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DESIGN CONFIGURATOR : A TOOL FOR ORDER ENGINEERING

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Abstract: *Configurators are essential tools in mass customization. While sales configurators and product configurators have received a fair amount of attention, this study extends the research to order engineering with a concept of a design configurator. Design configurators can be used to automate order engineering, helping to decrease lead-time for product quotations and custom designs, and bringing ETO companies closer to mass customization. By establishing requirements for and creating a description of a design configurator, this paper establishes a base for further research on design configurators. Utilizing multiple case study method applicability and benefits in different industrial contexts are evaluated.*
Key Words: ***Configurator, order engineering, mass customization***

1. INTRODUCTION

Mass customization is seen as a promising approach for splintered mass market [1,2]. By using flexible processes and organizational structures [1], mass customization enables companies to "providing tremendous variety and individual customization, at prices comparable to standard goods and services" [3]. In [4], where the term mass customization was coined, it was described as a solution for reaching the same large number of customers as in mass markets of the industrial economy, and simultaneously treating them individually as in the customized markets of pre-industrial economies. The most of the mass customization literature describes mass customization similarly, as a solution for consumers of mass markets desiring more individual products.

In contrast to consumer product industries, where standardization and mass production have dominated markets during the last century, in the capital goods sector products have continued to be designed to customer specification and manufactured in job-shop facilities [5]. Thus, in the industrial B2B markets the approach to mass customization is most commonly exactly opposite to consumer business. Some mass customization theories and methods developed for mass producers can also be applied to Engineering-to-Order (ETO) companies, but others are not applicable in ETO. The reason for this is a basic difference between incentives for the two types of companies to implement MC [6]. For ETO companies, the thrust and drive for mass customization is for the sake of shortening delivery time, variation management, and/or cost reduction [7,8,9]. Customers have used to get individual service and individual solutions to match exactly their preferences, but the customer sacrifice [1] they are expected in return is higher cost of individual designs and longer delivery times due to design process lead time.

In the pressure of global competition the challenge ETO-companies are facing to is to continue delivering quality and high customer value while pressing costs down and shortening delivery time. Current definitions of mass customization highlight the large variety or even individual solution and cost efficiency. In capital goods industries, a third competitive factor is considered being equally or even more important: the delivery time. Thus, prevailing definitions of mass customization are biased and defective from perspective of an ETO company. A more adequate definition of mass customization for ETO-companies could be as follows: "Mass customization enables companies to provide large variety comparable to pure customization strategy at significantly lower costs and/or shorter delivery time".

Yet, in capital goods industry too we can see variation in the level of customization of products, processes and transactions. Many researchers have described a vast amount of approaches between the two opposite extremes: pure customization and pure standardization. When defining what mass customization is and what it is not, a continuum on possibilities is laid down from mass products to craft work with various levels of standardization/customization combinations in between. Common for all descriptions is that if the extent of customization penetrates order-delivery processes all the way to the design/engineering phase the approach is considered as a pure customization strategy or an engineering-to-order operation model [5,10]. The accuracy of this view is reassessed in this paper.

Just like in consumer business, also industrial markets seek solutions to fulfill individual customer needs in a cost efficient way, utilizing mass customization concepts. According to [11], the genus of mass customization is the customer co-design process. Customers are invited to participate in value creation process by defining, configuring, matching, or modifying an individual solution. Successful design of customer involvement in the definition process can create a flow phenomenon which increases customer satisfaction to process and consequently commitment to the end solution [11,12]. In industrial markets where somewhat more rational reasoning and buying behavior is considered, a successful design of product definition process can decrease customer sacrifice by saving customer's time, money and effort.

In consumer business, sales configurators are seen as valuable tool in collaborative product definition process guiding and educating the customer in the product definition. Sometimes sales configurator is followed by a product configurator that is needed to transform the product features defined in sales configurator to product components for production. Similar approach is also used in industrial markets, but usually the sales configurator is used by an expert sales person and more rarely the customer directly [8,13]. Also, many companies are using hybrid product strategy offering customers standard products, mass customized products, and individually designed products.

