39. Workbench: A Planning Tool for Faster Factory Optimization

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A key requirement for a successful facility planning and design is to become suitable for new use as well as to be adaptable for new products, technologies or capacities. The software solution "Workbench" is designed for an Information Infrastructure System for the planning of large logistics networks as well as for the network structures of the facilities in an enterprise. The "Workbench" ensures a better information flow and basis for Factory planning and enables planners without great expert planning knowledge.

Keywords: Logistics and Production Network Structures, Knowledge Management, Facility Planning, Supply Chain Management, Business Process Reengineering

1. INTRODUCTION

In today's competitive global markets, facility planning has taken on a completely new meaning. In the past, facility planning was primarily considered to be a science, today it is a strategy. Companies, institutions, and businesses no longer compete against each other individually. These entities now align themselves into cooperatives, organizations, logistics networks, associations, and ultimately synthesized supply chains to remain competitive by bringing the customer into the process. In future real competition will happen between large logistics networks and not between enterprises anymore.

The method project M6 "Body of Construction Rules ", Collaborative Research Center 559[84] Modelling of Large Logistics Networks, which is financed by the German Research Foundation (Deutsche Forschungsgemeinschaft DFG), designed an Information Infrastructure System called "Workbench" for the planning of big logistics networks. The fundamentals of such networks are the plants and stores with the material flow and intralogistics. For six years now scientists from the fields of Logistics, Transport Engineering, Warehousing, Industrial Management, Factory Organization, Mathematical Statistics, Theoretical Informatics, Applied Computer Science and Systems Analysis have been working on joint research projects that ensure a wide range of interdisciplinary competencies.

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»Large Logistics Networks« exist where different goods or products are transformed and transported over several stages by different cooperating partners. They do not only include material and information flow, but also the organizational framework, the required resources, policies for planning and control, as well as the people acting in this environment (Beckmann, 1996). All partners in these networks provide multiple, but also complementary services or competencies. The components of these large logistics networks (organizations, resources, goods, information, knowledge etc.) are connected by numerous different relations (Kuhn, 1995). The number of connections is growing permanently, because there is an increasing demand for more competitive products or services that can only be satisfied by cooperating with powerful partners within these logistics networks (Beckmann, 2000).

Factory or facility planning can only be successful, if the structures are able to handle the logistics and manufacturing processes. To guarantee the business processes and to achieve the necessary performance of the factory the layout structures of facilities have to be designed in different alternatives and tested to get the solution closest to optimum. It should be mentioned, that factory or facility planning, as addressed in this paper, includes broad fields of application (production plant, warehouse, retail store). The already developed information Infrastructure System and knowledge management application “Workbench” is very useful for the planning of facilities or any portion of these. Factory planning uses a great deal of methods, empirical and analytical approaches. It is important to recognize, that contemporary concepts consider the facilities of a factory as dynamic entities. It is a key requirement for a successful facility plan to become suitable for new use as well as to be adaptable for new products, technologies or capacities.

The major benefit of the new construction method combined with an Information and Communication Technology ICT support, introduced in this paper, is the reduction of complexity, which is achieved by construction catalogues combined with best practices for organizational and technical design questions. The presented catalogues lead to reuseable construction elements in configurable networks which depend on changing frame conditions

2. CHALLENGES OF LOGISTICS NETWORKS DESIGN AND FACTORY PLANNING

The facilities we plan today must help an organization to achieve Supply Chain Excellence by a plant on demand. The plants on demand have to be designed and controlled in correlation to the logistics network (supply chain), the material flow, and the production processes. The high tech production processes, the permanent changing and improvement of technologies, and the complex logistics system are drivers of change for the innovation targets in factory planning and logistics network design.

These are the reasons for Factory planning and logistics to steadily grow more complex to be faster nowadays. Facility Planning is no longer a unique process at the start-up of an enterprise. Rather facility management is changing to a permanent planning based on a successful strategy to survive in the fast changes of competitive markets. Whereas it becomes more and more difficult for planners and operating companies to keep the overall views over these difficult and complex planning tasks.

