INFORMATION MANAGEMENT REGARDING THE PRODUCTION OF PRECAST CONCRETE STRUCTURES

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ABSTRACT

In this paper a process and information model with respect to planning, production, transport and assembly of precast concrete structures, in connection with actors in the precast industry, is described. The model shows the information flow between the involved operators, and between the basic parts that make up the overall process in regard to production of precast concrete structures.

With this survey as a starting point, comparisons are made with other industrialised businesses and modern information technology. Possibilities and problems in the information management are identified. Potential rationalisation gains in the information flow within the individual parts are set against the benefit of the whole in the overall industrialised process of precast concrete structures.

A future process and information model is described. The model focuses on ICT (Information Communication Technology) support concerning both the individual parts in the process, like CAD support and design software, and ICT for process support, like project networks and product model servers. Moreover, the model also includes chosen parts of ICT-applications from the manufacturing engineering industry that can be applied to the precast industry.

Conclusions are drawn as to how the ICT-support must change if larger efficiency improvements are to be reached.

KEY WORDS

Industrialised construction, precast concrete structures, information management, project network, product model servers

INTRODUCTION

BACKGROUND

In the Swedish construction sector, increased interest is focused on the industrialised construction process. The hope is that investments within this area will lead to greater efficiency, higher profitability, better quality and reduced life cycle costs (SOU 2002:115 2002).

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Within all industrial processes, information technology plays an important part. Today ICT represents one of the strongest changing technologies. Investments in ICT, in for instance the vehicle industry, have made large efficiency improvements possible.

However, investments in ICT when it comes to industrialised construction processes have had the character of isolated islands rather than support for the entire process. To gain increased efficiency improvements in the area of industrialised construction, the ICT support must cover the entire process from the initial stages to maintenance. The conrete precast industry is here of particular interest because it plays a major role in the Swedish and Scandinavian construction sector.

This paper is part of a research project whose object is to formulate an interaction model (for processes and information) regarding the process of precast concrete structures. The paper describes a survey of the process, product model and ICT system of a leading manufacturer of precast concrete structures.

OBJECTIVE

The objective with this paper is:

- Review a state of art regarding information management for the precast industry
- Through a case study present a process description of the activities in a plant, manufacturing precast concrete structures, including the ICT tools used in the process and a product structure of the precast elements.
- Present a proposal for a future process and information model for the factory involved in the case study

METHOD

By studying ICT platforms, information flow, information content, information structures and the organizational structure of an existing process regarding precast concrete structures, comparing this to other industrialised processes and adding knowledge of modern information technology, it is possible to produce models for a more efficient information management solution.

In the project case, a study will be accomplished to map out and describe the process and the information regarding precast concrete structures. Furthermore, the ICT tools involved in the process will be mapped out, in conjunction with the product structure of the CAD system used to plan the concrete components. Possibilities and problems regarding the information management are identified.

The case study consists of two parts. The first part, shown in this paper, is a description of the overall process and the overall structure regarding the ICT tools. This will be done from a perspective of the plant, i.e. the view from the owner of the process. The second part aims to follow a construction project, from purchase to erected building. In this part of the study, the different sub-processes outside the precast factory will be in focus.

STATE OF ART REGARDING INFORMATION MANAGEMENT FOR THE PRECAST INDUSTRY

IFC PCC

The purpose of project ST3 PCC (Precast Concrete Construction) has been to develop a standard for information exchange for the precast concrete industry. The project is initiated by IAI (International Alliance for Interoperability) and accomplished by The Nordic Chapter of IAI. The latest version of IFC is 2x, and ST3 PCC has been a so called increased domain project. The goal of these projects is to create add-ons to the IFC platform, thereby increasing the level of detailing.

In the project, typical elements have been defined (like columns, beams, structural floor, facings etc.) in a precast concrete framework. The geometrical account of the elements (shape and location) has been defined, as well as connected couplings. The technical solutions are aggregates of concrete, reinforcements, cast in materials etc. Information about boundary conditions and structural loads can also be applied on a component level. The project was concluded during 2003, and the result has been integrated into IFC2x2.

PCSC (PRECAST CONCRETE SOFTWARE CONSORTIUM)

This project is a large-scale venture to integrate design and engineering information technologies in the North American precast concrete industry (Eastman et al. 2003). The project's initiator is at consortium composed of a number of producer companies formed specifically fort the task.

