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PRODUCT PLATFORM MODULARISATION OF LUMINAIRE LIGHT SOURCES

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Product Platform, Product Family, Modularity, Functional Structure

Abstract

In an effort to better respond to heterogeneous customer needs, many firms find it appropriate to increase product variety i.e. the number of different products offered to customers. Some companies have met serious production problems derived from the large variety of their products. This forces them to develop product families with the common platform, whose variants are designed to meet different customer demands.

Product platform modularisation of luminaire light sources is described and analyzed in this paper. Such a platform would reduce lead-time and speed up the manufacture of new products. The creation of product platform was started by analyzing functional structures of all luminaire light sources produced in the company. After comparison of functional structures the common and unique functional units were determined and the modular product platform was developed according to the production requirements. Besides of the "hard" drivers the impact of the "soft" drivers, such as styling, common unit and recycling was investigated. Especially the styling has high driver values for consumer products. Using Module Indication Matrix (MIM) the functional units were analyzed and conclusive module drivers were set. Recommendations for luminaire light sources module development were formulated.

1 Introduction

A module is a structurally independent building block of a larger system with well-defined interfaces. A module is fairly loosely connected to the rest of the system allowing an independent development of the module as long as the interconnections at the interfaces are well thought of [Baldwin&Clark 00, Ericsson&Erixon 99].

The advantages of modularity are possible economies of scale and scope and economies in parts sourcing [Baldwin&Clark]. Modularity also provides flexibility that enables product variations and technology development without changes to the overall design [Ericsson-&Erixon 99]. Same flexibility allows also for independent development of modules, which is

Traditionally, when companies have searched for higher profit they have improved the product technology and manufacturing efficiency. Companies have been product and production oriented. Today companies are focusing to customer satisfaction with value adding business components rather than with superior products i.e. companies are customer orientated. [Björkstrand&Tuomi03]. Figure1 illustrates the polarities of business components and trend of change. These changes in business environment open both challenges and possibilities to traditional manufacturing industry and system providers.

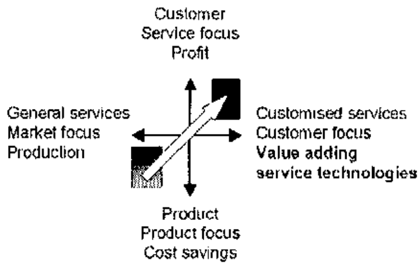

Figure 1 Dimensions of changing business environment and trend of change.

Product designers and developers have concentrated on developing products for customers and product models for company internal use and to be used as specifications for component suppliers. When a company begins to apply extended product models in customer interface in a business strategy-supporting manner several practices have to be re-engineered. Additional consideration must be paid to software integration, user oriented interfaces, product model representation formats, product modelling automation and product model features and attributes.

In this research we re-engineered the generic processes in customer interface by focusing to the product model. The Extended Product Model was placed between the customer process and corresponding company process (pre-, on- and after sales) to act as a platform for the interface.

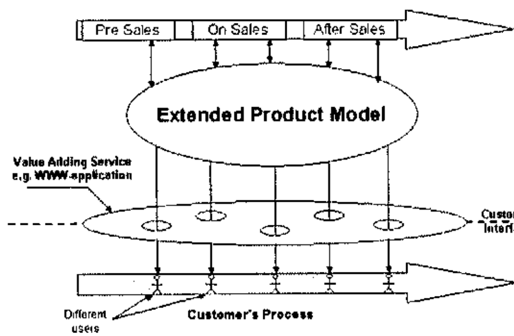

Figure 2 Extended Product Model as a data integrator and a source for the interface between company and customer [Suutala03].

One of our findings was that it is possible to offer added value to a customer with richer product model information delivery. The source for this interface and information is extended product model - XProMo. The content of the product model information, information sharing strategy and related information technologies are subjects to company business process design.

2 Objectives and Methods

Our research objective was to find ways to determine and satisfy information needs of a customer process from the point of view of the product model data. Our objective was also to develop a strategy-supporting and value-adding interface to the information in question as well as to determine extended product model concept.