Today it is impossible to plan a big factory or a large logistics network by only one general planner. Instead we need a network of specialists to solve these high complex planning tasks in logistics and production networks.

At the present time, we lack the experience of methodical construction processes that link organizational aspects, like network policies and value chain design, with technical aspects of information exchange and material flow. Most companies are in search of new instruments and technologies to extend their knowledge of setting up new processes, facilities and of designing organizational aspects like network strategies and policies, organizational structure, information flow, and performance measurement metrics.

Knowledge has become a main guarantor for market excellence, especially in high tech and service industry. Far from that, business partners face a growing lack of guidance through all the information avail-able. The challenge is to determine which information is relevant for whom and how to provide them with this information in different situations and planning phases of given projects.

The ultimate goal of the study of the structures of network structures is to understand and explain the workings of systems built upon these networks.

The progress in the state of the art of research for a better understanding of network structures is slowly growing in different faculties, like in chemistry (Fox, 2001), biology (Dune, 2002) and the information technology (world wide net) for example (Ebel, 2002), improving also the understanding of the effects of those structures.

3. THE GENERIC ARCHITECTURE OF WORKBENCH

This paper proposes a new approach to engineering logistics and network oriented facilities. The engineering methodology for planning tasks and aspects of facilities is achieved by using process models (Kuhn, 1995), project reference models (Kühling, 2000), and construction catalogues (Wiesinger, 2002) in combination with best practices for organizational and technical design questions. The facilities are not only planned as a physical object, but rather as process oriented and process fulfilling dynamic, adaptable and reusable modules for the following product generations.

The paper will also show how using the software tool “Workbench”, which provides alternative construction objects for different network structures, with changing capacities of processes in construction catalogues, can accelerate and improve the design process in facility planning. The technical concept of “Workbench” is a content management system which has been qualified for the specific needs of logistics engineers and facility planners by using UML specifications. The presented solution will show how new Internet based technologies will support the network design process.

This new approach to engineering logistics network oriented facilities will lead to the reduction of complexity and to a change from planning based on personal experience to a knowledge based information system for a planning on a new level.

3.1 The Process Chain Model of Dortmund University

The elementary model of logistics systems as the “germ cell” of logistics networks is the Process Chain Model from Prof. Kuhn (Kuhn,1995).

In recent years the Process Chain Model has been proven to be successful in more than 50 business-reengineering projects in the automotive, manufacturing, process, and food industry. The components of the Process Chain Model reflect the design parameters like policy, process, structure, and flow. The paper shows how the elementary model has been extended by a construction method for logistics systems that guides the engineer through the design steps in order to structure design questions and to link them with the construction catalogues.

Designing facilities in logistics systems requires both the modelling of static and dynamic aspects. The concept of the »Process Chain Model« (compare Figure 1) is based on the system theory and basic principles of cybernetics.

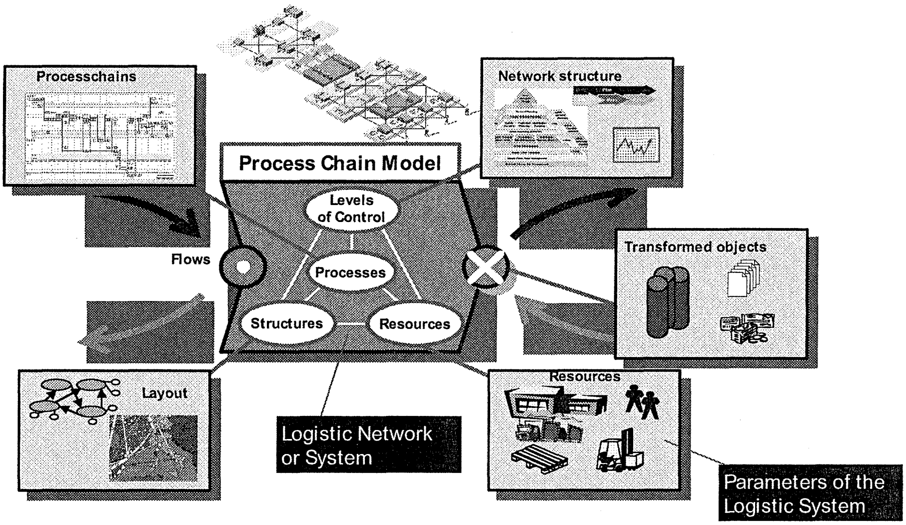

Figure 1 The Process Chain Model of Dortmund and its Parameters for the Modeling of Logistics Systems