In this paper, we present a third kind of configurator, a design configurator. Design configurator is examined as a tool for automation of order engineering process for tendering and product designing purposes in capital goods industry. We will seek to extend the mass customization ideology to ETO-products which are so far considered belonging outside the breadth of mass customization. By automation of order engineering process with a design configurator mass customization ideology can be extended also to some level of ETO-activities. We will define the concept and requirements for a design configurator and will utilize multiple case study method to evaluate its applicability and benefits in different industrial contexts.

The rest of paper is divided to sections as follows. In Section 2, we debate on special qualities and objectives of mass customization of capital goods. In Section 3, extant literature on configurators is reviewed. In Section 4, the concept of a design configurator is defined. In Section 5, some case examples supporting the idea of design configurator is presented. In Section 6, conclusions are drawn and further avenues for research are suggested.

2. MASS CUSTOMIZATION OF CAPITAL GOODS

An explicit mass customization strategy is unique to the company developing and implementing it [1]. In addition to company specific differences, several more general characteristics can affect to optimal mass customization strategy. Industry and product type affects the need for customization and to the extent to which customization is economically viable with prevailing technology. For example, mass customization of shoes has different requirements for and utilizes different techniques of mass customization than mass customization of digital content, e.g. personal radio or personal news portal etc. Also, consumer goods industries in general differ from capital goods industries, where more rational decision making of the industrial buyer is assumed and is guiding the development and selection of applicable mass customization methods. Approach direction to mass customization is also recognized as a critical factor when implementing mass customization, whether on mass or custom manufacturing [7]. Between these two extremes is continuum of other industries that calls for diversity of MC strategies [5].

Capital goods industry differs from consumer businesses in numerous of ways. Suppliers' product offering may be targeted to customer's production process or to be included in customer's end product. The industrial buyer is usually an expert of customer domain and possesses high level of requirements and product related knowledge. Also, B2B customers are considered being more rational buyers seeking optimal balance between product qualities, price and delivery time/accuracy. Typical offerings of capital goods companies span over a number of standard products, mass customized products, and products requiring order engineering or even new product development. In addition, life-cycle and value-added services are often offered separately or as a bundled product [14].

Customization strategy, or ETO-model, is widely used in capital goods industry to provide critical customer value. Customers typically have distinctive process or product related needs that require adjustment of offerings to specific customer requirements, realized with order engineering. Typical sales process is organized as twofold: external sales units are responsible for customer interaction, collecting customer requirements, taking care of the customer relationship, and for pricing decision, whereas internal sales support team is responsible for order engineering, cost calculations, and defining the delivery time. External sales are located near the customer and centralized internal sales support has high level of product expertise. The unique customer requirements, complex products, and organization of sales in capital goods sector introduce many challenges to operations and organization of sales.

Efficient customization might be difficult to achieve in high-tech or knowledge-intensive industries, such as many capital goods industries. In [15] it is described the qualities of order quotation process based on surveys conducted in UK and USA. Only 4% of respondents had never faced problems in meeting the proposal dates, whereas half had lost contracts due to proposal delays. An average project size amounted to 2 million GBP of which 12% was spent in advance in preparing the offer. Time spend for preparing the offer was in average 138 hours in sectors with normal product complexity, 772 in high complexity sectors and as much as 1030 in electronics and telecom sector. In effect, 62% of these hours never led to a contract. Especially larger companies suffered the biggest problems in both staff-hours and hit rates; up to 2881 hours were spent for offers per a realized contract. And still, the lack of accuracy in offers and estimates are exposing companies to significant commercial risk in the order fulfillment phase [15].

Mass customization and product configuration is proposed as an efficient solution to these problems, enabling large product variety while decreasing lead time and costs in every phase of order-fulfillment process.

And for sure, many industrial products too can benefit from modularization and standardization of modules, achieving increased competitiveness compared to ETO approach [8]. But for a large amount of products individual customization is still needed because of unique measures, qualities and preferences required.