Our research method was constructive. Current state was based on experiences of the research group and identified business needs. Case study at Fodesco Oy revealed challenges leading to ideas of first pilot-project. Ideas were scanned through technology evaluations and scenarios. Other cases expanded the empirics. Cases were executed by adapting different technologies.

Other methods used to collect the background and project pending information were half-structured and structured interviews, both on customers and pilot companies sites. The development was controlled by focus groups of the pilot companies. Use-case methodology (part of Unified Modelling Language) was used for the user interface development. Tools for analysing customer process needs were Pre-On-After sales (POA) matrix (fig. 3) and document owner/system/location/need table (D-table, fig. 4). In POA-matrix each need was inserted to corresponding voxel (phase/process/customership). Needs were compared to data in document matrix. These two components were used to build "a timetable" – a plan, where current possibilities (D-table) were compared to needs in relevance and strategy accordance. The voxel-information from POA-matrix was organised user-specific to form the role-based user interfaces. Furthermore the architecture of IT-system was defined by focus groups using D-table.

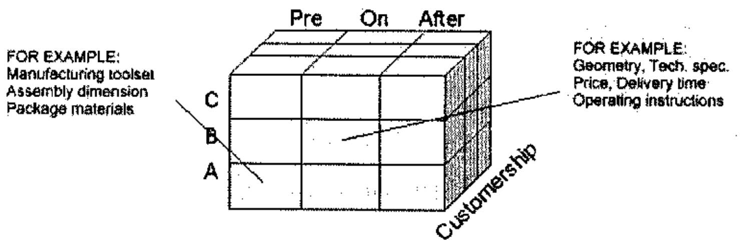

Figure 3 Pre-, On-, After-sales matrix organises needs relative to the product process, sales phase and customership.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3D-model	Geometry	3D-CAD	Design	PDM	no	Marketing, supplier
Drawing	Prod. inform.	3D-CAD	Design	PDM	no	Production, supplier
Exhange model	Visual inform	3D-CAD	Design	PDM->Extranet	yes	Customers designer
Installation doc	Assembly inform.	3D-CAD, editor	Design,Marketing	PDF->Extranet	no	installation partners
Delivery schedule	Delivery time	ERP	Production	ERP->Extranet	no	Customers, Sales
Mach. tools	Manufacturing pos	3D-CAD	Production	PDM->Extranet	yes	Customers designer

Figure 4 An fictitious example of a D-table. Document table was used to join needed data and information source to users. System-location/route-conversion columns were the ground for the system architecture.

3 Value adding business process application

Business process can be defined as to be a group of business activities undertaken by an organization in pursuit of a common goal. The value adding business process would therefore mean all those activities in an organization that add value and lead to common goal, most usually to profit. There are many sub-processes in a company – adapting the lean-philosophy; process activities of these sub-processes should not contain any overlapping tasks and they should support each other to the main process goal.

3.1 Extended product model concept

The product model was originally created to solve the problems of separated CAx-systems. The goal was to save the product model data in one place in order to control the data and to record data needed for manufacturing operations and logistics. This pile of information formed the model of the product in question – therefore it was called "the product model". [Laakko, Mäntylä, Mäntylä, Nieminen , Sulonen & Tuomi90].

In nowadays product information is separated in various systems. Not only in CAx-systems, but also for example in logistic information systems based on MRP-information. Basically the content of the whole product information forms "the product model".

XProMo concept is a set of sub-models that contains information. One main sub-model is a geometric product model created in 3D-CAD system. Other systems can be logistic management, configuration, simulation, FEM, customer management or ERP [Holmström, Främling, Tuomi, Kärkkäinen & Ala-Risku02]. Defining XProMo-system actually defines the interfaces and roles of system hierarchy in order to add value of a product to the customer. The system hierarchy should correlate to the strategic data structure.

The use of extended product model concept can be divided in two. 1) An internal data carrier from product development not only to manufacturing but also to various actions of a company 2) A data transfer method over the company interfaces. XProMo system as an internal data carrier can support knowledge management operations for example combining the decisions to actual (virtual) product.

When using XProMo as a data transfer method over company interface, value adding rises as a central question. The mechanism to add value is described in figure 5. In figure 5 there are two similar design processes examined in three points. Shorter R&D process uses supplier information as a resource of internal process in order to get "a head-start" on a way to accomplishment. These value-adding triangles can be for example component information packages containing product geometry and related information but also immaterial "learning packages" contributing to the development process with knowledge or calculation related service.