Therefore it is suitable for the process oriented modelling of logistics systems that they can be characterized. Besides other modelling concepts the main goal of the Process Chain Model is to integrate both, technical as well as organizational aspects. The core object of the Process Chain Model is the »Process Chain Element« and its five different parameters »Levels of Control«, »Processes«, »Structures«, »Resources« and »Flows«. The Process Chain Element represents a logistics system on different levels, e.g. a whole company, a warehouse, a department, a distribution network, or a business service covering all aspects which are relevant for logistics. Each parameter of a Process Chain Element can be visualized and documented by a number of methods. The most important parameter of a Process Chain Element is »Processes«, which can be modelled by a generic business process diagram suitable for the modelling of material and information flows between different organizations. Exemplary processes may be Material Delivery, Order Scheduling or Component Assembly. The other parameters, as described above, can also be modelled following rules based on experience. All the modelled objects of different parameters are linked with each other.

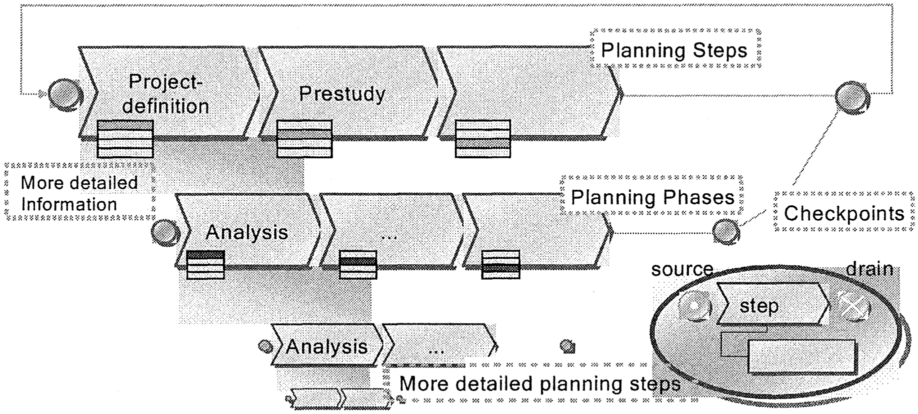

Figure 2. More detailed process chain models

3.2 The Process Reference Model of Dortmund University

Logistics and Facility planners use more or less complex or specified project templates or reference models for their design tasks. Examples are methods for facilities planning, software engineering, or business process reengineering. All of them use equal concepts and most of them can be transformed easily from one to the other. However, existing reference models lack important features like flexible structure, flexible checkpoints, or quality gates between different steps, as well as links to other objects like planning data, methods, or construction elements.

For a more extensive use of systematic concepts in logistics or facility design projects the existing models have been extended to this reference model. It is structured into the following phases »Problem Identification«, »Preparation«, »Master Planning«, »Detailed Planning«, »Prototyping«, »Implementation«, »Improvement und Controlling« (Fang, 1996) (see Figure 3).

The existing research, particularly in the domain of engineering, economics and informatics, has shown the need for the development of an integrated reference model for designing processes in logistics as starting point for a model-based planning approach. The reference model presented fulfills the following requirements:

- Generic model of a standardized documentation of design processes in logistics
- Guidelines for specific design tasks in all steps and phases
- Allows individual iterations and leave outs following the »Evolutionary Prototyping Process«
- Modular (phases, steps, activities; checkpoints etc.) and self similar
- Applicable for all kinds of logistics and facility design projects including technical, organizational aspects etc.
- Links to other components of the framework: data, methods, construction elements etc.