Technological development is seen as one possible solution for achieving cost efficient customization in ETO companies. For example, in [16] an industrial company is described proceeding from mass production to efficient and effective customization with aid of new technologies. The company Ross Controls, producer of pneumatic valves and air-control systems, focused on learning relationship with the customer and expanded their capabilities to meet each customer's changing needs. They utilized CAD design libraries to reuse old designs, quickly customize them to the specific needs of each individual customer, and utilization of direct electronic linkages to production for achieving speed and cost efficiency.

The main distinctive principle of mass customization is a mechanism for interacting with the customer and obtaining specific information in order to define and translate the customer's needs and desires into a concrete product or service specification [17]. Thus, mass customization often requires a mechanism enabling elaboration of customer requirements, e.g. a configurator [18].

3. CONFIGURATORS

The increasing competition in the global market has put much pressure on the manufacturing business where the challenge to deliver both quality and high customer value with cost effective means has led to new ways in producing products faster, cheaper and with large flexibility and variability in the design. For this need different kinds of configurators have emerged in the field of mass customization [19]. Configurators are focused on collecting enough information to define the product, service or more recently a bundled offering [14].

In some sources the mass customization term has been defined in a very pragmatic way to highlight the importance of technological development and the role of IT-systems: "the technologies and systems to deliver goods and services that meet individual customers' needs with near mass production efficiency" [19]. The role of different kinds of information systems is highlighted in case of mass customization since information can be regarded as the most important factor for the implementation of mass customization [20]. Compared to mass production, mass customization necessitates a direct customer relationship in interactive definition of the product, gathering product related information from customer. Compared to pure customization, in mass customization this information needs to be gathered in a more structured and disciplinary way to support cost efficiency. Mass customization is successful only when it can cover this need for information and communication both purposefully and efficiently [20]. If the customer interaction has been designed poorly, customers can be overwhelmed by the number of choices during product configuration [21,22].

In [17], configuration is defined as:

"Configuration means to transfer customers' wishes into concrete product specifications. While the solution space is set up at the enterprise level, elicitation activities take place with every single customer's order. For new customers, first a general profile of their desires and wishes has to be built up. This profile is transformed into a concrete product specification and order. For re-orders made by regular customers their particular existing profiles have to be used. The old configuration may be presented and customers just asked for variations. The objective is to make subsequent orders of an existing customer as easy, efficient and fast as possible – an important means of increasing customer loyalty."

This definition too resembles the consumer business, but similar issues can be identified in B2B sector. For example, customer profile can affect directly to product requirements, i.e. different safety regulation in different countries, which is reoccurring requirement.

Also, an important aspect in achieving effective mass customization operation model is the definition of fixed solution space set before hand. The customer interaction process to configure the product inside this solution space should be made as convenient as possible. Automation of many activities is a vital part in this. Configurators are used to support in the definition process of suitable products and for automatically constraining the choice alternatives to the limits of the solution space. Tiihonen [23] presents the configuration process, where he divides the process into three stages, in each having their own type of configurability.

In extant literature, configurators are typically divided to two main types of configurators: 1. Sales configurators and 2. Product configurators. Sales configurators are used to collect the customer requirements, preferences, and selections. They are used by the sales personnel, more typical in capital goods industries, or customers directly. Product configurators are used to translate customer requirements to product structure for production. Product configurators are typically used by internal sales support or automatically according to input from sales configurator.

In addition, a third type of configurator can be identified: a design configurator. In this paper we focus on the examination of design configurator concept as a possible solution for more automated order engineering process for tendering and product designing. By automation of some previously manual tasks with a design configurator, integrated to CAD and PLM systems, transfer of order from sales to manufacturing can be hastened.

The fundamental difference with design configurator compared to sales and product configurator is that it extends the concept of configuration process, e.g. producing customer specific individual products, by creating individual CAD designs within CAD, PLM and ERP systems environment. This ability to automatically create unique drawings for components and products differs from sales and product configurators and justify the introduction of third class of configurators: Design configurators.