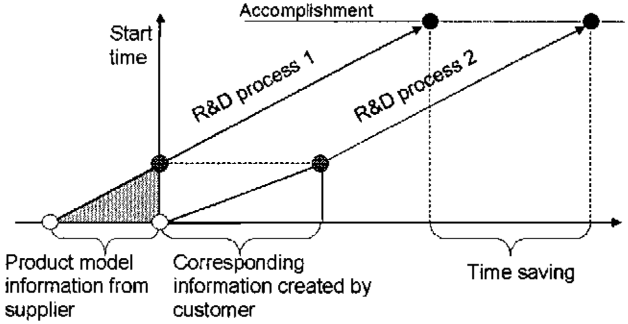

Figure 5 Extended Product model adds value by speeding the R&D process up.

Related to one definition of extended product, XProMo should not be seen only as an intangible surrounding of a product but as a data source for both tangible (geometric product model) and intangible (extended product model) product. The immaterial dimension of tangible product, such as systems control software, can be executed in virtual presentation of an extended product model for different purposes. Intangible part of a product, for example the service models, can be modelled and linked to XProMo.

For virtual enterprises extended product model concept is a method to form a communication system for the partnership network. The virtual enterprise could be built up by using extended product model as a data transfer method.

3.2 Framework of extended product model dimensions

To understand the information logistics of extended product model it is useful to visualize the processes it supports. Extended product model supports also the customer process as the traditional product model supports the company-internal manufacturing process. These main processes have several sub-processes that are supported case-specifically.

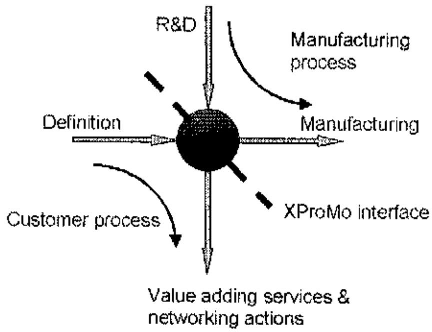

Figure 6 Dimensions of extended product model concept

Furthermore framework of utilizing this concept can be shown. The list shows also the natural path from initial situation to high-end usage of extended product model concept.

- Traditional: The concept is focused to efficiency of manufacturing process, system backbone is a 3D-CAD software with extended data flow from R&D functions to manufacturing actions. The product model data extension, in form of attributes and features, explicates the information needed in sophisticated manufacturing.
- Product process support: The concept utilizes the (interface) extensions created in R&D that allows the product definitions to be made on customer site or in sales organization. The system is enriched by a definition view to product model that extends the traditional method to cover also the pre-sales phase of the product. This requires usually integration of different systems, mainly the system containing the configuration model but also other systems depending on information needed.
- Customer process support: The concept has a "full size" interface to the product model and R&D functions has been re-engineered to create value adding services and networking actions to support value adding goal of total business process.

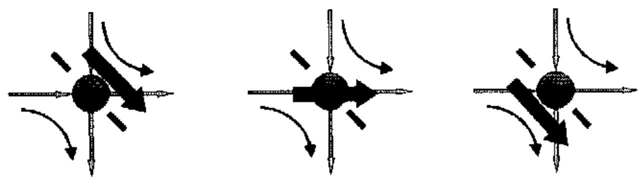

Figure 5 Different ways to utilize Product Model Data (see also fig. 4)

3.3 Strategic point of view

Understanding the strategic meaning of knowledge intensive systems is essential when implementing such systems. The system should focus on three things: data structure, data integration and information technology. Data structure should support strategic goals, the system should be able to integrate the data in correct form and technologies should support the structure and integration. [Finger, Tomiyama & Mäntylä99]

Data content of XProMo system can be classified in two. 1) Geometry data and 2) extended product model data. The geometry data includes conventional geometry model and "static" information suitable for geometric presentation. The data required by the current business relationship model is saved and modified in extended product model that can handle "dynamic" information.

