technologies exist, how they are used and how an effective application can improve their business processes. This demand for first-step consultations at a first stage is symbolised by the first ascending trapeze in figure 1. Today more deeper and subject-specific consultations are requested, which is demonstrated by the second trapeze.

During the first two years, companies often lacked the understanding of what modern information and communication technologies can offer. Consequently, a further project was started that aimed to compensate this deficit. Together with business enterprises, the Demonstration Centre for Electronic Commerce was set up in March 2000. It is unique in the nationwide network of competence centres and offers a wide range of electronic commerce applications. Using concrete scenarios, possible applications in the individual business areas and Electronic Commerce strategies are presented. A series of workshops was developed for the scenarios, which focus on topics that have been classified as important, and these are implemented with the aid of experts from business and science. KEG Saar regularly conducts guided tours through the demonstration rooms where an expert explains and demonstrates the characteristics of Electronic Commerce. The following topics and possible applications in companies are shown: online shopping, video conferencing, connection to standard software, electronic procurement, payment systems, eLearning, global working, Open Source applications, mobile technologies like W-LAN and bluetooth, and broadband transmission via satellite.

Interested enterprises can test different types of applications in real-life situations that are relevant for Electronic Commerce. Within the context of guided tours, workshops and trainings the entrepreneurs not only learn about the use of IT-Systems and application software, they also receive suggestions on how the use of Internet-based information technologies can help them arrange their business processes more efficiently. Figure 2 illustrates the electronic commerce scenarios and gives an impression of this special demonstration area.

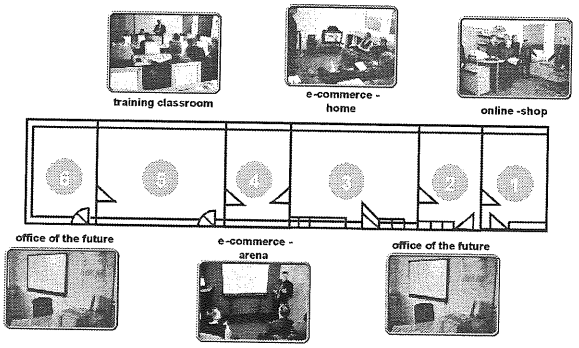

Figure 2: Commerce Scenarios

The demonstration centre is thus a central meeting point for regional enterprises for the presentation of innovative and modern information and communication systems as well as a practical consulting platform for enterprises and individuals who wish to expand in the Electronic Commerce.

VI. Electronic Commerce Reference Concepts for SME

Another main field of activity of KEG Saar is the development of reference concepts for Electronic Commerce solutions. The most sophisticated of those concepts is SaarBRIMA (Internet reference marketplace for SME in the Saar region) which aims at a collaborative approach to Electronic Commerce that will allow small and medium-sized enterprises in the region to profit from their closeness to the customer and their knowledge of the regional market, whilst avoiding the disadvantages of being a small, locally operating company.[7]

SaarBRIMA introduces SME to the use of the Internet by offering "package" solutions, comprising transaction, customer service, interaction and information components, thus providing a fast and economical access to the Internet. SME with their shops in almost every town bundle their services on the platform and become one *virtual delivery company*.

This virtual company as a role model for the future requires a suitable Electronic Commerce solution. The Internet marketplace makes it possible to build a strong brand that can be found under a single URL, and to advertise it jointly. The customer can use the marketplace as a starting point to gather information, to find services and to do shopping.

A. "Centralized order-taking, decentralized fulfilment"

The Best Practise case described below is the regional Internet marketplace *backstube.saarland.de*. It is the first practical implementation of SaarBRIMA.

Contrary to conventional online-shops, orders are taken on the platform, but are then forwarded to the respective business in the vicinity of the customer which will then deliver the goods. There is no need of a central control because every trader decides for themselves on the services offered (like delivery or collection and method of payment). The information component offers up-to-date content and tips, which makes the site interesting for regular visits. Consumer advice, recipes, a lexicon as well as press releases complete the variety of information. The service component creates added value by a wide variety of interaction possibilities. There is, for example, a search function for certain services like delivery or Sunday opening. In addition to that, job offers and training vacancies can be found.

For the trader this means an extension of their shop counter onto the Internet. The platform offers customers the possibility of choosing a well-known shop that offers good quality and service. The aspect of trust in particular is a critical factor for shopping on the Internet, as many customers have their doubts regarding on-line transaction security. A solution, which leads to trust not only because of the technology used, but also because of the reputation of the regional shops taking part, certainly has the competitive edge. Thus the virtual delivery firm has *"centralized order-taking, decentralized fulfilment"* as a motto.

The first modular reference platform has been presented exemplarily for the baking trade guilds of the Saarland. It is supported by the Saarland Ministry of Economy and Commerce. During the first five weeks of operation there have been ca. 17,000 visits to the site "backstube.saarland.de", and more than 300 registered regular customers use the revived rolls delivery service.[8]

B. Trade is High-Tech: Application to other sectors of business trades

The reference concept developed by IWi and the modular generic structure allow the platform to be open to other sectors of business. The next step will be for the central office of the German baking trade - in cooperation with IWi - to evaluate the transferability on other regions.

The experience and the results gained in this project also leave their mark on the work of KEG Saar, with its training and information events.

VII. Conclusion

Initially, the aim of KEG's events was to provide medium-sized enterprises with fundamental information on the topic of Electronic Commerce. At a second stage, special topics were raised. The individual consulting that has been carried out by the competence centre over the last few years was primarily related to issues like the setting up, optimisation and successful marketing of Web pages; the setting up of online shops; payment systems; Internet law; security on the Internet and online marketing.

After more than four years of intensive experience with SME due to numerous activities carried out by KEG Saar, the following hypothesis can be established:

- The use of E-mail and a standard website have become common in the medium-sized enterprises; they are often even part of the value chain.
- In international comparison, German SME do not implement many Electronic Commerce applications of higher value. Mainly, there is need for action with regard to Web page optimisation, setting up online shops and development of suitable advertising actions.
- There is still a large discrepancy between Electronic Commerce applied in medium-sized enterprises and big companies. Medium-sized enterprises have a lower level of IT expertise than big companies.
- The factors that hinder the extension of business processes to the Web are reduced budgets, a lack of security, the time required, high staff requirements, problems integrating existing systems and incompatibility with existing business processes.
- According to the survey of MR&S only 13% of medium-sized enterprises focus on the use of Electronic Commerce solutions. The uncertainty over success and return-on-investment (ROI) of Electronic Commerce investments as well as fear of failure during the introduction phase prevent a wide-ranging application of Electronic Commerce in SME.
- As shown in the Best Practice case, especially for locally operating micro companies a collaborative approach to Electronic Commerce within a regional market place holds great potential.

For that reason and in order to effectively make use of the potentials of the Internet, medium-sized enterprises rely furthermore on consulting services allocated by the network of Competence Centre for Electronic Commerce. The Federal Ministry of Economic and Labour Affairs has decided to continue sponsoring the nationwide network of competence centres until the end of 2005. This means that the KEG Saar will be able to maintain its services and support the companies moving towards Electronic Commerce through neutral information and consulting service. Reference concepts like SaarBRIMA strongly support these consulting activities. Alongside a basic information and qualification service, consulting will in-

creasingly move to special and higher-value topics that can be covered by the networking of the centres.