The first step of the project was to formulate process models for each of the contributing companies using a method, developed at Georgia Tech, called PPM (Procecss to Product Modelling). By integrating the collected information from the used process models, a common product model is deduced. This method differs from the prevalent procedure for developing product models, where the main focus is to identify a general and universal process model.

PCSC's second objective for the process models was to come up with a specification of requirements for an advanced parametric 3D-modelling tool for design and engineering. A synthesis of the information from the process models were used as a basis in developing a specification of requirements. Georgia Tech carried out mapping and testing of the applications found on the market. These were evaluated according to the specification of requirements. The final choice was TEKLA, who then has realized the criteria described in the specification of requirements, and released a TEKLA® Structures Precast Concrete Package.

PRODUCT CONFIGURATION IN THE CONSTRUCTION BUSINESS

This project is a Danish research project, and cooperation between Aarhus School of Architecture and The Centre for Product Modelling (CPM), a Danish research institution under the Department of Manufacturing Engineering at the Technical University of Denmark DTU. CPM is dedicated to researching automation of routine engineering tasks in the product specification process, manly for the manufacturing engineering industry.

Within the engineering industry configuration systems are used to handle a large amount of product options to fulfil the customer's demands and needs. With platform thinking and a far advanced modularisation, you can satisfy the customer's various demands. The configuration system is an ICT-tool that, on a basis of the rules applied to the platform and its modules, can specify the product and generate the information needed further on in the production process.

In the Danish project methods (e.g. Loer Hansen 2003) developed for the engineering industry has been used. The method has been tested on several producers of building materials (Hvam 2005), among others Dalton Betonelementer, a company that manufactures precast concrete structures.

Experiences from the project show that producers in the construction business often do not have standardised variants of their building systems. This rule out the standardised configuration systems found on the market, which are suited to configure-to-order where the product is distinguished by standardised components and modules. For products that fall under modify-to-order or engineer-to-order, there is instead need of an ICT-system that can handle geometrics and logic, which reduces the range to CAD systems that support the work process, and that can generate specifications (e.g. construction drawings) and information needed further on in the production process.

IMPACT

This swedish software package is developed by Structural Design Software (StruSoft) for the precast industry. The development of the software started 1990 by Skanska software (now Strusoft) as a commission by Skanska Prefab. The software has been on the market since 2002. IMPACT has been constructed to serve the generation of drawings, bill of quantities and other reports from the design, construction to the production of precast structures. All information in the product model is managed and stored in a Ingress database server.

The system consists of three modules Model, Project and Element. The model is created with objects representing the prefabricated elements and presented in AutoCAD. The project module administrates the entire project and all the product information. IMPACT element calculates and generates the reinforcement and creates element drawings. From this module it is also possible to send data to economy systems and to production systems as planning systems or form plotters via a CNC-file.

ELIPLAN

Eliplan is a finish ERP (Enterprise Resource Planning) system for the precast industry managing functions for tendering, project management, scheduling, material management, quality control, cost calculations, storage management, machinery maintance and manufacturing. The system was developed on the initiative and in cooperation with a leading finish precast producer.

From the system several types of reports can be generated to support the internal process as well as all the documents that have to be distributed to the customer along with the product. All the information handled by the system is stored in a Oracle database. Connected to product determination software like a expert CAD-system all the data like dimensions and material information are transferred to Eliplan and then used for casting programs, truck-loads plans and dispatch lists.

CASE STUDY

A SWEDISH PRECAST COMPANY

The precast company in this study develops, manufactures and sells precast concrete structures for housing, offices, industries and farm buildings. The company has several factories, but the plant studied in this paper is a new one from 2004. The factory is one of the most automated in Europe. The production capacity is 400 000 m² cast area per year at full utilization.

In the factory concrete elements, filigree floors and double walls, are produced. In a building project this production method means that walls and joists are produced at the plant, and then filled with concrete at the building site. No stock is kept at the factory, but production and logistics are guided to deliver the building components straight to the building site when needed, according to the principle "just in time". The components are placed on loading pallets in assembling order according to an erection plan. At delivery the double walls are prepared for installations since electronic boxes, electronic tubes, slevee couplings and recesses are fitted at the factory.

