THE UTILIZATION OF PRODUCT MODEL DATA IN PRODUCTION AND PROCUREMENT PLANNING

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ABSTRACT

A new way to perform quantity take offs in building construction has been introduced in a form of value engineering concept. Value engineering tools allow the user to model the building three dimensionally using CAD (Computer Aided Design) -interface and an expert system. Nowadays this product model information is used for cost estimation purposes only. This highly detailed and structurized information could be used in production and procurement planning too. Product model information is enhanced with production information by allocating methods and resources to appropriate construction activities. These activities will then be scheduled in the scheduling application. Importing this activity timing data back to our production planning system we can conclude the needs for the resources: what, how much, when and where they are needed. This paper presents an effective procedure to utilize highly detailed product model information for production and procurement planning purposes. Data warehouse concept is also introduced for analysing the procurement data for management purposes.

Keywords: Product model, value engineering, production planning, procurement planning

1. INTRODUCTION

Throughout the life cycle of a construction process there exists different phases. The present way is to design and plan these different phases individually with almost no electric data exchange between different phases of the construction project. The result of all this is the loss of data and increased amount of errors which are due to re-keying the same information again and again into different systems. Example of this is the present tendering process where contractors are performing quantity take offs from the drawings and after the bid has been accepted, they will do the same again more accurately. The total amount of quantity take offs performed by a contractor can be as high as six during different phases of the project.

The information should be enriched as the construction planning process advances. This can be referred as a value added data flow [Oinas et al. 1997]. Data which is already being produced is available for the following phases supporting decision making processes with adequate and accurate information. Because there is less redoing of processes it allows us to use more time on the critical operations: effective and thorough preplanning, scheduling and managing of the whole construction project. Company specific knowledge bases contain company's valuable information which is based on years of experience in construction. Using expert system applications, this information can be used as a basis for productive and customer satisfying construction.

2. MODEL BASED TOOLS AND THE VALUE ENGINEERING CONCEPT

Model based construction and value engineering development started in 1993. The chosen expert system environment for YIT Corporation was Design++ and the created product model applications are called COVE (COst and Value Engineering) and CORVET (Customer ORiented Value Engineering Tool). The primary target for YIT was to achieve capabilities to use the cost estimation package in the early phases of the building process [Laitinen J. 1995]. COVE supports IFC/IAI (Industry Foundation Classes/Industry Alliance for Interoperability) -format which is compatible with STEP (STandard for the Exchange of Product model data). When construction designing programs and firms are able to produce data in IFC/IAI -format, COVE is ready to utilize this information and then the re-modeling from paper drawings or CAD-files becomes unnecessary.