The findings and activities that have been outlined exemplarily show in their totality the competence of KEG Saar as a partner for SME discovering the Internet as a new field of business activity and Electronic Commerce projects.

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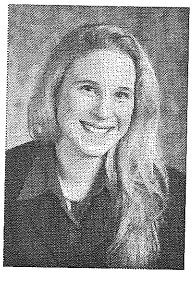
Biography



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A PEER-TO-PEER APPROACH FOR BUSINESS INTEGRATION

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Abstract: **In recent years, the field of Business Integration has gained in importance due to a raising number of heterogeneous business applications in combination with strategic cooperation between enterprises. The consequence is a high demand of reliable solutions to provide interoperability between different IT systems, enabled by a seamless transition from business level requirements to system-level execution. In this article, we present a peer-to-peer integration approach that deals with the strategic business level as well as with basic principles in the context of implementation.**

Index Terms: **Business Integration, EAI, peer-to-peer, Architecture**

I. INTRODUCTION

Emerging the internet was an unpredictable evolution. All the same, important criteria such as reliability and robustness always came to the fore. As a result, users had the opportunity to get access to a highly available data network that stays operative even in case of a breakdown of some single nodes. Since file sharing tools like eDonkey or Grokster are one of the favourite applications for a large number of internet users, the peer-to-peer idea experiences a new boom. Indeed, the functionality of current peer-to-peer applications is limited to quite simple actions such as searching and downloading music files or movies. Hence, to benefit from peer-to-peer technology, there is need for additional, innovative features. A predestinated field of application is the context of Business Integration, where various distributed IT-systems act jointly by exchanging data and control flows.

Employees need improved applications with enhanced functionalities to manage their all-day work. These applications replenish existing legacy systems which means long-ranging a heterogeneous network of computers and applications. In some way, all these components require each other and have to be brought together. A first naive solution to provide an interaction of those systems is shown in Figure 1. Apparently, an appropriate description for this point-to-point integration is described with the term '*Spaghetti Integration*':

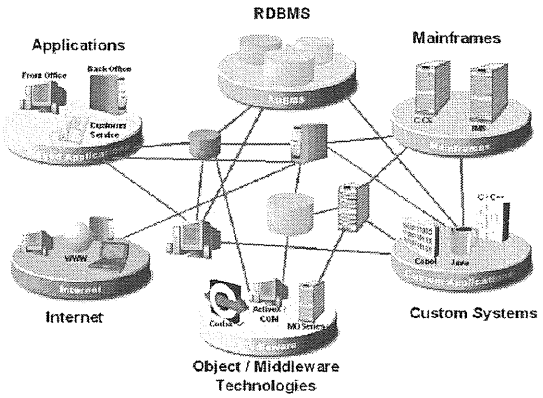

Figure 1: Typical heterogeneous Enterprise Architecture

Source: IDS Scheer AG, Germany

The (n:n)-connection of resources can not be maintained properly, as it contains too many non-standardized interfaces. After experimenting with those scenarios, most enterprises admitted that there has to be found another solution for a reliable integration of business applications. Some years later, the effort of bringing together single systems to one logical unit is paraphrased with the term *Enterprise Application Integration (EAI)* [1]. EAI means a bold venture, as the communication between business applications is restricted due to several constraints:

- different interfaces and protocols,
- syntactical differences between applications,

- business modelling methodology differs from the technical implementation

Anyway, the market for specific integration software is estimated to grow from actually 12 billon US$ up to 30 billion US$ in the year 2004 [2]. In the environment of business integration, most development activities focus on 'old-school' solutions that rely on client/server architectures, although some crucial advantages of peer-to-peer technology (performance, resilience, load-balancing) are well-known to many software architects. With the appearance of *Web-Services*, a new paradigm was born. Now, it is technically possible to search the internet for certain services and to let these services interact via XML. Unfortunately, common Web-Services do not include any functionality that would be capable to control complex business processes. Furthermore, one needs a central Repository for the *Universal Description, Discovery and Integration of Web Services (UDDI)* where a catalogue of all offered services is stored.

In this article, we present the idea of a peer-to-peer integration environment that solves the structural problems of traditional integration approaches. It allows a decentralized integration of data, applications and processes without the common insufficiencies of existing EAI solutions. At this time, peer-to-peer technology comes into play: Why should it not be possible to build up a peer-to-peer based architecture that is not dependent on any central component and that allows a standardized exchange of business process data and control information? The advantages would be evident: The abandonment of EAI-Servers that are hard to maintain is as fascinating as the easy customization of the single peers and the dynamic joining of new peers during run-time.

II. Business Integration and EAI

As already mentioned, an integration of the core IT-systems is essential to guarantee a frictionless handling of business processes. Conventionally, business-level specifications of business processes are treated as abstract maps without direct linkage to the system behavior. Business Integration tries to close this gap by holistically tackling both levels and by realizing a seamless transition from business level to system level and vice versa. The result would be an IT-executable Enterprise Architecture that appears as one single system, supporting the interactions of all relevant business processes.

So far, the efforts to manage this integration contain a set of technologies and concepts such as Middleware, ETL-Tools and EAI-Software that focus on a central planning and control of business applications in real-time. In Figure 2, an example for embedding an EAI Server into the enterprise architecture is shown:

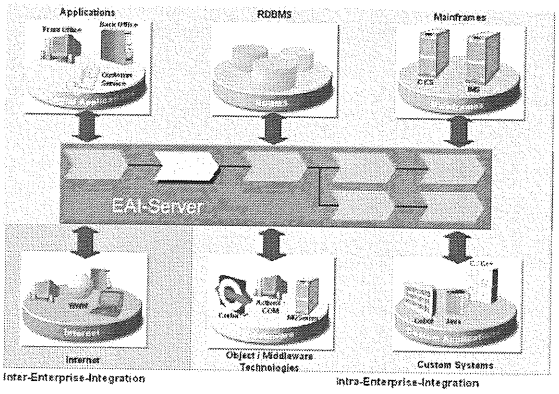

Figure 2: Introducing an EAI System

Source: IDS Scheer AG, Germany

A central EAI-Server manages the control of both, control and data flow, between the attached systems. In this manner, the number of required interfaces can be reduced, as there exists only one connection from each system to the server. The central component is ordinarily called *Information Hub.* Major well-reported problems of these approaches are the following:

Single point of failure: The Information Hub is the central connector between the different applications. In case of a breakdown, all business processes are affected.

Bottleneck: All network traffic has to be forwarded through the Information Hub. In a situation of peak load, the system performance will crash down dramatically.

Configuration Icebergs: The distribution of information has to be represented by formal transformation rules. Because of its complexity, interdependencies and lots of exceptions, the number of configuration rules raises exponentially. This may result in an insufficient and fault-prone integration.

In recent years, the awareness of the cost-intensive administration and the insufficient management of complex business application systems by centralistic approaches has arisen. New fields of research such as *Autonomic Computing* gave thought-provoking impulses to find a better alternative for the management of business integration.

III. Actual Applications

Peer-to-peer means a networked structure where the participants (herein called *peers*) interact and share resources directly and equitable between systems. In contrast to client/server architectures, peer-to-peer networks do not own any kind of hierarchical

structure. As the peers are independent from specific hardware platforms, potential peers comprise a wide range of systems, reaching from PDA via desktop computers up to mainframes. They are all characterized by the following properties [3]:

- **Client and server functionality:** Every peer is able to receive data from other peers as well as to provide data for others.
- **Direct exchange:** There is no central instance controlling the communication between the peers.
- **Autonomy:** It is in charge of each single peer when it provides which service, data or output to the network.