The digital transfer of information between construction and manufacturing takes place via machine file from CAD model, via preproduction engineering to robots in the factory. The production apparatus with robots and advanced control equipment renders possible a production where concrete parts no longer have to be manufactured in long series, or where the production apparatus must be reset for every new type of element. No two elements have to be alike. Thus flexibility is provided, and the production can be adapted according to the customer's wishes. This factors is one of the characteristics that distinguish agile manufacturing (Naim and Barlow 2002).

PROCESS AND INFORMATION MODEL

One of the aims of the case study has been to map out the existing process, in conjunction with the information flow, in the production of precast concrete structures. In connection with visits to the precast factory for the purpose of study, people from sales, construction, preparation and manufacturing as well as people with transport and assembly competence participated.

The method of mapping out the process emanates from a workshop with personnel from all the departments in some way implicated in specification and manufacturing of the concrete elements. One person led the workshop by interrogating the participants about what activities are accomplished by which department, and about the information flow to and from each department. Based on the descriptions of the participants, the survey leader used a whiteboard to gradually draw up a process schedule. The procedure was interactive, since the information flow schedule changed as the participants revised their view of the flow between departments. At the same time an actual description of the plant's information model was conducted.

The result was documented as a process model (see figure 1), and an information model (see figure 2). At the session the sub-processes marketing, design, planning, manufacturing, transport and assembly emerged. A project starts when the marketing department receives an inquiry to deliver precast concrete structures for a building project. The department sends a number of documents, see figure 1, to the projecting department. This material is delivered analogically on paper.

Product determination of the double wall elements and filigree floor elements are made in IDAT (AcadWand and AcadDecke) from Germany, a CAD system developed for the precast industry. For increased flexibility the plant has also adapted its ICT structure (see figure 3) to enable projecting with the Stomkon and IMPACT systems. This makes it possible to buy projecting from designers with access to these systems. The actual CAD systems are object oriented expert systems. They handle the rules and limitations which controls the specification of the concrete elements, including electronic tubes, cast in goods, cable lifts etc. All the systems are developed with AutoCAD as platform, and thus are not parameter-controlled CAD programs. Both IDAT and IMPACT are systems to buy on the market. Stomkon is not for sale and is a system developed and owned by a consultant company.

When the elements are specified the system generates a machine file. For this to be possible the CAD system must be adjusted to and work together with the production control and monitoring system. The projecting department receives basic data digitally from architects and installation contractors in the form of dwg- or plt-files.