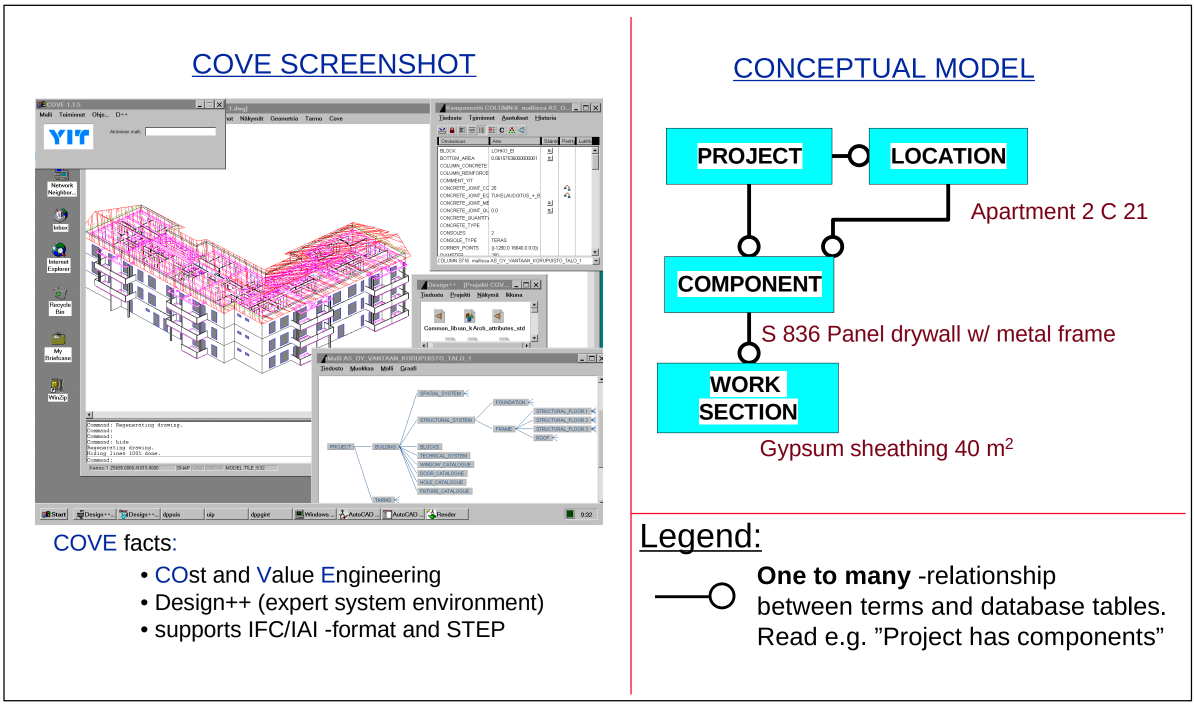


Figure 1. COVE-application and the simplified conceptual model of the data.

Figure 1 shows an example view of an unfinished COVE-model. COVE uses CAD-interface which provides virtual building type of visualisation of the model. Expert system handles the stored data in the database by taking care of the connections and features of the components via hierarchical product data structure which is shown on the lower right corner of the screenshot in Figure 1. COVE-model produces highly detailed information about components and their attributes. The simplified data structure is shown in conceptual model format on the right in Figure 1. Notation connecting terms represents the relationship between relational database tables e.g. project has several components and locations. Component which can be a space, a structural component or an HVAC-element has a location and work sections. Location attribute depends on the component. For some components it is e.g. Building A but for some other component it can be as specific as a single room. There is a hierarchical relationship between different locations which makes it possible to use this information later in production and procurement planning (Figure 2).

The fact that COVE-model has information about work sections connected to its components reveals that it is more than what is traditionally considered to be a product model. COVE-model is in fact partially a production model too. This makes it a very useful tool in a tendering process. A work section in the component's structure is the factor which takes both design and production viewpoints into consideration. The similar idea has been presented and the work section type of entity was denominated to BOD (Basic Operation required by a Design object) [Kim et al. 1996].

The CORVET-application is a specially customized tool for certain type of industrial plant modelling and tendering. The COVE-application's main target sector is the apartment building construction but it can be used for modelling other types of buildings too such as office buildings.

3. THE USE OF LOCATION INFORMATION IN CONSTRUCTION PLANNING

The highly detailed data, in a form of numerous components and work sections, is available from the modelling tool like COVE. In one apartment building there can be up to 10 000 components which have approximately 5 worksections each. This gives us the magnitude of the amount of information that we are dealing with. The data has to grouped and organized to enable effective production planning. Conceptual model in Figure 1 presents that each component has a descriptive location. Using this location segregation we are able to use certain selecting criterias when handling the vast amount of product and production model data. Questions like "Where is this component located?", "How many gypsum sheets are needed in Floor 3?" and "What type of partition wall is used in kitchen in Apartment 1 A 11?" can then be answered.

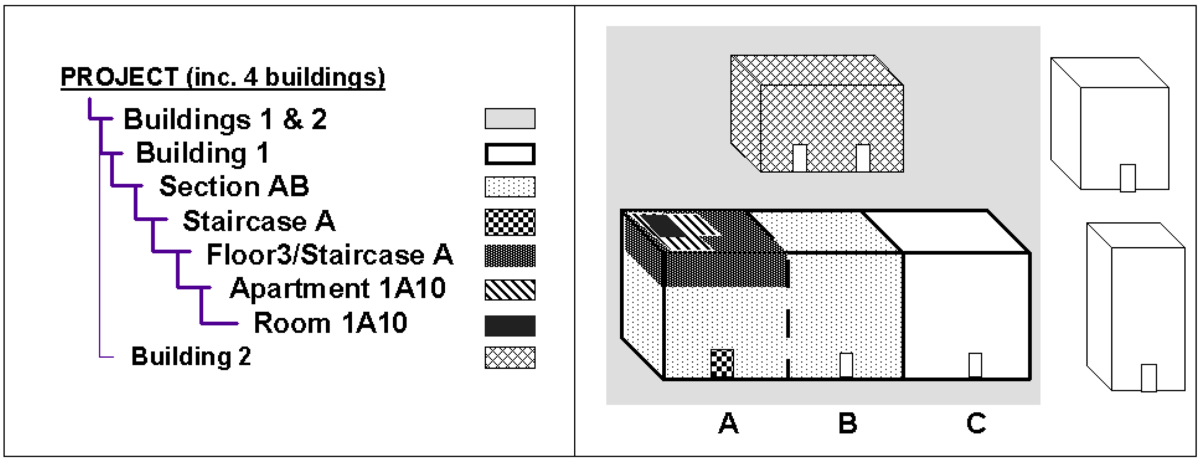


Figure 2. Hierarchical locations of a building construction project.