Especially the property of autonomy is of special importance for the integrated use of mobile computers such as notebooks, PDAs or mobile smart phones, as these per se can not be available to the network permanently. Actually, peer-to-peer technology is used for non-commercial, private or academic purposes. Well-known examples are file-sharing applications (e.g. Napster, eDonkey, Kazaa) or grid computing projects (e.g. seti@home) [4]. Current peer-to-peer applications that are usable within business integration scenarios are seldom. In particular, existing approaches can be categorized in two main clusters:

Communication support is the most common kind of applications for peer-to-peer networks within enterprises. The best known representatives are ICQ, AOL Instant Messenger or the Microsoft Instant Messanger for sending and receiving instant messages. These applications are characterized by an open and highly dynamic number of participants.

Instant messaging applications are used for the direct, real-time communication between peers. Thus, they allow the determination who of the known participants is online at the moment. This accelerates business communication processes because it ensures a text-based synchronous communication that enables a direct reaction on incoming messages, respectively business events. *Video conferencing* means the real-time transmission of video and audio data between two or more participants. It mainly serves to support cooperation and collaboration processes. Thus, natural communication is possible trough wide distances. Currently, real meetings can be substituted by the use of videoconferencing. Time and traveling costs can be reduced significantly.

Resource sharing can profit from the exponential development of the computer performance in the last decades. In parallel, price for computation power has decreased in at least the same dimension. Subsequently today the capacity of the clients is used only rarely, as most of the work load is assigned to the server(s). Peer-to-peer can use these idle resources and hereby achieve a drastic cost reduction, combined with other competitive advantages. The sharing of resources is implemented in two concepts:

File sharing, also very common in the non-commercial area, provides shared access to any files that are stored locally. They consist of special, efficient mechanisms for searching as well as algorithms to non-central storage [3]. Compared to central data storage applications, this kind removes the single point of failure, transfers data to low-cost mass storages and levels off the peaks in network traffic. The main problem areas comprehend ensuring of data consistency within the network as well as a 24/7 availability. After all, in the business context only those applications that do not affect mission-critical cases found their way.

Distributed computing is used for complex business computing tasks such as product construction, simulation, financial forecasts or data mining. Here, the main factor for these time-consuming processes is computation power. Distributed computing can substitute powerful single computer systems with a network of peers by decomposing (dividing) the problem in small sub-problems and spreading them within the network. Even world-class enterprises use distributed computing for this purpose: Intel introduced distributed computing in 1990 for the development of new microprocessors [5].

IV. A PEER-TO-PEER INTEGRATION APPROACH

Assigning Autonomic Computing to the context of business integration means that all systems and components of an enterprise work in a self-organizing manner. This allows a flexible and dynamic coupling of applications and processes. Thereby, administration and integration costs can be reduced [6], [7]. A basis for this approach is the decentralized architecture of a peer-to-peer system which can offer the following advantages:

Non-central topology: The complete IT-infrastructure is defined by a variable number of flat (non-hierarchical) peers. Every peer offers at least one service (e.g. generate an order, create an invoice, check consistency of data, dispose payment, etc.)

Reliability: There is no central component that may cause problems. If a peer breaks down, another peer with similar functionality can replace the broken peer.

Scalable performance: The performance of the network can be enhanced nearly unlimited by appending additional peers while existing components do not have to be replaced.

Easy configuration: It is no longer necessary to customize the whole EAI system by central transformation rules. Every peer only contains the business knowledge it requires to accomplish its functionality. The configuration of the complete architecture results from the configuration sum of the single peers.

Adaptive self-configuration: By implementing intelligent search mechanisms, a peer can find the next service in the process chain by broadcasting into the network. If another peer is able to offer the desired service, it responds. From now on, this peer is part of the complete system and can accept tasks from other peers as well as delegating services to any peers. While the advantages mentioned above are mainly of a technical nature, these features will not be sufficient to manage the complete field of business integration. There is also a high demand of adequate logical representations of business processes to provide an essential view reflecting also economical aspects. The vision of distributed business processes that are associated with distributed IT-systems, allows an optimization of the processes as well as improving IT applications without interacting each other.

In our research project *Peer-to-Peer Enterprise Environment (P2E2)*, we will develop an integration architecture that focuses typical Business Integration scenarios. To prove our concept, we will also implement and evaluate a prototypic system. For achieving this ambitious goal, we collaborate with the working group for Databases and Information Systems of the Max-Planck-Institute (Germany) and several partners of the software industry. In Figure 3, a peer-to-peer scenario is shown that gives a first impression of our intention:

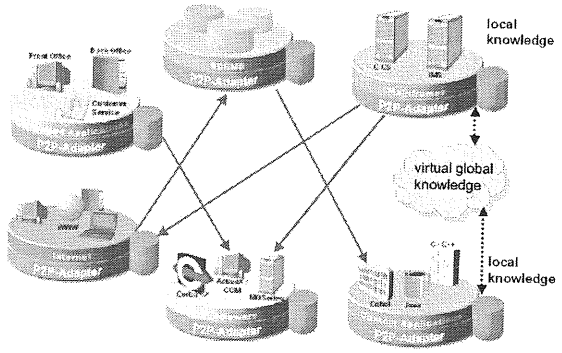

Figure 3: Peer-to-Peer Integration Scenario

All application systems (AS) that contain parts of the whole business processes are enclosed by a P2P-Adapter. Every Adapter enhances the functionality offered by the single components with additional Web Services (WS) that allow a composition of very complex services by a dynamic interaction of different adapters. A peer can initiate business processes, embed local processes in the application flow and even get embedded by other peers. It only has his own *local business knowledge*, but can also acquire *global business knowledge* by interacting with other peers. In this way, a comprehensive management of meta-data can be achieved without requiring centralistic client/server architectures. The whole integration environment is built up by a number of adapters that are attached with each mission-critical IT-system of the enterprise

The core idea of our peer-to-peer adapter is a strict separation of business processes (business knowledge) and its technical implementation (system knowledge). During the configuration of every single adapter, an intermediator layer is created that connects the two layers to reduce the inherent complexity of the business-system interdependency. When the 'arrival' of a business process is registered, this event is translated into a precise action in the system layer. After this action is performed, the next part of the process chain is defined in the business layer. If the necessary function can not be provided by the system layer of the current peer, it can broadcast a request for a service performing that function to all other peers. If a suitable service is found, the whole process is transmitted to the next peer. To ensure the efficient use of the procedure models and methods, we will conceptually and technologically develop an integrated tool support that includes an *Adapter Development Kit* as well as some important pre-customized standard adapters and an *Adapter Management Tool*.

The problem faced above is complex and versatile. Therefore, a highly structured and planned proceeding will be necessary. In contrast to other approaches, we follow a 'meet in the middle' strategy, analysing the problem space and creating solving concepts both from the business oriented as well as from the system/technology oriented direction. This ensures that the conceptual solutions are suitable for the business problems targeted and that they are realizable with today's state-of-the-art technologies.