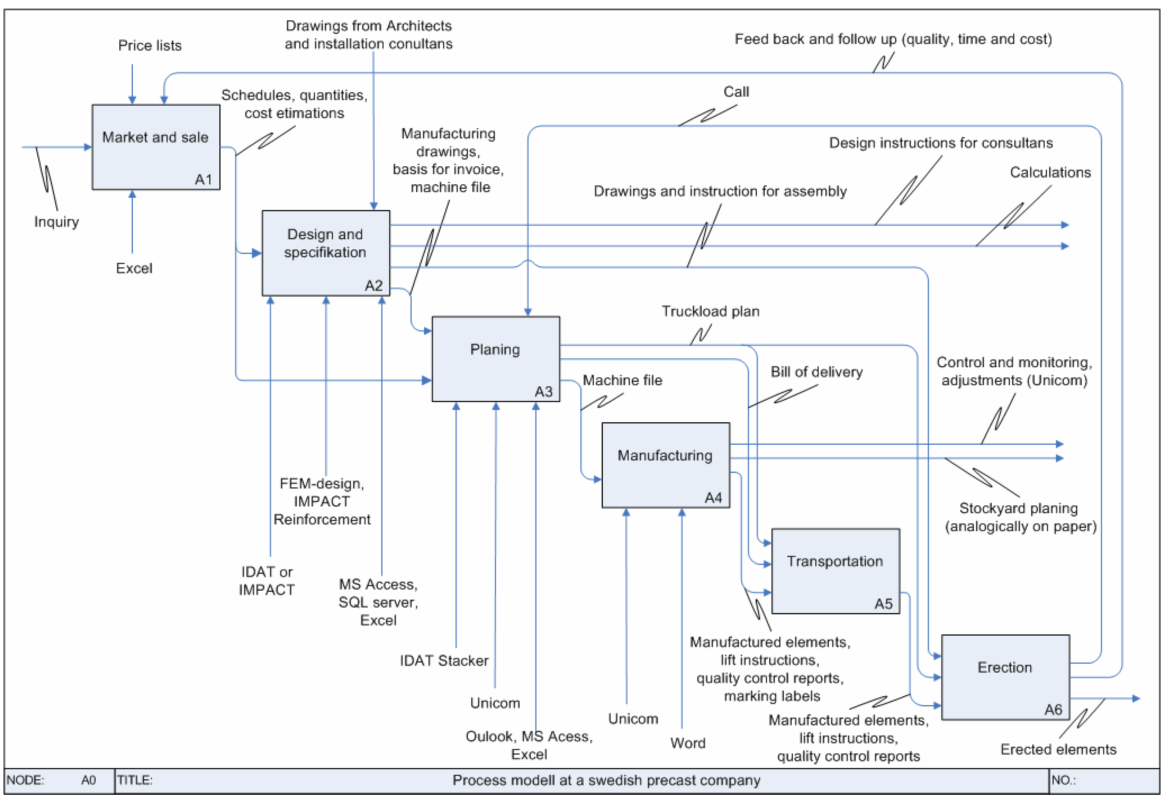

Figure 1: Process model at a swedish precasat company.

During planning a preproduction engineering is conducted, where the generated machine file is tested by error search, before it is sent to the manufacturing apparatus via the control and monitoring system. In a planning tool called IDAT Stacker a loading and detail plan is made. The tool contains a 3D interface, where the elements are placed on a loading pallet, based on the elements checked off from the working place. The order of assembly decides how the elements are loaded, and thereby also in which order the elements are manufactured. The planning department also prints the construction drawings.

It is via the ”Stacker” that the machine file is prepared for manufacturing. The file is sent to a control and monitoring system called Unicom. Here any adjustments to the machine equipment are made. Labels are printed from the system to identify the different elements before they are transported. The manufacturing department provides the transport company with documents for inherent control. Lifting instructions are described in Word-document. Documentation of any temporary storage and loading plan are handled analogically at the plant. The planning department creates a delivery note for the transport company, and loading lists for the transport company as well as the erection company.

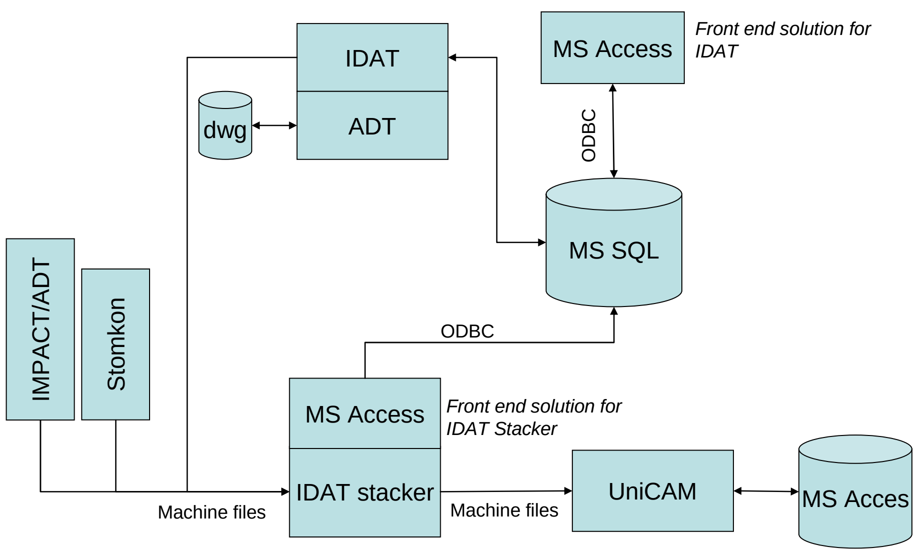

Figure 2: IT system model

PRODUCT STRUCTURE

The building system at the precast company from the case study consists of double walls and filigree floors. In figure 3 below, the double wall product structure is described as it appears in IMPACT. For each customer IMPACT develops a factory standard, which includes a product structure and allowed variants of the double walls. The chart below shows the factory standard structure regarding double walls at the precast company. To the right in the figure below an extract of the variants that could appear is shown for the different types of materials. The labels are identification numbers used for the various articles managed in the production.