Hierarchical locations of a building construction project are presented with an example project in Figure 2. The tree view indicates that the location database table includes recursive data. This recursion has been done using parent-child approach e.g. Section AB's parent attribute is Building 1 and so on. Different patterns in the Figure 2 outlines the hierarchy between locations. A floor and a staircase are overlapping locations. In this case this has been solved using a location called floor/staircase. This represents a part of the floor which is accessible using the staircase for entry.

4. ALTERNATIVE VIEWS TO THE DATA MODEL'S CORE

Figure 3 presents multiple views to the data model's core. Having the data in the same model we can handle the large amount of data being produced during the process thus keeping it updated [Oinas et al. 1998].

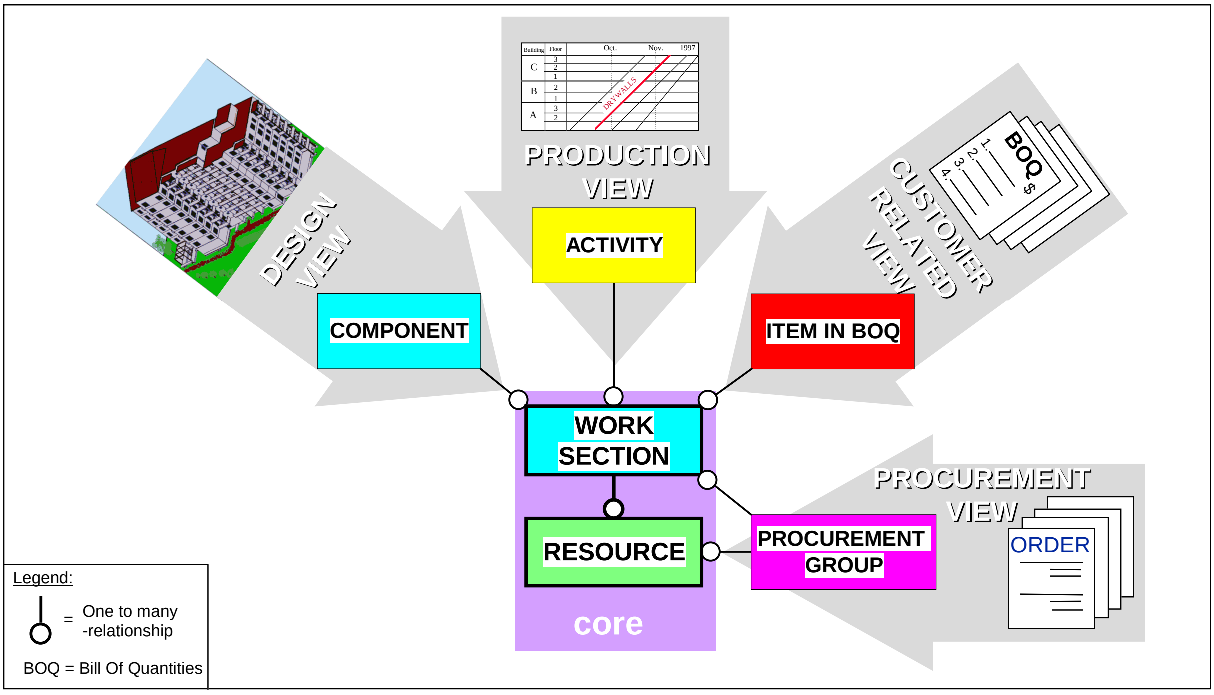


Figure 3. Alternative views to the model's core.

Design view is formed first using structural allocation of work sections and their resources. In our case COVE and CORVET are the tools that break down the building's structures into components and work sections providing information about their quantities, locations etc.. Quantities can be imported to the model from other quantity measuring systems too.

Production view is formed when activities are being brought from the knowledge base using work section code as a selection criteria. Activities will then be scheduled and their composition altered if necessary. Cost monitoring of the activities is performed collecting actual performance data and comparing it to the planned data of each activity.