Sales configurators are typically focused to collect customer order for wide variety of mass customization models, and even for virtual mass customization models. In addition to manufacture-to-order and assembly-to-order operational models, they can be used also for more light-weighted customization. One of these models, suggested for automakers, utilizes locate-to-order operational model, a virtual and more cost-efficient version of build-to-order model [24]. In cases like this the sales configurator operates more like a selector for standard products [25]. The focus of sales configurators is to collect enough customer information for product definition.

Product configurators, on the other hand, focus on configuring the product structure for production, to identify items from solution space fulfilling the customer requirements. They utilize readily designed component and module libraries and matching and selection rules to build a coherent product structure. Sometimes the collection of customer requirements is integrated with product structure definition functionality, i.e. sales and product configuration functionality is implemented to one configurator solution, whereas in other cases the configuration models are detached to separate sales and product configurators.

Design configurators too need to collect customer requirements and might also include configuration of readily designed components, in addition to creating new drawings. Similarly, sales and product configuration functionality can be integrated to design configuration functionality in one total configurator solution, or these functionalities can be realized in separate but interoperable configurators. But distinct for design configurator, is its ability to create new components and modules.

This kind of adjustment to match to the exact needs of customer and to create new CAD drawing for new components and modules and whole products was previously considered belonging solely to pure customization and having nothing to do with mass customization concept [5]. With swift advances in ICT, especially in CAD and PDM tools, mass customization concept can now be extended to order engineering process as well.

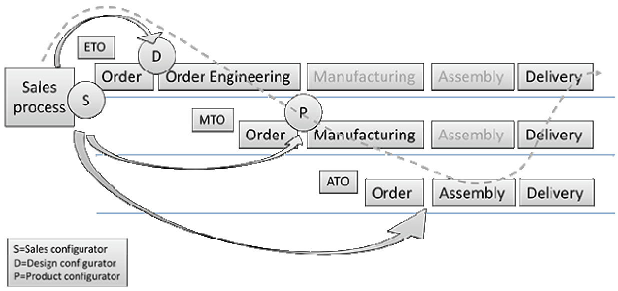

Fig. 1. Different configurator positions in order-delivery process

Figure 1 illustrates the typical uses of different types of configurators in different operational models. According to core functionality of each configurator type, each configurator can be locate to different phase of order-delivery process. The sales configurator can be located to between customer and sales or between external sales and internal sales support. The role of product configurator can be located to between the sales and manufacturing/assembly with no direct interaction with the customer.

A typical sales configurator can be seen to work between customer and sales either by operation of the company sales personnel or in custom software which the customer can use to make his choices for the product. When we compare the configurator to the process control methods figure 6 in [13] we can see that the production and processes are mostly ship-to-order (STO) and in some cases assembly-to-order (ATO) based with the sales configurator where the products have less customization but high mass production rate.

A product configurator usually acts as a link between the PDM / PLM software and ERP systems environment where the configurator uses fixed product structures to construct product details. These details include the product variants with selection rules to generate the appropriate manufacturing structure and documentation for the product at hand. Comparing product configurator to the process control methods figure 6 presented by [13] we see that production and processes with this configurator are more make-to-order (MTO) and assembly-to-order (ATO) based. The customization with ready-made components and ability to mass produce them are both on the average scale on the chart. In order to achieve desired efficiency it is claimed that modulization of product is an essential requirement [3]. One essential aspect of product configurator (like sales configurator) is that it acts as a user interface between the user and more complex PDM/ERP systems, thus simplifying tasks and responsibilities of user. As such a product configurators aim to tackle the difficulties of information linking when combining, selecting and mapping commercial and technical product data in the configuration process. Doing so it enhances the efficiency and responsiveness of companies which are key components when considering mass customization and product variety management. [26].