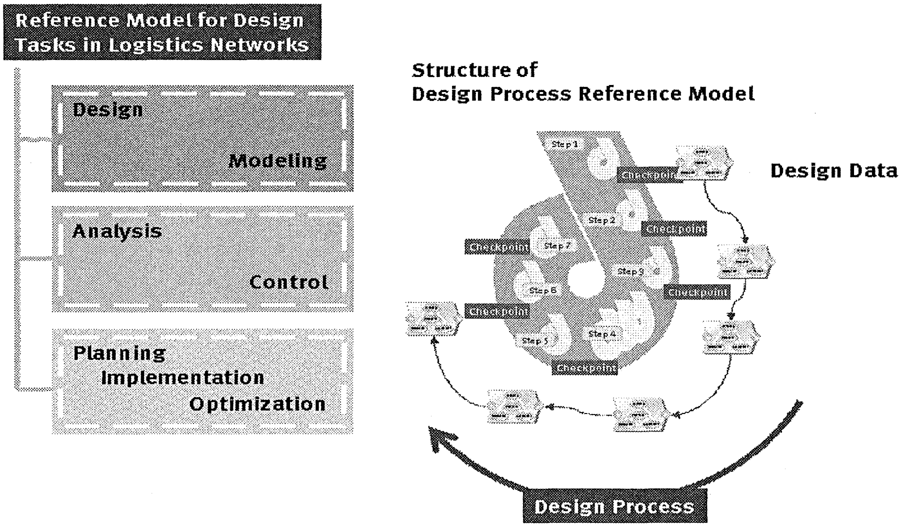

Figure 3. Design Process Reference Model

During the different phases the designer has to solve different planning tasks, which are rougher for example in the first planning phases and more detailed in the final realization planning. The modularity and the self similarity of the "Design Process-" and the "Reference- Model" results from the structuring of multiple design processes especially in the detailed planning phase. To solve a complex design task (for example the planning of a distribution concept for a specific sales channel) a huge number of detailed problems have to be solved, like warehousing, transportation management, structure of distribution network, communication standards etc.. These problems can be divided into independent, but related projects. They also can be described by using the same reference model, taking into account all relevant interfaces between the different levels. In other contexts (different superordinated project, different project focus, other partners etc.) all projects stand for themselves and can be started independently. Therefore, logistics planners gain profit in both situations.

Every phase or step of a project modeled using the reference model represents a complete unit with fix requirements and expected results, so that every participating planner knows its input data, course of activities, and out-put. Within a project the defined checkpoints or milestones have to be fulfilled.

An additional result after performing a project in that way is a newly modelled and documented prototype of a logistics or facility planning project. Examples for such projects are: Development and Implementation of a Postponement Strategy, Direct Delivery, Collaborative Demand Planning, Planning of a Warehouse, Customizing and Implementation of a Shop Floor Control System, Planning of the material flow in a layout, or Implementation of a B2B procurement scenario. All these project examples follow a generic structure placing emphasis on specific project steps and requirements.

3.3 Method Toolbox

A further benefit of the developed project reference model is found in the integrated concept of the method toolbox. It makes a specific adjustment of the design methods possible by taking into account specific project goals and the given situation. The overall structure of a project can be documented by using the project reference model. In detail, the solutions of partial problems can be achieved effectively by using manageable but systematic methods. Usually, the application of a single method is not sufficient in order to solve a common problem in logistics. Therefore on a lower level the project reference model has interfaces to specific methods to describe the solution of certain problem solving tasks. This microstructure allows a flexible composition of different types of existing methods and other related project steps.

Workbench contains helpful techniques for structuring and sorting the knowledge contents. The two most important techniques are categorization and cataloguing.

Categorization: The category system helps to ontologically classify comprised knowledge objects. The system is equipped with main categories as so-called roots, which orientate by the knowledge objects of the work-bench. Therefore, the roots methods, model elements, planning tasks, and project steps do already exist. The category system allows associations between the individual categories.

Cataloguing: In addition to that construction catalogues can be de-fined. Functions and elements of a catalogue are frequently used in systems, which are to be designed differently. The catalogues can be subdivided into a pattern part with systematizing classification characteristics respectively and further attributes.

Successfully proven modeling elements like methods, construction elements (Wiesinger, Laakmann and Hieber, 2002) and design process patterns (Kühling, 2000) will extent the knowledge base of the Workbench.