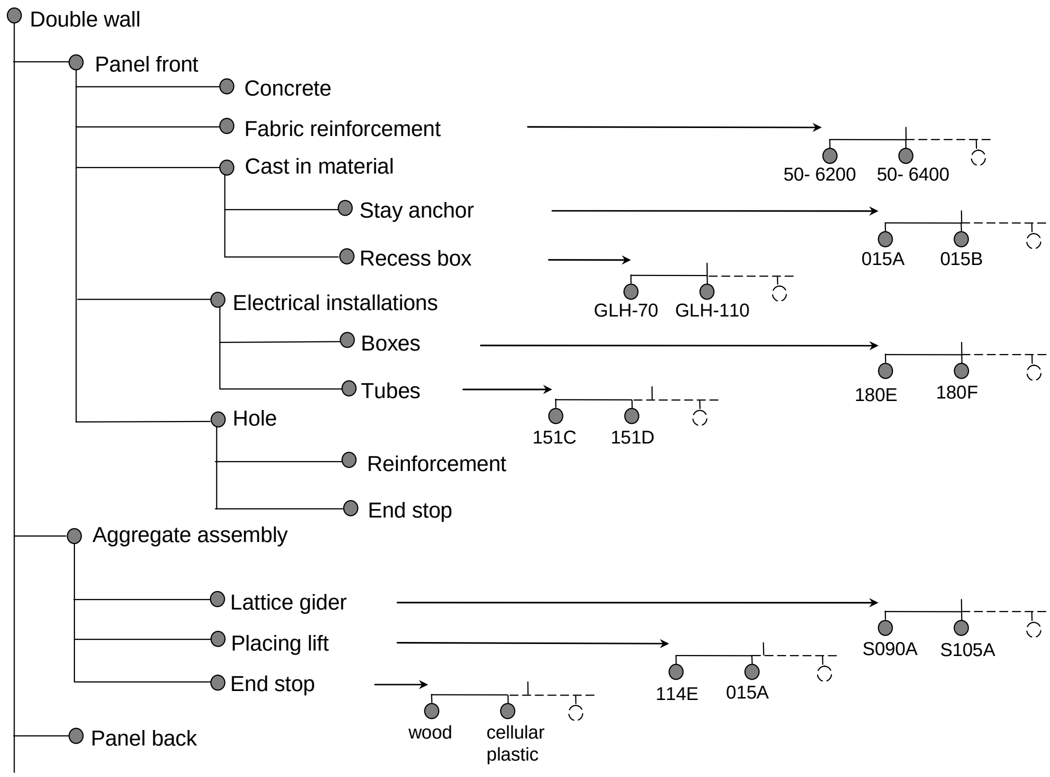

Figure 3: Extract from a product structur in IMPACT of a doblewall

A FUTURE PROCESS AND INFORMATION MODEL

An analysis of the process diagram in figure 1 reveals that the same information is fed into the process on several occasions. Some of the information transfers between the different operators are made analogously by printouts on paper. Different kinds of document are generated from the programs to be stored in a file structure. This complicates the document version control.

A number of different ICT-tools are used to generate documents, like calculations, timetables, quality documents, drawings etc. In most cases the tools are not connected. Moreover, the ICT-tools use different databases, and for them to be able to communicate with other tools an interface is developed between each system. The case study shows that several information transfers take place by means of machine files, see figure 2.

A description of the product structure of a building system is an important factor when designing a product model. Such a description includes the components and articles that forms part of a building system, the relations between these components and the variants that may occur. Different interpretations of the double walls and filigree floors product structure are found in the factory's ICT-system information structure (see figure 3). The information structure is then adjusted to the customer's specification of demands.

An alternative to the above would be for the factory to develop a product model which supports the company process model and the product structure produced by the company. This product model is stored in a database, and the other systems collect and supply information via a standard interface, based on standardized transfer formats or a de facto standard. Figure 4 shows what such an information model might look like.