Extended product models will act as integrators of structured product model data. Product modelling technologies will give us possibilities to freely publish different forms of information. There will also be possibility to transfer data across CAD-systems in more knowledge intensive manners. [Xue, Yadav & Norrie99]

3.4 Needed changes in product development

Depending on the method (fig. 5) a company has selected there is a need in R&D functions to provide more specific information and also new types of information – using new development tools. These are sophisticated electronic toolkits to aid design and development

activities. This includes inter-firm and intra-firm co-development with linked CAD and CAD/CAM systems.
From product development point of view this means implementation of knowledge intensive development tools to reach demands on more efficient cost-time factor in innovation processes. It also means changes in personnel of R&D functions – there is need for coders and humanists beside the engineers. Comprehensive development tools and need for comprehensive information requires comprehensive know-how.

4 Research results

Based on our laboratory research environment applications and industrial case studies we have found three important success factors for XProMo implementations in customer interface. Our latest finding is that these factors are in line with Rothwell's [Rothwell94] managerial, organizational and technological fifth generation innovation efficiency success factors. The problem in creating added value is not technological barriers, it seems to be non-digitalised knowledge, lack of practices to record needed information and lack of motivation to develop such systems.

First there has to be **an identified customer need** for the system. A company has to study thoroughly the customer's processes to find spots where they can answer that need with superiority. Finding the true need might not be easy – sometimes even the customer can't say (or can't see due to the narrow "departmental" scope) what would be the optimal input for the best solution. It is quite usual that development group studying the customer's processes relies on a second hand source of data (e.g. sales persons), which can lead the development group to the wrong direction. When finding the need one must also ask: who is our "customer" – sales department, business partner or end-user? We found the Use-Case methods (part of Unified Modelling Language) quite effective in developing the user interface for the extended product model [Suutala02].

Secondly customers have to **pass the entry-barrier**. This can be achieved through sufficient publicity and by an application that motivates the customer and also gets an acceptance at customer's administrative level. The application has to be superior to the competitors and focus exactly to the need identified in step 1. The system to be built has to give a perception to the customer in order to make things roll at customer's side.

Thirdly the application has to **serve company's own goals.** The company serving information must have clear vision of the earning power of the system. If the service is given free it must convert to cash flow elsewhere. The cash flow could increase by increased volumes of the customers (indirect benefit) or by supporting later company's own processes (e.g. ordering process). Best influence is achieved by supporting the buying decision of the customer. This means that the information that supports customer's process should be formatted so that it follows customer's process and "returns" to the purchase. For example information given in the design phase doesn't necessarily correlate to increased selling. It might be that on the moment of purchase the address, where support and information came from, is lost and investments to the system would be useless. Thus management of the information flow through customer interface is essential.

5 Industrial cases

5.1 Fodesco Oy

Fodesco Oy is a small company selling mould bases and other parts for the plastic injection industry. Mould bases are globally standardised, therefore the competition happens through general service, prize and terms of delivery. The development project followed the success factors introduced.

First it was **identified** that the mould designers handled Fodesco-information in early stage of mould design, right after they received the model of product – they actually modelled the mould plates using inaccurate drawings of paper catalogue. This was of course time consuming, didn't acquire customer's special know-how and was hazardous for mistakes. There was need for 3D-models of the mould base to speed up customer's process. The customers mainly used three different CAD-systems and they all expected native formatted models.

Second finding of customer's process was that quite often other people than the designers ordered the mould bases. There was a need to carry data inside a customer company.
Third need was found internally – most orders arrived via fax and very common problem was that orders were incomplete, ambiguous and indistinct causing Fodesco to contact the customer for further information.

Fodesco was about to share product information and deliver it to the customers in a form best suitable to customers. First problem was the incompatibility of CAD-systems. There are three ways to serve 3D-models: 1) model each part separately (traditional component library). 2) 3D-CAD systems configured to act on a server modifying the generic parametric model, which would serve the parts in question to the customer. 3) Serve parametric model of a product for each CAD-system and modify a web-based catalogue to print out a definition file corresponding the order made on a web-catalogue. This was the Fodesco's way.

According to the fundamentals of an extended product model the system was built to integrate existing systems. The integrator in this case was a web site, which could be described "a product catalogue". The publishing software was capable to use data exported from financial management (promoted to ERP in figure 8) adding part numbers and corresponding prize information. The products catalogue itself was developed further than normally.