The business oriented approach will evaluate the requirements of enterprises within internal or collaborative business integration scenarios. The main reference objects here is the (abstract) business process that has to be supported. Thus, the business oriented conceptual solution has to provide mechanisms and techniques how to interconnect independent business processes using the peer-to-peer paradigm. The main challenge here is the lack of a central coordination instance. As a logical consequence, appropriate business process negotiation techniques have to be developed. Looking at the system oriented problems, the main question is how to find a mapping between heterogeneous application systems in conformity with the business processes and rules to be supported. This does not only mean to connect interfaces, but also requires to find semantic matches within concrete con-

texts, as well as to handle a reliable control of the interaction.

Peer-to-peer technologies have been proven as very flexible and robust. Therefore, it seems to us as an appropriate approach. Hence, new methods and algorithms for a distributed interface and interaction management will be created using the peer-to-peer paradigm. Our idea is to enable an auto-configuration of the interaction between two independent application systems that succeeds to predefined business processes and that is also compliant to existing, constraining business rules.

Finally, only developing the two solving concepts described above is not sufficient, as there are interdependencies between business- and system-layer. The formation of business process chains within business integration use cases is always limited by the capabilities of the existing applications supporting the business processes. On the other hand, the applications itself can only be interconnected in a way that the combination of systems is supporting a predefined business process. Hence, a relationship between the two partial solutions has to be found and specified. The combination of these three concepts will be a conceptual methodology for a dynamic binding of business processes to the behavior of the distributed environment via a (semi)automatic reconfiguration in case of need.

The technological *P2E2* results will consist of a family of congeneric components (adapters) that can be linked to application systems. These components will provide a non-central IT-support for interactive business processes within distributed business integration environments. The adapters themselves will include both client and server-functionalities and will not have to rely on a central control unit. This addresses those business cases where a central integration approach is not reasonable, not desired or not realizable due to technical restrictions. Moreover, *P2E2* extends the focus of classic EAI solutions by the aspect of user's interaction and influence. Thus, the differentiation between front-end and back-end will become obsolete. This also reflects the business level view where such a distinction is not reasonable. Expected properties of the *P2E2* implementation are robustness, fault tolerance, adaptability, dynamic behaviour and scalability.

For business usage, a coherent computing of business process is necessary, but not sufficient. For the purpose of analyzing and optimizing processes continuously, a detailed history of operating figures and key values is required. This data is in particular used on tactical, dispositive level to manage the performance of critical core processes. Within business integration scenarios with several systems involved, the gathering of these figures by measuring the processes is difficult and complex. *P2E2* will cope with this problem domain by integrating special measurement and control instruments within each peer. Thus, an integrated and consistent business process controlling and measurement within distributed environments will be enabled. Hence, *P2E2* will develop the measuring methods, implement them in the adapters as well as create a reporting and analyzing tool for process performance measurement.

V. Conclusion

The sustainable success of peer-to-peer technology within the non-commercial sector (file sharing and instant messaging) advises it also for the business sector. Within enterprises, there are several potential application cases for the productive use of peer-to-peer technology. Especially for business integration scenarios, peer-to-peer seems to be an interesting alternative, in particular those with are characterized by non-hierarchical, flat organization structures. Thus, the integration of application systems using peer-to-peer technology is obvious. *P2E2* addresses this aim by creating a family of generic components that provide a general connectivity between business application systems and that act with client and server functionality. Hence, the classical separation between client and server will be resolved in favor of functional ad-hoc decisions. The coordination and control between the single adapters will not be managed by a central unit, but case-based negotiated between the adapters and afterwards transferred as needed. Thus, there is no functional dependency of the whole functionality network from only one edge.

Within a consortium of 6 partners, covering basic academic research, applied research, software industry and IT-consultancy, *P2E2* will research this problem domain. At the end, the project should not only have generated a prototypical implementation of the environment, but also a concrete business scenario that will have been integrated by *P2E2* technology. This scenario will be considered as a proof of concept. Finally, the use of peer-to-peer technologies within business integration scenarios marks a young area of research and development within the field of business information systems. *P2E2* has made a first step into this domain trying to solve some of the common problems, leaving some others open and maybe also rising new ones. The way to consistent, operative environments that integrate enterprises and enterprise application trough peer-to-peer technology will be long, but with *P2E2* we have entered the road.

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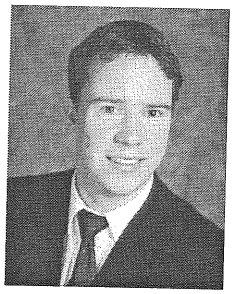

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RESULTS OF BATCOS ON-LINE COURSES PILOTING IN THE CONDITIONS OF SMES

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Abstract: **The paper describes some results of BATCOS on-line courses piloting. The brief characteristics of both the project and developed on-line courses are included. The piloting results are described in the three areas: 1. Priorities in the course activities structure, 2. Requirements for the delivery environment, 3. Role of a tutor.**

Index Terms: **BATCOS, E-Learning, On-line course, Piloting**

I. INTRODUCTION

BATCOS project is an international three-year project aiming on the development and piloting of on-line courses intended mainly for training of employees from small-and middle-sized enterprises in European countries. The project was solved in 2001- 2003 and it is financially covered by the EU in the framework of pilot projects from the Leonardo da Vinci II program. The project is coordinated by UWB in Pilsen. Altogether 21 partner organisations from the Czech Republic, Germany, Italy and the Great Britain cooperate on the project. Project's key partners are the University of West Bohemia in Pilsen, Charles University in Prague, Tomas Bata University in Zlin, Universita di Genova (Italy), Berufliche Fortbildungzenter der Bayerischen Wirtschaft GmbH (Germany) and King's College London (Great Britain).

The main target of the BATCOS project is to develop 5 sets of multimedia on-line courses intended for education of employees from small- and middle-sized companies. These courses are to be supplemented by off-line multimedia textbooks on a CD-ROM. Besides the development of the above-mentioned instruments, the other project activities focus on tutors training during the piloting preparation stage and the piloting of developed courses in a group of minimum 50 employees of small- and middle-sized companies and 25 unemployed people looking for work.

II. BRIEF CHARACTERISTICS OF THE BATCOS COURSES

Within the project 33 on-line courses are being developed focusing at: 1) ICT application inside company; 2) Company management; 3) Project management and 4) Production processes. The created courses are available in four languages: Czech, German, Italian and English.

The developed on-line courses are accompanied by electronic textbooks serving as off-line support of on-line courses. Individual students then can study the course study texts also on computers that are not connected to Internet.

The core of the developed on-line courses is formed by a course schedule that can refer to activities like: study text, task, exercise, discussion, test, autotest and survey. Courses created in such a manner require a LMS meeting both the requirements of the designed courses and the requirements of the users from the target group. In the BATCOS project two LMS have been selected LMS: LMS Eden and LMS Cornelia (LMS of the project partner from Germany). Tutor's participation is anticipated during the on-line courses organisation.

Figure 1 shows an example of a course schedule for a course implemented into LMS Eden.