3.4 Construction Catalogs and Construction Rules: Level of Modeling and Examples

Construction catalogues can also solve certain organizational problems, which are selected, sorted, and structured problem-specific for the documentation of exemplary solutions in the context of organizational architecture. Construction catalogues are manually manageable information memories, which are adjusted to the parameters of the Process Chain Model, the project reference model, and the method toolbox. They are structured systematically and each element has additional characterizing attributes. By using this structure, the planner has access to the content of the construction catalog, represented by the construction elements. Every decision for selecting a construction element follows a systematic procedure, so it can be reconstructed from every following project step.

With a catalog as documentation form, research has a suitable tool for documenting results and experiences for practical use. This meets the requirement for an extendable repository for the different fields in logistics. Examples of converted catalogs within the range of camp planning are de-scribed by Fang (Fang, 1996).

3.5 Collaborative Knowledge Workbench

The practical use of reference models during the logistics planning shows that their application and the quick and straight access to the knowledge is a sophisticated and time-consuming activity. Today, the support of the model-based project execution by information and communication technology (ICT) is a critical factor for the success of this concept. The efficient co-operation of all planners in a project for the design of certain fields of Large Logistics Networks or a complex factory planning needs an integration plat-form. Important features of ICT are the administration and management of the information objects and their links, the workflow management, project management and documentation. A collaborative Workbench allows the connection of all components of the modeling framework presented in Figure 4.

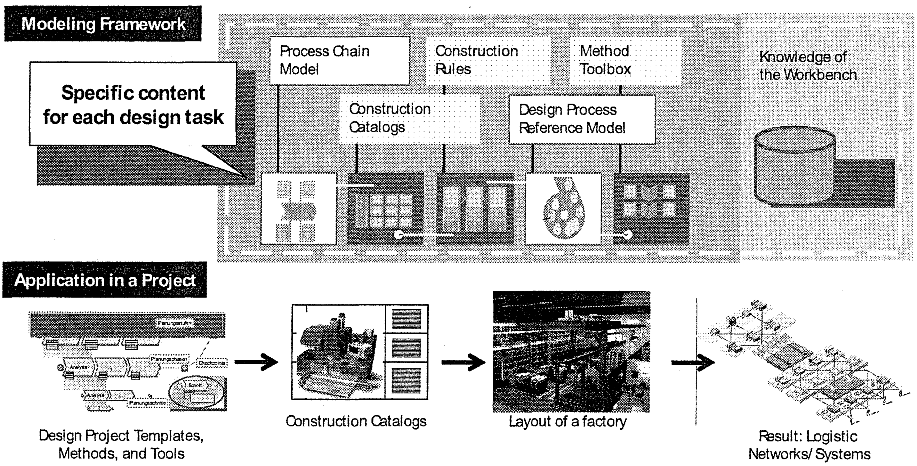

Figure 4. Modeling Framework and Application in a project by the "Workbench"

The technical background of the collaborative Workbench is based on a content management system, which is qualified for the specific needs of logistics design projects. With the widespread use of the Internet and the opportunities of e-Business and web services the technical concept has already been outlined. A substantial component of Workbench is the modeling and configuration of individual design projects based on the predefined patterns. Other modules of Workbench allow the planners to identify relevant planning data for certain steps, the documentation of results and the availability check of all required project outcomes. By using this structured and unified modeling framework, the process modeling language and the approved concept of construction catalogs will simplify the design of components of logistics networks.

The general procedure for logging on knowledge has proven to be successful in the past. It is structured into several steps and does not exclude iterations. Because it was presented at the DIISM conference in 2002 (Wiesinger, 2002)(Wiesinger, 2002a) this reference procedure will not be explained in detail again.