Customer related -view allows us to estimate and plan the construction using our activity oriented knowledge bases and still giving the tender in the form that customer requires it. Depending on the type of construction, it is quite common that tenders are required in BOQ (Bill Of Quantity)-format. Keeping this BOQ-allocation while updating the core information during the construction phase, we are able to give accurate reports to our customer easily.

Procurement view is formed when planned work sections and resources are organised so that they can be used a basis for procurement and purchasing.

5. VALUE ADDED DATA FLOW THROUGH THE PROCESS

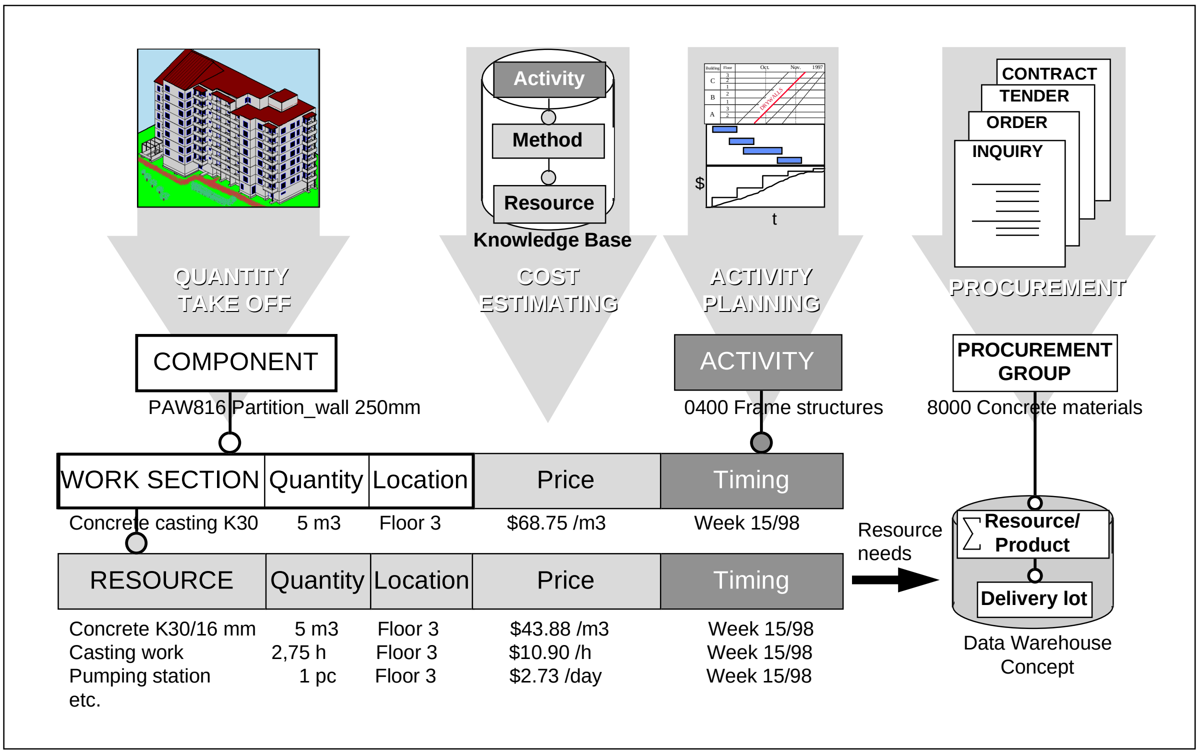


Figure 4. Detailed figure of the model's core with example data added.

5.1 Quantity take off

When the COVE-model is considered to be ready for the cost estimation purposes, it will be imported to the production planning system. COVE breaks down the building into components and their worksections. This information is marked with white boxes on the left on Figure 4. This structural data of the building must be checked through to ensure its completeness. The system enables the user to edit and add components and work sections.