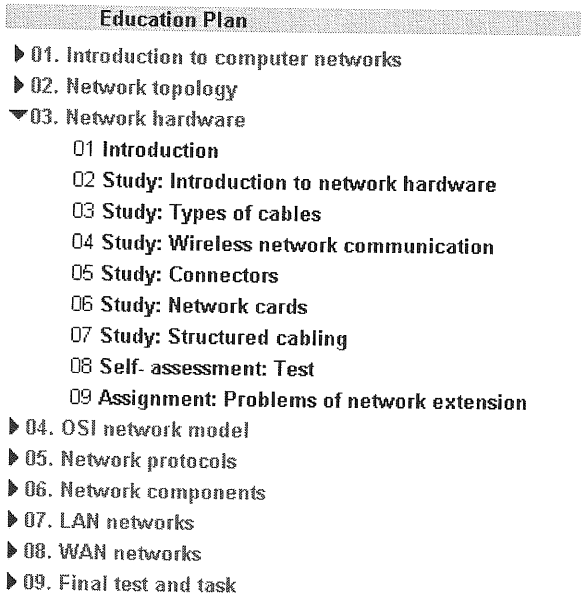

Figure 1: Example of the course schedule (in LMS Eden)

Study texts for individual courses are designed in a manner preferring visualisation of information. BATCOS project team used several anticipations, the basic ones being:

1) Considerable deal of study content (in any topic) can be visualized in a certain manner;
2) For majority of the student types (with partial regard to the BATCOS project target group) is the learning process more effective with the application of graphic information visualisation than without it;
3) In certain aspects parallel lay-out of text and visualisation components is more suitable than serial lay-out.

Based on these anticipations such a lay-out of a study activity window was designed as shown in figure 2.

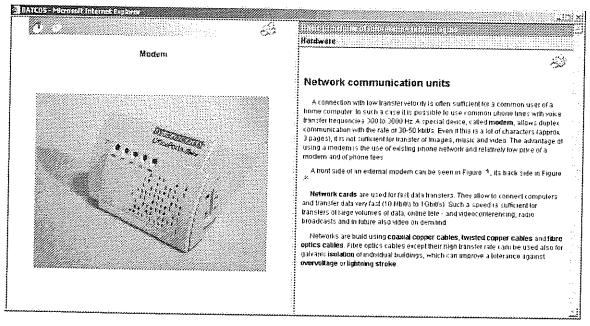

Figure 2: Presentation window of a study activity

The left part of the study activity can show pictures, photos, animations, slideshows, videos, screenshots and simulators.

Study duration of individual courses is different and it ranges from 10 – 60 study hours.

III. PILOTING OF COURSES

Piloting of courses represents a methodological sub-stage evaluating the correctness of the developed on-line courses in relation to meeting the needs of the target group users' needs and thereby the level of meeting of the project goals. It takes place before full implementation of courses into the real system of the company's human resources development.

With regard to a larger amount of the developed courses, several piloting stages taking place from 4/2003 to 9/2003 were set in the BATCOS project. In every stage a corresponding amount of courses is piloted. Piloting designed in such a manner allows including of results from one piloting wave into the performance of the following wave. During this substage piloting takes place in the original languages of the courses and in the national conditions of these courses. Participants of the individual piloting courses were selected as a representative sample of the target group of the project results users.

On a general level, the methodology plan of individual piloting courses consists of the following steps: 1. Kick-off meeting, 2. Long-distance course, 3. Final meeting.

A. Kick-off meeting

The goal of the kick-off meeting is to prepare the individual course participants for effective and successful study. In order to meet this goal the content structure of the meeting contains the following parts:

- Mutual introduction of students and the tutor
- Introduction to the course (educational goals, content structure, evaluation methods, manner of communication etc.)
- Instructions for using of LMS

B. Long-distance course

Long-distance form of courses allows the students to study independently of time and place. Pilot courses students in the BATCOS project log on to their course systems from their homes, workplaces or special computer study rooms of the piloting organisations. Course tutoring methodology, to which the individual tutors were introduced, guarantees to the students that the relevant tutor responds to possible questions within 24 hours – majority of the piloting courses preferred asynchronic form of communications.

In the piloting runs the courses were tutored by their authors.

C. Final meeting

The purpose of the final meeting is first of all official closure of the course together with reporting the

study results of individual students and final course evaluation. Course evaluation by the participants takes place in two levels:

- By means of final evaluation survey,
- By means of final evaluation discussion.

After the final meeting, individual tutors summarize the results of the evaluation surveys and together with the results of the final evaluation discussion they analyse the obtained information. Results of the evaluation analyses serve the individual tutors as a source of modification proposals for their courses. These proposals are further incorporated in the project.

Further on, tutor's handbooks for individual courses are developed in the course of the post-piloting activities. The tutors-authors provide in them detailed instructions for tutoring of their courses based on their experience with course tutoring and created course content.

IV. Some Results of Course Piloting

Analyses of the evaluation surveys and discussions showed plenty of ideas for modifications to both the individual course and the tutoring itself. Among other things the participants also evaluated the application suitability of relevant instruments for the courses distribution.
Based on the comparison of evaluation information results acquired from applying one BATCOS course on two different target groups (in two independent groups) - university students and industrial enterprise employees - we could see different qualities of these groups demonstrating in their satisfaction with the on-line course content, delivery system, tutor's approach etc.

Some general results of the piloted on-line courses evaluations (by project's target group) are provided in the following sub-chapters.

A. Priorities in the course activities structure

Although when designing the course the individual course authors chose a certain didactic method of achieving the course goals matching both the final users target group and the proposed course content, the piloting showed certain drawbacks in the proposed study plan structures (structure and content of individual study activities).

Evaluation information analysis demonstrated that the project target group attributes the following priorities (1 – highest priority) to individual types of activities (or their parts) of the on-line course:

1. Study text – text (1,55)
2. Practical examples (1,95)
3. Pictures, graphics, animations (2,4)
4. Exercises (2,6)
5. Sound- and video- recordings (3)
6. Tasks (3,25)
7. Tests (3,6)

(8. Tutor's advice; 9. Discussions with other students)

Note: Piloting of BATCOS course in university environment in a group of ca. 30 students showed the following priorities:

1. Study text – text
2. Practical examples
3. Tasks
4. Exercises
5. Tests
6. Discussions with other students
7. Pictures, graphics, animations

(8. Tutor's advice)

B. Requirements for the delivery environment

The course piloting proved the application of LMS Eden as suitable. The participants of individual courses did not have any substantial comments on the functionality or graphic interface of the system; they considerably appreciated the possibility to study on a computer that is not connected to the Internet by means of an electronic textbooks (particularly participants studying at home).

However, system quality in relation to the support of meeting the course targets cannot be fully derived from the system functionality evaluation, mainly because the course participants did not have the possibility to compare the LMS Eden functioning with functioning of another system.

Regardless of the above-mentioned fact it is possible to state that the project target group considers simplicity of the system and absence of "useless" function elements important. Majority of the participants also prefers minimalization of interactive steps necessary for obtaining of necessary information.

C. Irreplaceable role of tutor

The course piloting prooved the tutor's role to be very important. The courses, in which the tutor's activity was low, received in general worse evaluation than courses, in which the tutors fulfilled their consulting and evaluating roles on a quality level. Low or poor quality of tutor's activity had influence not only on the tutor's evaluation but also on the evaluation of other course aspects.

Evaluation of one course renders the tutor's role in the following manner: "Only the tutor turns an on-line course into an on-line course".

V. Conclusion

Regardless of the above-stated facts, according to the evaluation questionnaires and discussions analyses there persists incapability of many participants to make full use of the on-line courses possibilities. Many participants tend to use the on-line course only

as an electronic textbook on the web. For example, two following findings from the evaluations questionnaires demonstrate this:

1. Course participants (mainly among the employees of industrial enterprises) were not too interested in communicating with each other (some of them not even with the tutors – contrary to Chapter IV.C)
2. Many course participants tend to view the course content as an organized pack of information without using the pedagogical instructions too much – some of them considered this information connection step as useless.