4. ARCHITECTURE OF THE "WORKBENCH"

Based on the described design architecture, the Dortmund LFO implemented collaborative Information- and Knowledge- Management system "Workbench", a computer aided application. The planning tool "Workbench" is able to pre-process the planning knowledge with the most important planning aspects by using the planning knowledge of already realized projects. By using these experiences in a structured knowledge management system for future planning projects, the planning is getting on a to-tally new dimension. The modular description of building, construction, manufacturing, and planning steps, which are the aspects of the service pack-ages, enables the planner to manage the current planning task by using the experience of projects already realized by the explicit knowledge of the Workbench. "Workbench" is an intelligently linked database, subdivided into knowledge categories, which are important for the respective project tasks. As there are for example strategies, processes, methods, design aspects, and so on (see Figure 6). This tool provides useful assistance during the planning and optimizing phase of logistical networks. As a particularly user-friendly and internet-based system it supports the execution of logistical planning projects. Furthermore it can be used for cross-linking the partial projects of SFB by correlating the main results within the platform.

The access to this form of knowledge database helps the planners on the one hand to coordinate their work and on the other hand to accelerate the exchange of data and information in order to improve and speed up the whole planning process. Furthermore it helps to support all processes and phases within the whole product life cycle as an integrated system and thus provides high flexibility, utmost cost saving potential, and a great deal of up-to-dateness to the manufacturer.

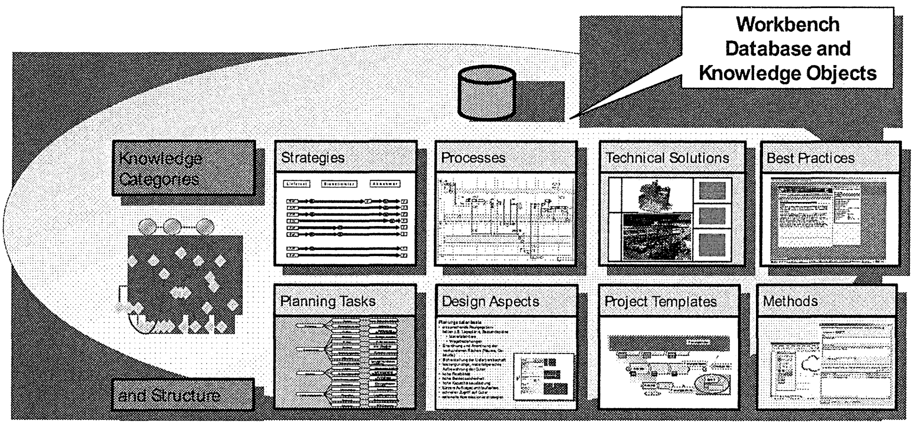

Figure 5. The planning aspects handled in the Workbench

The planning knowledge contained in "Workbench" is filed into so-called knowledge objects, which can be combined to knowledge object groups. The term "knowledge object" illustrates that planning knowledge can only be integrated into the data processing system when it is described in detail according to formal guidelines (compare figure 6). The following knowledge object groups are used in the Workbench system for user administration: "classifying knowledge objects" (category system, construction catalogues), “knowledge objects for description of logistical systems” (model elements, attributes, and planning parameters), “project related knowledge objects” (planning tasks, processing models, and project steps), and further data objects.

The planning tasks, as terms of reference for planning projects, were also included into the Workbench. Planning tasks are the starting point for further knowledge objects, which can be networked problem-specific, for example planning targets, planning aspects, planning data, or processing models.

The result of our efforts is a construction kit for planning large networks in logistics as well as network structures of a production layout plan. Standardised model elements were set up, which serve as generic term for several knowledge objects. As model elements real objects were set up (resources) as well as abstract facts (concepts, strategies, processes). The differentiation of model elements was done by means of the classifications according to the categories and catalogues mentioned above.