In addition to user group focused division of configurators, they can be divided into four theoretical variations according to knowledge modelling requirements and support they provide to users:

1. Primary
2. Forced sequence
3. Interactive
4. Automatic

In the first variation the selection of product components/modules are done from a pre-defined list. Forced sequence makes the selection of product components/modules happen from a list in certain order, reducing following available options after each selection. Interactive configurator makes each selection reduce other selection possibilities but the order of selections is then free. Last is the automatic selection which requires heavy modeling for transforming the use environment characteristics and user requirements to product features and components as the automation defines use-environment characteristics and requirements and not pure product components/modules from any list [8]. Another suggested division classifieds configurators into fabricators, involvers, modularizers and assemblers [27].

In addition, other type of configurators are also mentioned and described in the literature, with some similarities and relevance to design configurator introduced next. In [25] also a parametric component configurator is described for managing components whose parameters (such as length, width, height, diameter, etc.) change continuously, e.g. radius of a round table. Yet, no new drawing of the component is necessary in these cases, since delivering the varying parameter alongside with the product definition to production is enough. Also in [28] a parametric configuration is introduced that "enables the creation and selection of a product design without the necessity of pre-engineering and rules-based product documentation". Yet, even in [28] no new components are automatically designed, rather a larger assembly of pre-designed components/modules and their geometric and physical relationship is configured. A parametric configuration will "customize product designs; generate lists of features and parts for the product design; to generate a price quotation; and to enhance other post-design processes".

In [25] also a metaconfigurator is introduced for supporting a designer to rapidly "come up with a general product design that, even if approximate, must be reliable". A meta configurator might include complex rules such as technical regulations, safety standards, aesthetic features, economic aspects etc. to "provide tentative solution to to the designer" [25]. Design configurator introduced here can include similar rules but the target is to achieve final and complete design of individually customized products. Similar cases to design configurator are also already introduced in the literature. For example, in [29] a tool for the design of customized biomedical devices was introduced. A parameterization tool was used to modify the tracheal stent's general dimensions to fit a specific patient.

Thus, some case examples and literature has already emerged toward a design configurator concept, but more precice and clear definition and description and positioning of the concept is still required.

4. A CONCEPT OF DESIGN CONFIGURATOR

Design configurator extends the scope of mass customization and configurators towards the engineering processes. One primary characteristic of design configurator is that it requires a transformation from modular based product design approach to parametric design. Utilization of parametric CAD-models offers close to comparable variety to pure customization while offering possibilities to automation in model manipulation. Therefore it increases solution space compared to manufacturing-to-order approach while lowering lead time and possibly also engineering costs compared to engineering-to-order approach.

Thus, design configurator affect the variety level, costs and delivery time on way or other, depending on approach direction, from MTO or ETO, as illustrated in figure 2.

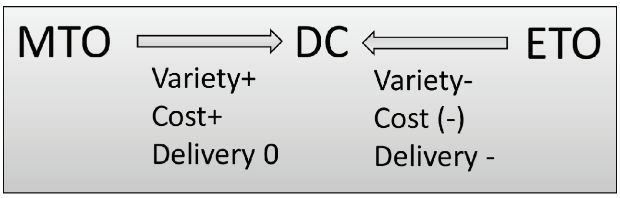

Fig. 2. Effects of a design configurator on variety, costs and delivery time when approaching from MTO or ETO

In this concept the digitized product structures are kept e.g. in PDM system and then constructed via different selective parameters through the configurator. The product skeleton is then pushed onward to CAD designing software where the digitized product model can be handled parametrically. Each line and dot in the product model within CAD can be controlled by the design configurator and details updated via ERP or PLM environment as needed. In figure 3 design configurator now bridges engineering-to-order (ETO) process closer to mass customization .

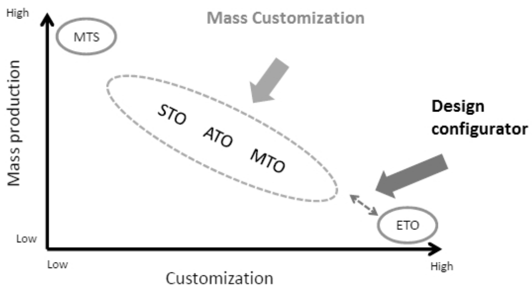

Fig.3. Design configurator in relation to mass customization (modified from [10]).