Majority of participants expressed their satisfaction with study by means of an on-line course, the most frequent provided reason was the possibility to manage one's own time and place of study and often there also appeared information about satisfaction with the manner of the information visualisation. Quality Internet connection was the most frequent stated condition for successful study and recommendation for future participants.

BIOGRAPHY

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THE LEARNING ADMINISTRATION

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Abstract: **Nowadays the public administration sector is being pressured to act effectively and efficient. In order to retort their increasing indebtedness they have to meet the requirements of citizens and enterprises. Concepts like New Public Management or the recent eGovernment enable public authorities becoming a modern, marked-oriented service provider.**

Thus, the employees qualification as well as the constant enhancement of their knowledge constitutes an important precondition for reaching the stretched goals of the modernization of administrational processes, the implementation of change management strategies and the realization of an comprehensive eGovernment.

Therefore the supplementary application of Knowledge Management and eLearning technologies are promising. Especially the linkage between these convergent elements secure an all-embracing supply with real-time information and didactically edited know-how. The Quality of Service of administrative processes can be better adapted to customer needs and will be improved as a whole. The article in hand shows, how such a linkage can be realized and how it can be technically supported.

Index Terms: **eGovernment, eLearning, Knowledge-Architecture, Knowledge-Management, Organizational Memory System**

I. THE MODERN ADMINISTRATION – CHALLENGES

Today, public administrations are in most instances structured in a bureaucratic respective hierarchic way and face increasing difficulties to live up to the demands posed by the citizens as well the businesses [1]. Additionally, the economically instable times are increasing the tax payer's awareness concerning the commensurate use of public funding [2]. From the administration's point of view, the constant rising indebtedness of the public authorities during the last years boosted the desire within the politic area for an optimization of the administrational acting. Complex processes, little transparency, missing basic data, ambiguous responsibilities, intricate communication as well as high and increasing personal costs are identified as the main challenges [3]. The necessary improvement of the efficiency can only be realized by drastic changes in composition and behavior within the organizational structures and optimized (administration-) processes as well as in the relation to internal and external target groups.

The application and optimization potentials of modern Information and Communication Technology (ICT) are discussed within the field of "eGovernment". "The data has to run, not the citizens" is the claim for the future. Thus, the usage of ICT technology is a crucial point of the political agenda for the support and optimization of the administrational processes. Thereby, the spectrum of the procedures ranges from simple, well structured production workflows to complex decision processes. In between, numerous processes are detectable. The way how their complexity will affect the process can't be foreseen at the point of their beginning [4].

Promising concepts for the acceleration, cost reduction and transparency of business processes result from the approaches of *Business Process Reengineering (BPR)* and *Continuous Process Improvement (CPI)* [5], [6]. Within this context, the implementation of enhanced or new processes – usually supported by the implementation of an adequate ICT – shall lead to the aimed improvements of efficiency and effectiveness. Within the field of public administrations, the staffs knowledge affects exceedingly the execution of the processes and, according to this, the improvement of their performance. The employees are the central resource and are aware of current challenges, hold the relevant know how and have to act as a primal medium for changes [4]. Thus, the employ-

ees qualification as well as the constant enhancement of their knowledge constitutes an important precondition for the optimization of the administrational processes and the realization of the benefits linked to the implementation of an comprehensive eGovernment.
In this context, Knowledge Management and eLearning have become central terms ensuring faster reaction times and precisely counteracting the described dynamics in the scope of a lifelong learning phase. Taking into account the above-mentioned aspects of an efficient administration using ICT as a central resource for the exchange of information and the implematation of transactions, the double effect appears:

- Knowledge Management and eLearning support the acceptance as well as the usage of eGovernment solutions by providing current information and improving the employees know how
- Knowledge Management and eLearning themselves are objects of the eGovernment related activities by raising questions about adequate technical, organizational and didactical concepts.

The aim of *eLearning* consist in the didactically structured mediation of relatively time-constant basic knowledge in the form of basic knowledge, specialized knowledge, concept knowledge and methodical knowledge. The learner will be enabled to use the mediated knowledge independently and the mediated methods for fulfillment of practical tasks. *Knowledge Management* deals with the constant identification, storage, supply, distribution and further development of current core knowledge. Thereby, the deficits particularly consist in the provision of loose data and information. Following the consecutive understanding of the terms "information" and "knowledge", information only develops into knowledge through the accumulation of applied and action relevant contexts by the employees [7], [8].

II. Technologies – State of the Art

As shown, the two approaches turn out to be complementary and ensures the supply of relevant knowledge along the whole knowledge chain, from basic via advanced education up to the continuous quality assurance of state-of-the-art knowledge in the everyday working environment. The described dynamic and complexity of change processes within the public administrations as well as the significance of employees as potential knowledge carriers indicates the high importance of intelligent designed knowledge supply and education processes. The identification and combination of distributed, specialized knowledge carriers and knowledge bases within a *holistic knowledge architecture* is realizable with the deployment of modern ICT infrastructures. The accumulation of basic knowledge as well as consistent, specific and up-to-date information in the sense of a dynamic, intelligent (education) organization takes place with the development of integrated eLearning and Knowledge Management systems. The specific interaction between the named systems contributes to an integral satisfaction of knowledge need. Though the described synergy, similar approaches are not or only insufficiently given in practice and research [9], [10].
Currently, many different kinds of Knowledge Management Systems exist on the market that support a broad spectrum of functionalities but lack in particular cases an comprehensive approach to meet all requirements of companies. The authors refer to the term of the company memory, which is supported by an Organizational Memory System (OMS) [11]. Scientific papers, which deal with the embedding into the organizational and individual working context exist only for a short time. The authors lead the way both in the theoretical pervasion [12], [13] as well as in the use of innovative technologies for context oriented and process bound information gathering and utilization, distributed system services and self organized and adaptive functions [14].
A problem regarding today's *eLearning Systems* persists in the disregard of the active information need of the learner in terms of his daily work. It has been found that it is discouraging the learner, if information that is very present in his daily life is merely depicted by Web Based Trainings (WBT) so that they often fail in creating an increase of benefit. This can be avoided by providing a personal learning unit fitted to the current task context and offering the needed state of knowledge without great redundancy. Contrariwise, *Knowledge Management Systems* can profit from the user friendly, learning goal oriented and didactically prepared presentation of information units. These provide usually only information according to the estimated user's need, whereas standard of knowledge, learning goals and learning units are neglected. Therefore, the drawback of both systems is the missing consideration of the learner's (individual) view on the presented information. A presentation of the content, classified after eLearning categories will complicate the access to the subject from the knowledge management's point of view. A dynamic classification according to the individual view of the learner will remove such barriers.

III. Ubiquitous Administration – Think Mobile?

The future challenge consists of the development of an internet based integration and interaction platform with adequate front ends, that *link eLearning to Knowledge Management Systems* and therefore en-

able the dynamic accumulation of WBTs with up-to-date information in an organizational-specific and application specific way. Beyond that, strategies, concepts, methods and ICT- tools have to be provided, that contribute to the satisfaction of heterogeneous learning and knowledge needs. Mechanisms for the composition of systematic interaction and interchange relations, as well as the creation of effective concepts for the organizational introduction of Knowledge Management and eLearning in the administration will complete the concept.