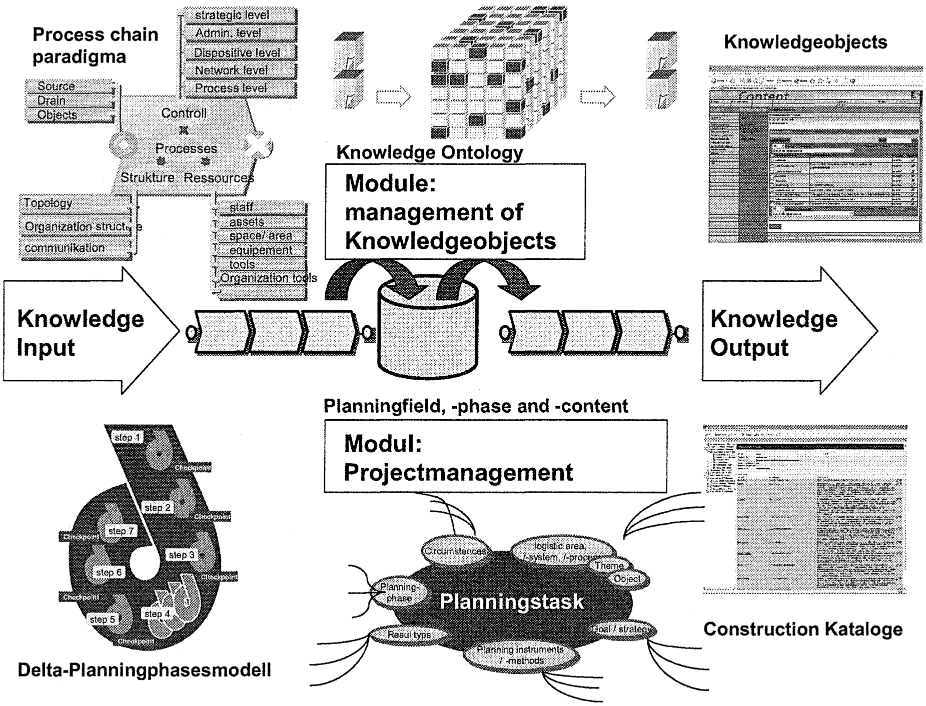

Figure 6. Input and Output of the Knowledge management system "Workbench"

In retrospect we succeeded in designing a platform for supporting planning, modelling, and optimisation of logistical networks and to fill it with basic contents, which will allow access to as well as networking of knowledge of processes, structures, and resources.

5. CONCLUSION AND OUTLOOK

Different industries require a common demand for a concept or tool for the big challenges of global markets to a permanent readiness for strategic innovation projects and derived facility planning activities. The author led a study of the BMBF "Faster ramp-up processes for production systems" in 2002 in Germany. This study examined and analyzed the methods, instruments, tools, simulation concepts, modelling concepts, and the general state of the technology of relevant industry partners in automotive, electronic and mechanical engineering branches. The result of that study was an urgent need for supporting tools, instruments and methods to accelerate and ascertain the ramp up phase in serial production industries (Kuhn, 2002).

The rapid product lifecycles and the efforts of a shorter time to market and time to customer (Wiesinger, 2001), needs in future more Ramp Ups of serial products than we have today (Wiesinger, 2002b). This greater amount of Ramp Ups should also be realized in a shorter time, because only in the starting phases especially high tech product can achieve highest prices in the market (Wiesinger, 2002c). The slower competitors will lose these valuable gains of the first phases because of the saturation of the market and the following product generation of the high tech product (Wiesinger, 2001). "Workbench" as a powerful Knowledge Management Tool can be used to manage a faster ramp up to achieve a shorter time to customer.

The Dortmund SFB 559 (SFB559, 2004) owns a unique pool of logistical and planning knowledge. The manifold findings and experiences of methods and application projects of SFB 559 resulting from interdisciplinary experience should be edited and documented for future research and utilisation by planners.

The Workbench of our partial project M6 allows documenting the findings and experiments in a knowledge management system in a structured and user-friendly way. The enormous amount of explicit and implicit planning knowledge acquired by SFB 559 can now be structured and documented by the design architecture of partial project M6 without a loss of their dependencies mutual influencing. The intelligence of the logistical net-work, so to speak - will not get lost in the knowledge management system.

The focus of the works of the just now appropriated third SFB phase till 2007 is supposed to be put from the development of a technical solution to the utilisation of the design environment. The existing registration system concerning integration and processing of real planning knowledge can be used by the generalisation of this knowledge, leading to standardised contents which are available for reuse.

The main target of the project is to continue the collection of knowledge, either already existing or still to be gathered, to create a complete and viable platform which can be used project-specifically. For this purpose the knowledge has to be documented, structured, and finally networked intelligently by means of the design architecture and Internet based data processing support developed by M6.

Acknowledgments

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