A design configurator hence enlarges the solution space from where all the product variations can be thought to reside. Basically it enables almost infinite variations though only inside the defined borders of the product specification which have been parameterized. Conceptually defined the design configurator handles the order engineering process as a whole. It takes input from sales, makes CAD design using some pre-defined models and in the end forwards its output to production. The key is in automating the design stage in order engineering and thus shortening the engineering lead-time. Automation can also lead to fewer design mistakes caused by human error and it can reduce repetitive manual work.

While research suggests that modularization is the essential requirement of effective mass customization implementation in MTO using product configurators, it is not necessary in ETO using design configurators. The essential factor in configuration of design is parametric models and supporting manufacturing system. This also have an organizational impact, when repeating part of engineering work can be automated and manipulated using configurator. Main design tasks are then linked in maintaining the parametric models, while the product variations are generated semi-automatically.

Looking at the impacts of design configurator on a corporation coming from either MTO or ETO side it can be argued that design configurator will affect the order engineering work significantly and thus, the organization of new activities and jobs should be designed jointly according to Socio-Technical System View [30]. This is because design configurator is an information system that involves complex interactions between people, machines, and the work environment.

There are several attributes and requirements which can be attached to a design configurator and one such list is seen below with a division between non-technical and technical requirements.

Designing principles of design configurators (non-technical):

- Regarding to socio-technical system view, design configurator is designed to certain task in certain social context and a fit should be found between these.
- The complexity of the task affects to how much resource is needed to complete the task. A design configurator should either decrease the amount of required resources for the completion of the task or to provide other advantage, such as better quality or shortened delivery time.
- What parts of the total effort are automated with the design configurator and what parts are done manually should be considered according to evaluated impact on business.
- The impact might be difficult to calculate, e.g. will the shortened throughput time lead to increased amount of orders? In some cases the solution might provide tangible cost savings which are easy to calculate and provide justification for the investment. In other cases, justification is probably based more on expectations on increased competitive capability leading to increased amount of orders. With design configurator, the amount of orders is not anymore linearly connected to needed personnel resources and thus, increase in orders/quotations will lead to increased cost-efficiency of order engineering with design configurator.

Designing principles of design configurators (technical):

- Ideally the configurator should be centralized in the order-production process where it can both initiate and handle the design process as a whole.
- It must operate then CAD-system with parametric models and optionally make queries with ERP, PLM and other needed software and push ready-made drawings to production when the order is finalized and accepted.
- Depending on the production environment the logical model and specific implementation place of design configurator must be thought thoroughly as various implementations can lead to very different levels of underlying model complexity and overall challenges in construction.

Because of the diversity of MC strategies between the mass and custom manufacturing mass customization practices can be implemented into ETO business with various ways. Inside these strategies the implementations of configurators also vary and in the case of design configurator different strategies can also be listed. In addition to fully automated configuration process a variety of partial configurators exists [25]. Below are few examples of these implementation strategies from very partial level configuration process to fully automated one. These examples were also found from the case studies and from literature.

- offering component library, utilizing standard components in design
- offering assisting design tools for standard solutions
- Re-Use of designs
- Parametric CAD-models
- Automated

5. CASE STUDIES

Next, we present three short cases to illustrate the current development in ETO companies toward mass customization. Cases also demonstrate that a continuum of different strategies and methods exists also inside what we have here labeled as a design configurator.

5.1 Case Peikko Designer [31,32,33]

Peikko Group is 1965 founded family owned company specializing in composite beams and fastening products for concrete connections. They provide innovative solutions to help customers make their building process faster, easier and more reliable. Their target is to supply a large selection of concrete connections and composite beams both for precast and cast-in-situ (cast-in-place) solutions in wide variety of applications.