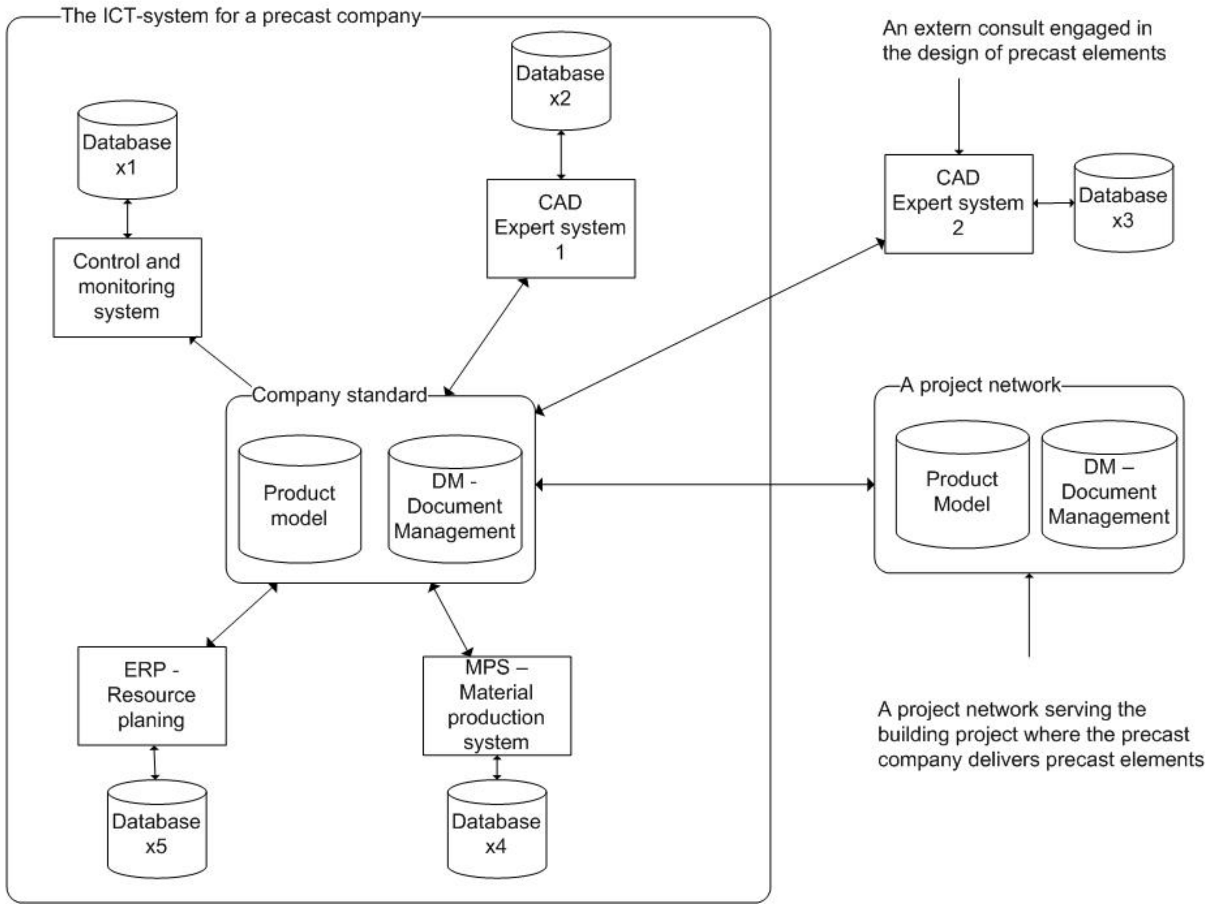

Figure 4: A future process and information model

The documents needed in the internal process are generated and stored in a document management-system, together with documents to be delivered to the construction project. Documents could be objects in the product model server but could also be stored in a document management system.

Subsets of the product model, as well as documents for the construction project, are distributed to an external project network that administers all information management in connection with the construction project. The project network is serving the whole building project i.e. installations, complementary additions to the framwork etc. It comprehends documents and models from other suppliers and consultants. The builder owns and runs the project network.

In the other direction, the factory collects basic data for its design. Information about the size of windows, doors or other holemaking is collected from the architect's model, and information about electric installations is collected from the electric consultant's model.

CONCLUSIONS

By studying the activities in a precast company and map out and describe the process, ICT-platforms and production structures gives possibillitys to identify potential improvments in the information management. Like in the engineering industry implementation of such improved ICT-technology should lead to rationalisations with increased productivity better quality etc. (Björnsson 2003). In a future process and information model the process owner develops and maintains a product model server in conjunction with a document management system. Other ICT-systems going to connect to the product model server adapt their translation format to the information structure in the product model of the precast company.

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