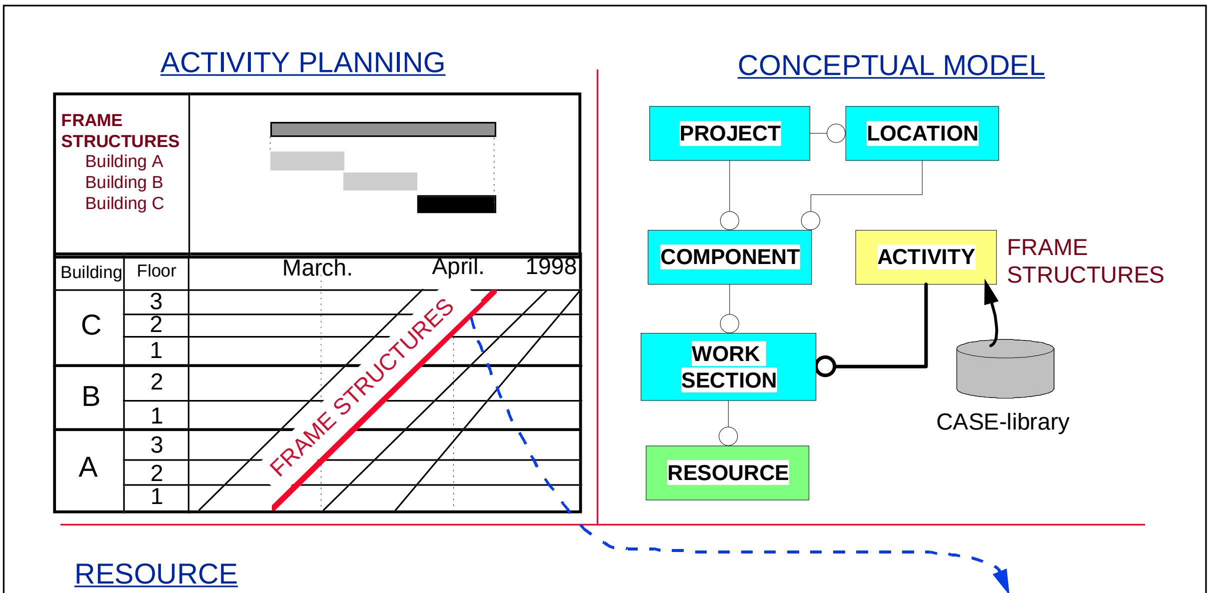
Quantities of structures can be measured and then imported to the system using also other than value engineering tools. It can be done e.g. with the help of a digitizing board. To make it possible to use location information later in the process, the quantity measuring has to be done using appropriate location segregation. Instead of measuring the total amount of e.g. foundation walls in the project, the measuring should be performed using section or building segregation.

5.2 Cost estimating

After checking that the model includes all the structural data we desired, it is time for the cost estimating. This is done using YIT's knowledge bases. They include updated price and performance data of different activities, structures, work sections and resources. Knowledge base contains method information about what kind of resources are needed to perform a certain work section. Using work section codes as keys we import appropriate resources from the knowledge base to our project database. The imported information is marked with light grey boxes in the Figure 4. Cost estimation for the project can be given in this phase but it is not totally reliable yet. We do not know if we can perform the project within the duration assigned by the customer. Resources which are now allocated, inherit attribute data from the work sections. Now we know what and how much we need and where.

5.3 Activity planning

A process planning usually includes a stage called scheduling. Until so far we have made only very rough estimations for the duration and timing of the project in hand. Knowledge base includes a section called case-library. The case-library contains valuable information about activities and structures that are recommended to be used. This best-practise knowledge is gathered during the last decades in YIT's Building construction. When applicable case-project has been identified, its activities are being brought to the project database. Work sections are then allocated to appropriate activities. This allocation is performed depending on the work section code so this way the activity has the knowledge of which work sections are in its range. In activity planning phase, this allocation can be altered if e.g. sub-contractual limits are supporting this alteration.



definition	quantity	unit price	location	date needed
Concrete K30/16mm	50 m3	$68.75 /m3	**Building C Floor 3**	**Week 15/98**

Figure 5. Activity allocating and scheduling.

When activity allocation is more or less ready, activities are loaded into scheduling program. The left side of Figure 5 shows activities in the bar chart (also known as the Gantt-chart) and in the line of balance schedule [Programming house building, 1967]. The line of balance method is very suitable for building construction because it presents location and timing information in the same schedule. Activities are then planned and scheduled in the diagram taking constraints and dependencies into consideration. After the scheduling is done for this stage, activity based information will be written to the project database. Dashed line in the Figure 4 demonstrates how the drywall activity gets its timing information in the scheduling program and how the resources inherit timing information depending on their locations. If resource and cost information is imported to scheduling application along with activities, the necessary cash flow and resource allocation diagrams are able to be produced easily.

5.4 Procurement

By managing production model information as presented we have managed to set location and timing information for the work sections and resources. This means that we know what types of material, product or service are needed, where it is needed and when. Arranging resources as groups wi§th the same location and date we can form so called sets which are needed for logistic delivery planning.