Peikko Group's vision is to be the leading company in the field of fastening technology for concrete constructions (both precast and cast-in-situ) and with Deltabeam composite beam for slim floor structures. This leadership for Peikko means innovativeness of products, high recognition among designers and end-users, and local presence globally.

To aid different companies in deciding and utilizing Peikko’s structural solutions Peikko have created a specific design and calculation software for its customers which is focused on assisting structural architects in their jobs. This free and interactive 3d designer platform can be used to design and calculate bolted column foundations and punching prevention reinforcement structures. The end result can be exported to AutoCad and all the component details with calculation results can be printed out. The main benefit using the software is the ability to calculate the actual results with the real structures which can then be exported to other design environments. Peikko also offers design components to other design environments like AutoCad where Peikko’s structures are added as product library to the underlying program.

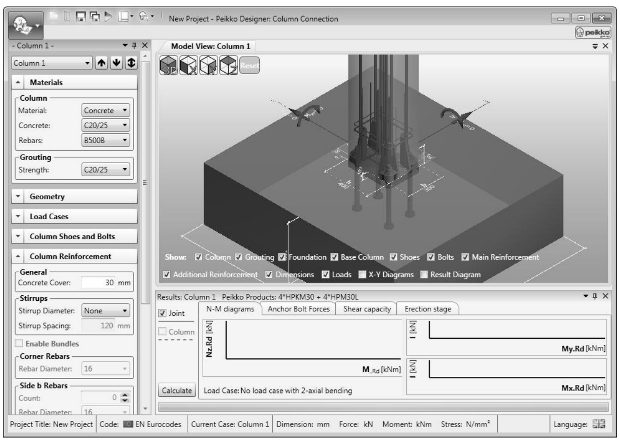

Fig. 4. Peikko Designer

The main benefit having Peikko's design components as a product library are the up-to-date details on the structure components that Peikko regularly maintains. This way the designer can be assured that he uses right kind of structures and can view the end result with calculations immediately on his overall product.

5.2 Case Cargotec MacGregor [34,35,36]

Cargotec MacGregor, part of Cargotec corporation, offers integrated cargo flow solutions for maritime transportation and offshore industries. One of their product groups are hatch covers.

Each merchant ship design is a complex puzzle of thousands of components and materials with varying requirements. Hatch covers are a vital part of this puzzle. Cargotec and its partners have developed a systematic and fast computerized configuration model for side-rolling hatch covers, which reduces design throughput time, improves productivity and provides a platform for consisted quality throughout.

Hundreds of customer requirements are compressed to a few dozen engineering parameters. Computer modeling finds an optimal customized solution by analyzing data systematically and quickly. Shortening the process speeds the purchase of critical parts. This brings competitive advantage, increases productivity and saves on costs.

As a result, design lead-time was reduced from average of 8 week to one or two days.

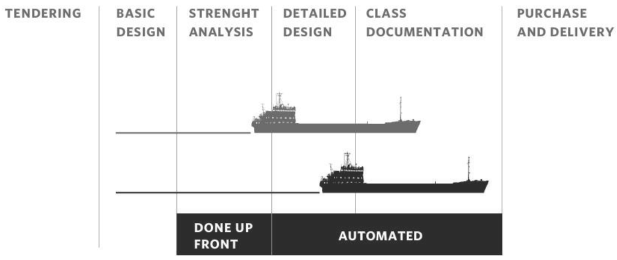

Fig. 5. Change in engineering activities [36]

A typical project needs four separate model configurations and about 30 drawing are automatically produced from each hatch model, which fully describe the design for the shipyard, manufacturing and the ship classification society.