The outlined approach experiences an expansion by the intelligent distribution of relevant knowledge to the "administrations point of sale". Through the stronger decentralization and dissociation from physical infrastructures, an area-wide information and content supply by interacting knowledge systems, e.g. in the scope of administration wide decision support systems, can take place. In distributed organizations one has to think about a multi channel support with information and flanking education measures, real time information about status of processing and availability as well as other dynamic contents. Intelligent control concepts and tools for the technology supported transfer of current knowledge and education measures to the customer interface, which account for the respective appropriate infrastructure are necessary. The further ambition aims on the flexibility enhancement of the professional life and the local allocation of access to the shared knowledge bases considering the deployment of physical infrastructures and wireless as well as mobile technologies. To present the multi-channel capable learning content on various devices, current mark-up-languages like XML are being used.

The knowledge distribution to the customer causes an integration of administrative internal and external, customer oriented process flows and supports the understanding of transaction oriented cause-and-effect relations. As an example, the flexible knowledge distribution on the basis of an improved technology support provides relevant information to the administration officer enabling a faster internal decision making as well as a shorter response time to stakeholders. This generates added value for the customer and contributes to a higher customer satisfaction. Contrariwise, their needs can be detected and documented systematically. In effect, administrative processes and services can be better adapted to customer needs, the "Quality of Service" will be improved as a whole. Consequently, direct effects on the efficient implementation of administrative processes according to the intentions of eGovernment will be realized [15].

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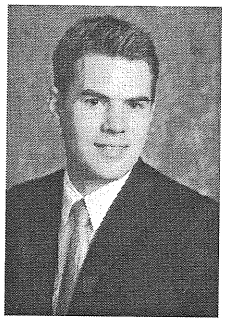

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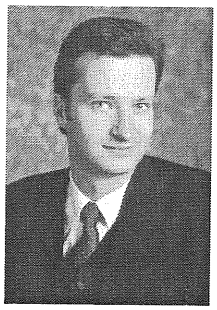

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TECHNOLOGY ENHANCED LEARNING IN EUROPE'S 21ST CENTURY

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Abstract: **Recently companies discover their employees knowledge as one of the major critical resources they need to have for successful business. Advances in technology enhanced learning provide the necessary means by which companies and employers are able to maintain and grow their knowledge assets. This being recognized by the EU several main objectives have been identified and will be tackled in the network of Excellence in Professional Learning proposed in the 6th EU framework programme. The objectives are critical for advancing the state-of-the-art and ensuring the European leadership in technology enhanced learning thus will be pursued by integrating European research in the Network of Excellence.**

Index Terms: **Technology Enhanced Learning, eLearning, Professional Learning, R&D, outreach to industry**

I. EUROPE'S NEED TO RESTRUCTURE RESEARCH ON TECHNOLOGY ENHANCED LEARNING

The remarkable developments of the still-dawning Internet Age have left an indelible mark on modern business organization. In today's knowledge economy, information and human capability are as much required raw capital resources as land and machinery were during the agricultural and industrial ages. Technology Enhanced Learning and eLearning are the means that enable companies to prepare for and succeed in this challenge by providing their employees with the ability to constantly learn, discover, create, capture and exploit. The best way to successfully move an existing enterprise forward includes continuously creating and sharing new knowledge within the organization.[1] Thus, at the heart of most innovations lie the two major activities collaboration and learning.

According to recent studies, up to now, the United States can be seen as a trendsetter of how fast eLearning as a new form of education will prevail. US enterprises already invest 20 percent of their budget (13 Billion US-$ out of 66 Billion US-$) for professional education in eLearning activities.[2] A similar trend becomes apparent for Europe, too. According to researches of the Gartner Group, the European market of corporate eLearning had a capacity of 829 million $ in 2001, and it will grow to 7,4 billion $ till the year 2004.[3]

In spite of the existing need that is shown by these figures, it has repeatedly been reported that the actual impact of R&D on learning technologies remains quite limited, leading to the situation that few R&D results are picked up in actual practice. One of the major reasons for unfortunate situation is that researchers in this field are scattered in isolated communities, with often a very limited awareness of each other. In order to really advance the state-of-the-art and to realize a substantial impact on the practice (especially in corporate settings), research institutions and individual researchers must exchange their results in a more effective and efficient manner – within the R&D community as well as with practitioners in the business world. This is all the more relevant as Europe has a strong position in R&D in this area, as

recognized by the numerous references some of the more successful US based initiatives include to initial European achievements. But this leading position in isolated R&D efforts is not translated in a strong impact on the field in general.

II. Areas of Research

In order to fully capture the complex field of technology enhanced learning, the domain has to be split up into different working areas. Categorized into seven different areas, research within the next years will focus on:

- **Personalized Adaptive Learning**. Personalization is a key aspect in advanced technology enhanced learning environments to support ubiquitous, experimental and contextualized learning and virtual collaborative learning communities. Learning material of all kinds will be adapted to in order to satisfy the personal needs of the single learner.
- **Interactive Media.** eLearning can provide a much more interactive experience for the professional learner than the traditional book or training lecture. Learning is an interactive and constructive process and therefore has to aim at learning experiences that leverage the learner's interactions.
- **Online Experimentation.** Active working with artefacts and problem solving helps learners to acquire applicable knowledge that can be used in practical situations. Active learning by means of virtual and remote laboratories aims to provide distance education students and professional learners with hands-on experiences in first class experiments without the need to leave their workplace and travel.
- **Learning Objects, Metadata and Standards.** Another focus in research is the notion of reusable multimedia content components, called "learning objects". By developing and employing appropriate standards, the reuse of such components leads to important savings in time and money, and enhances the quality of digital learning experiences.
- **Brokerage Systems and Learning Management.** Today's technology enhanced learning landscape is characterized by a huge number of heterogeneous content and service repositories. The existence of brokers or marketplaces which integrate the existing repositories, thus creating completely new services, will be extremely beneficial for enterprises (especially SMEs) whose success relies on a workforce educated to the best-possible standards.
- **Business Models, Processes, Markets.** As the demand for access to E-Learning services is growing rapidly, it is increasingly important that sustainable business models emerge for market players, such as service providers, users, policy makers and market regulators. Also, the focus will be on reference models for organisations deploying technology enhanced learning. Those models address issues such as corporate learning strategy definitions, requirements analysis, integration processes, financing and allocation of funds (esp. higher education institutions), definition of learning scenarios, knowledge transfer and corporate learning.
- **Knowledge Work Management.** European companies depend more and more on their intellectual properties than on their physical assets, often specializing in knowledge intensive products. Work processes have to be targeted as enablers for professional learning. Also the knowledge community has to aim for learning arrangements taking into account both knowledge workers, organisational processes and appropriate infrastructures.

III. Objectives

Activities in technology enhanced learning will consist of a set of 'horizontal' and 'vertical' working areas. The vertical dimension as shown in chapter II will have to advance the scientific understanding of each working area by carrying out research and development. By complementing the vertical dimension, the horizontal dimension has to support collaboration, exploitation, and dissemination of research results with and into corporate and educational institutions. The need for integration of research efforts within research and towards practice can be summarized under the three dimensions scientific, technical, and socio-economic objectives.