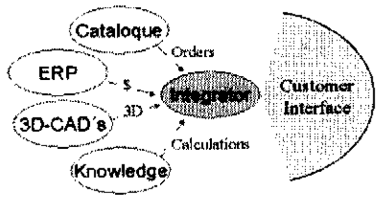

Figure 8 Integrating information from several sources to meet customer need

Product configuration was converging and it was supported by calculations to achieve correct mould assembly. On the background the web site collected information of the order and turned it to a collection of parameters and ordering numbers. These parameters were used in 3D-model phase. At the end of configuration the user arrived to "Download 3D-model". At this point user selected one of three supported CAD-systems, downloaded only once the generic 3D-model (which could be inserted to the customer's process by adding customer specific information and still be configurable by Fodesco web-site) and the order-based definition file. Each generic 3D-CAD model had a small program beside that read the definition file and modified the dimensions of the model (first need). The same program wrote also the part numbers from definition file to the parts of the assembly carrying the ordering information within customer's CAD-system and finally through bill of materials to purchase (second need). Of course the site also created a fax-ready form of the order (third need).

The main thing to notice about the systems is that there was only one definition of the product, re-using data managed elsewhere, and it was integrated to three CAD-systems.
The benefits for Fodesco were publicity, improved orders, decreased order handling, growth of business (also other things involved) and tighter customer relationship. Benefits for the customer was accelerated design process, correct orders and correct models. After six months of announcement of the system in Finland 30% and in Sweden 60% of the orders came through the system.

5.2 Tulikivi Oyj

Tulikivi Oyj is a company selling and manufacturing soapstone fireplaces. One of their main business areas is called "covering stone" – it's selling stone elements as a material to stove industry. This case concentrates on Tulikivi's extranet application created to meet the needs of this business area.

Unlike case Fodesco the application couldn't base on the geometric model to share information because Tulikivi's role in process is to provide the material and it's manufacturing. The philosophy can still be implemented - we can consider Tulikivi's information as a sub-model of the (extended) product model of the customer. In this case very thorough customer process / need analysis was needed in order to best serve the customer.

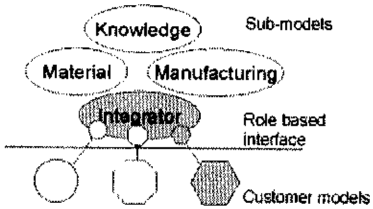

Figure 9 Information as a source for customer product models

Other difference from Fodesco was that the users of the system differed greatly. Therefore we ended to implement so called Use-Case analysis to **identify user specified needs**. Results of this analysis were also used to create a role-based interface for the information on the web site. This "information you need"-interface and strong involvement of the customers during development phase should support the crossing of the **entry-barrier**.

The system provides the customer wide range of information from soapstone's material properties and tutorials to design soapstone components to the history of soapstone and visual material - all identified in customer's process, given in suggested form and partially guiding to solutions suitable for Tulikivi (e.g. to design shapes compatible to Tulikivi profile tools etc.). By opening a part of Tulivi's knowledge of manufacturing it was achieved not only beneficial solutions to the customer but also reduced the amount of work at Tulikivi.

6 Conclusions

Product development processes need to be re-engineered to carry data and documentation for the value adding business applications. This means wider and better usability of product development information. Technologies and tools to create system interfaces that fill the above-mentioned requirement need to be concentrated. In value adding business strategy extended product model information can be used in the manufacturing logistics processes as well as in customer interface processes like pre- on- and after sales.

Customerships should be classified and analyzed and the extended product model data structure should be linked to these requirements. Simultaneously a company has to take in consideration information needs of production technology and manufacturing logistics systems. After this the extended product model content and structure can be designed. Because the interfaces of extended product model vary and are numerous, the task to realize practical applications is highly knowledge intensive.

Three important success factors for XProMo implementations could be recognised – identification of the customer need, helping customers pass the entry-barrier and serving own business goals. One of our main findings related to product development is that above mentioned factors are in line with generalized managerial, organizational and technological corporate innovation efficiency success factors.

7 Acknowledgements

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