5.3 Case Asoma Studio [37,38,39,40]

Asoma plc is a 1942 founded producer and a contract manufacturer of technically advanced precision components using a vacuum forming method. Their production method uses heat and negative pressure to shape plastic sheets. The advantages of vacuum forming over other manufacturing methods include low mould costs, lightweight, shock-resistant and readily shaped products, rapid R&D, and a 100 per cent material recycling rate. Their customers are typically leading enterprises in the automotive and electronics industry, the engineering and appliance sector, and the hospital and sanitary industry. Asoma offers services from product development to full production of ready-made products according to customer requirements. Minimal start-up costs and rapid R&D phase of vacuum forming enable short series production and ETO operations.

Asoma's vision is to generate added value for its customers at all stages of the R&D process from design to final manufacturing. The most important question in sales process is whether or not Asoma's manufacturing technology fits for the customer's product. In order to speed up the sales process Asoma launched a portal service called Asoma Studio in the beginning of the 2012.

Asoma Studio offers tools for customers and enables them to evaluate their designs against Asoma's production technology, calculate costs, manage the order process of even large projects, and view, comment and adjust 3D-models with designers. It saves time in customer new product development process and enables 3D-designing even if the customer wouldn't have their own design tools. It also educates customers about possibilities and limits of different technologies, applicability of materials and costs of production, fostering customers' NPD-processes. It also stores and manages all documents and comments related to order process ensuring up-to-date design documentation during the whole order-delivery process.

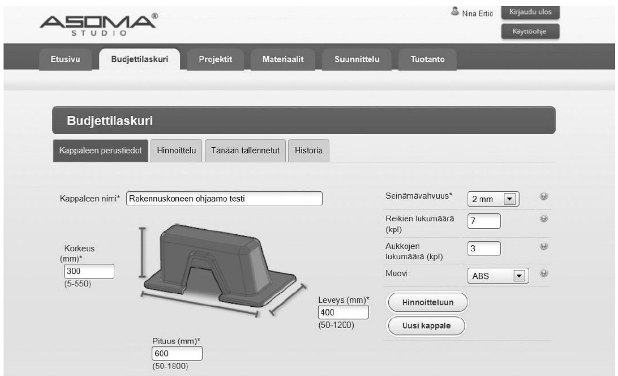

Fig. 6. Asoma Studio's budget calculation tool based on different measures, material selection, material strength and number of holes [40].

Asoma studio is built on cloud service and is based on Microsoft technologies and CadFaster 3D collaboration tool. It provides tools for collaboration, streamlining the sales process and order engineering, cost calculations and for project management.

6. CONCLUSION

As cases demonstrate, many companies are already offering different kinds of engineering tools to assist customers in the product definition process. Increased global competition lead to automation and digitalization in non-cost-competitive-countries, not only in production but also in product development activities, order engineering being in the front line. Current development and these first examples suggest that eventually full blown design configurators for order engineering will be constructed as a solution to increased competition in industrial markets. Design configurators promise faster response times for product quotations and order engineering process, critical for winning orders in turbulent business environment.

Design configurators enable fast response and can decrease order engineering lead time even dramatically, but they also require modeling capabilities of complex products, sophisticated design systems and maintenance. As such, they do not necessarily decrease costs but rather change how the work is organized. With design configurators, the most of the order engineering work is done in advance, i.e. modeling the product architecture, scalability, qualities, options, and their legal variations. Needed work for order engineering become more stable and incessant from nature; fluctuation in demand does not anymore have such dramatic effect on needed workforce, merely more computing power is utilized. Some of the old job vacant become unnecessary (order engineer) and new job vacant emerge (product architecture designer, product variation manager, product modeling expert, etc.). Benefit for competitiveness arise from better response ability to customer quotations and orders.

However, some difficulties still exist, such as handling the FEM calculations feedback and adjusting the design automatically accordingly.

Future research is needed to improve our understanding of CAD-level configuration process, required IT-system integration, the use of and effect that design configurators will have in order engineering process, and limitations of design configurators.

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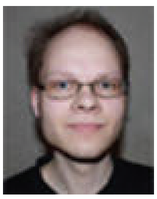

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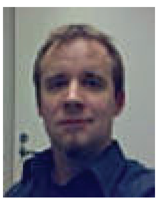

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