A. Scientific Objectives

- **Objectives for Applied vs. Theoretical Science.** As it is essential in this field, the vertical working areas embody a mix of applied and theoretical science. For example, one of the theoretical scientific objective will be the development of new pedagogical models for e-Learning and mobile learning. However, this theoretical work must be implemented via a significant applied scientific advance in the interoperability and modularity of learning management systems together with a simplification of the authoring process.
- **Objectives for Technical vs. Social Science.** Alongside technological scientific advances, critical social and pedagogical approaches will also be emphasized. None of the technologically focused work can advance the state of European

science without a full understanding of the social and pedagogical context of its application.

- **Objectives for Public vs. Academy Science.** Scientific research results will have a major impact on society changing the way eduction will be carried out, thus are of significant public interest and will also have to be considered (e.g. the impact of electronic and mobile learning on society resp. specific target groups with different needs).

B. *Technical Objectives*

Research in the next years will improve access to knowledge and educational resources (including cultural and scientific collections) and generate new forms of cultural and learning experiences. The following technical issues will have to be addressed:

- The R&D on personalized adaptive learning, brokerage systems and learning management will contribute to the development of personalized adaptive systems and services for contextualized learning. Furthermore new systems for "learning" marketplaces will emerge enabling a simple and successful "trading" of learning material and services.
- Equally important is the application of knowledge-based approaches to realize the adaptation of the learning process to the end user. The main idea here is to enable different ways to "mine" the learning object space for those resources that are relevant to a particular user.
- The R&D on interactive media and educational laboratories will facilitate the development of rich content that will truly engage the learner and will support him in linking his conceptual models with realistic phenomena. True interactivity with real and simulated (virtual) feedback will provide realistic learning situations for learners.
- Through initiatives such as ARIADNE foundation [4] and others the development of an open learning object infrastructure will be extended. By actively participating in standardization committees at DIN, IEEE and ACM the European point of view will be significantly promoted.
- The notion of semantic interoperability between learning objects, repositories of such objects, the services, and the underlying technologies will allow for hybrid architectures to integrate more traditional client-server approaches in more novel and flexible paradigms that rely on advanced technologies like semantic web technologies and peer-to-peer. The emerging web services approach will be relied upon to reach this goal.

C. *Socio-economic objectives*

The rapid development in ICT is having a fundamental impact on employment, skills, work patterns and company structures within Europe. The field of technology enhanced learning is contributing to strengthen the investment in human capital by providing access to learning resources and services more cost effectively, efficiently and conveniently to individuals and companies. Workers and employees of enterprises and public organisations are considered the main user groups and also the final beneficiaries. This covers a large group of citizens at various stages of their lives.

For the European economy to be successful, the workforce must actively participate in life-long learning, the employees need to keep personal development plans because the needs are constantly changing and the employees need to be even increasingly multi-skilled. At the Lisbon European Council (March 2000), the EU strategy was designed to enable the European Union to regain the conditions for full employment and to strengthen cohesion by 2010. In order to contribute to the employability and adaptability objectives under the European Employment Strategy [5], research institutions will have to focus on new developments that rectify the shortage of skills associated with the new technologies and improve social inclusion.

Current EC policy documents emphasize the danger of division of the Information Society in the information-rich and the information-poor citizens, also referred to as the „Digital Divide". Availability of appropriate training for everyone helps to promote digital literacy and to overcome the risks of a societal splitting. The objectives of the various research activities are aiming at finding new solutions to the needs of all corporate workers and employing companies, not only the digital literate ones. The area of personalized adaptive learning for example is focusing on the different aspects on how to provide the right tools for the specific users.

IV. PROLEARN: A EUROPEAN APPROACH FOR INTEGRATION

Within the first Call of the European Sixth Framework Program the Learning Lab Lower Saxony (L3S) and the Institute for Information Systems (IWi) at the German Research Centre for Artificial Intelligence (DFKI) have proposed a Network of Excellence (NoE) for the integration of R&D and practice in Technology Enhanced Learning. The proposed network "Professional Learning" (PROLEARN) focuses on two key issues for future eLearning scenarios and contexts, namely state of the art technology enhanced learning resources and the use of these learning resources for professional training in SMEs and larger companies. The network will advance the state of the

art in learning resources in the key areas personalized adaptive learning and interactive media, with learning resources connected to real-world settings and reusable in different contexts. Furthermore, it will investigate and advance issues especially relevant for professional training in enterprises, including brokerage platforms and services, business models for specific markets, and advanced eLearning and knowledge work management arrangements.

To accomplish these goals, PROLEARN brings together the most important research groups in the aforementioned areas, as well as key organisations and users, thus bridging the currently existing gap between research and education at universities and similar organisations and training and continuous education that is provided for and within companies. Through the PROLEARN awards, best practice examples, show cases and workshops the network will advance European professional training in technology enhanced environments, and through roadmaps and policy guides it will chart and analyze future trends relevant for future professional training tools, environments and scenarios.

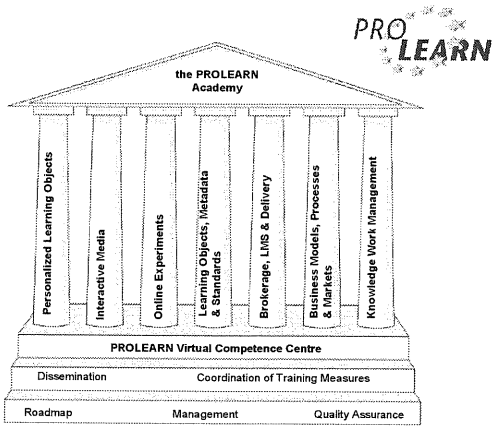

Figure 1: Network of Excellence Professional Learning

PROLEARN has set up a 'Joint Programme of Activities' that focuses on large scale research cooperation and coordination in the context of a PROLEARN 'Academy', setting up a virtual research center comprising all consortium members, as well as on exchange and transfer activities especially with industrial partners in the context of a PROLEARN Competence Centre. It will integrate existing and future activities of the NoE partners, and ensure the critical mass necessary for mutual complementary exchange of technologies, tools, experiences, and scenarios.

V. Conclusion

As mentioned above the "Lisbon goal" of the European Commission for the next years is to become the most competitive and dynamic knowledge-driven economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion.[6] By means of various initiatives such as eEurope and eLearning [7] the European policy makers defined a number of strategic actions that are necessary to reach the challenging goal. One of the main Community levers for the implementation of the eLearning Action Plan is the IST program.

Apart from clear compliance with the IST strategic objective of "Technology enhanced Learning" PROLEARN is also very much in line with the EC policies and is contributing to the implementation of the eLearning initiative and thus in the broader context also to the eEurope initiative. The eLearning initiative, which was presented by the EC on March 2001 developed an action plan that clearly places emphasis on the deployment of content, services and learning environments which are sufficiently advanced and relevant to education in terms of both market and public sphere.

Summarizing the objectives in chapter III it can be concluded that the PROLEARN Network of Excellence will be actively contributing to the implementation of the goals of the Copenhagen Declaration adopted by the education Ministers of 31 European countries and the EC in November 2002.[8] The declaration has been developed within the perspective of lifelong learning and focuses on the design of common European tools to support the use of vocational training opportunities. Vocational training at the workplace, which has to be tackled by the research community, is one important aspect in the Bruges-Copenhagen process.

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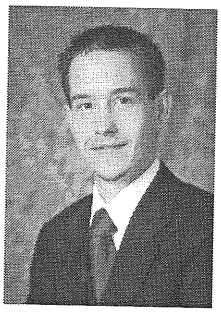

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