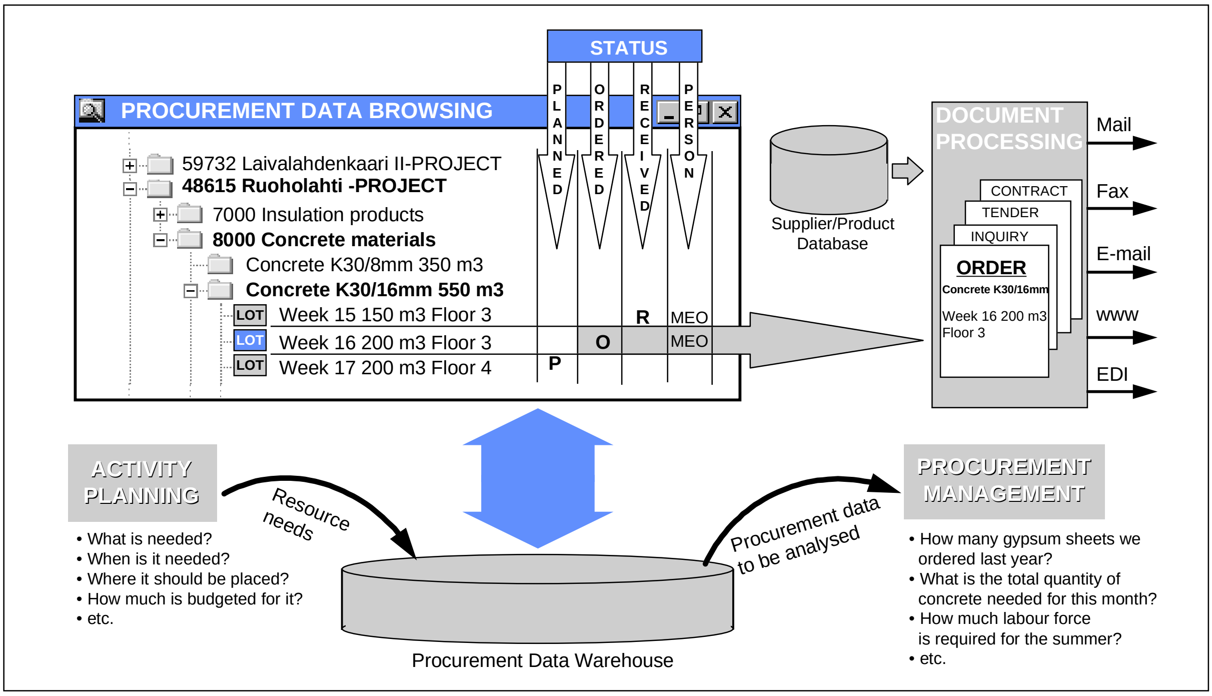


Figure 6. Procurement data producing, managing and analysing.

Data warehouse -technology is a quite new and interesting concept which has been developed to help managing large amounts of data thus providing multiple possibilities. This centralized data is available for all kinds of analysis and reports. Figure 6. introduces a way to use data warehouse for procurement purposes. Earlier chapters showed us the way how activity planning system produces information about resources which are needed at the site. Using metaphorical terms we can say that activity planning system “pours“ these resource needs into the “bowl“, which in this case means the procurement data warehouse. Different views, analyses and reports can be imagined as being alternative “scoops“ which are used for obtaining data from the data warehouse for different purposes.

Procurement data can be browsed and updated using the procurement system. The upper side of Figure 6 presents a sample view of the procurement data browsing. Each delivery lot of a certain material has a status which represents the actions that has been taken to get this resource delivered to the construction site. Person who is in charge of the action has his/her initials marked on the line too. The change in the line’s status from planned to ordered triggers the purchasing module and transfers the items to be ordered into the document processing. With the help of supplier/product -database we are able to check e.g. whether there is a valid long term contract to refer to. After that the prepared document is ready to be sent using the selected format e.g. EDI(Electric Data Interchange) or e-mail.

6. CONCLUSION

The introduced information system for production and procurement planning purposes can be designed, coded and implemented in sequential phases using modular application development. However it is essentially important to recognize this functional integration and data interchange at the early phases, when decisions for the overal structure of the information technology infrastructure are being made.

The next industrial revolution is said to become in a form of product specific data management. Large amounts of product specific attribute data e.g. environmental attributes will lead construction industry into problems if it is not ready to handle and store large amounts of information in an electric format. The arrangement of the information is more important than ever before. Those construction companies which are able to produce, handle and utilize this data have the advantage in construction business in the very near future.

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