Attacking the Critical Parts in Product Development

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Marin Platform - Building Flexible Structural Elements for Boats

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Abstract. The product cycle is changing, where time legs are shorter, high volume- and cash cow-phases fading. Rapid product introduction and customization are keywords, and often associated with modularization. The objective is to create a flexible product design, not requiring changes in the overall product design every time a new variant is introduced. This has been a feasible strategy for manufacturers of small boats in high-cost countries where an incremental development process is well suited for modularization. However, also more radical innovations are needed, not only change modules and product configurations but also have to develop new product platforms. We then have to deal with the critical, resource demanding processes. This conceptual paper describes how boat builders take modularization to a higher lever by attacking the critical parts in product development, i.e. the structural elements of boats.

Keywords: Innovation, modularization, product development, leisureboat

1 Introduction

At an IMS (Intelligent Manufacturing System) meeting in Zurich in 2007, leading academics and industrialists identified four major drivers for change [1]; globalization of manufacturing; extended enterprises; digital business; and innovation. The financial crisis that hit global markets from 2008 reinforced this picture. We have seen how tough market conditions are met by enterprises that try to gain new market shares by surpassing the customer's expectations, innovate and constantly establishing new market standards. The product cycle is changing, time legs are shorter, high volume- and cash cow-phases fading. Consequently the initial innovative- and product development phases of the product life cycle are getting more and more important. Companies need to find ways to reduce costs and/or gain good money in these initial stages.

The above changes are reflected in recent manufacturing paradigms such as "mass customization" introduced by Stan Davis [2]. He describes mass customization as when a large number of customers could be reached as in industrial "mass production", but at the same time be treated as in customized markets like craft production. However, product differentiation has normally resulted in higher prices than standardized products [3]. This is also the situation in the leisure boat industry (and related industries) where it has been difficult to get a higher price from more innovative and

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customized products then the competitors. As a consequence strategies based on customization, frequent product introduction and innovations must be based on resource effective product development and production.

Modularity is a key to achieve low cost mass customization as products built around modular architectures can be more easily varied without adding too much complexity to the manufacturing system [4]. A modular design strategy reduces product costs by partitioning some functions in a product architecture into component designs that will be used in common across product models or reused in future architectures. Standardized modules allow for mass-customized products to achieve the low cost and consistent quality associated with repetitive manufacturing [5].

It is very resource demanding to develop a completely new boat model. Instead of searching for "an optimal design for an optimal product," the objective should be to create a flexible product design, allowing product variations without requiring changes in the overall product design every time a new variant is introduced. However, even though module-based design is an efficient way of reducing product development costs, the steps for the initial overall product architecture and platforms, might be found very resource-demanding. For boat builders these costs are often related to the hull-development, inner liner and structural elements. Focusing on these critical parts in the product development process could reduce time and resources thus enabling competitive prices for customized and innovative products.

The purpose of this conceptual paper is to illustrate how modularization could be the key for more effective (time and resources) product development and production of boats, when focusing on the critical parts of the boats – the structural elements.

The paper is based on a R&D project involving manufacturers of leisure boats and boats for the professional markets. The project is at an early stage and so far the activities have mainly been to develop hypothesis, challenges, and how to approach them in concrete contexts. The project is closely related to what is happening in the companies (case studies) and the researchers aim to participate in the product development processes in order to improve them through action research. Literature studies have also been important for the project (and this paper) at this early stage.

Section 2 presents theoretical perspectives on innovation and modularization. Section 3 presents the R&D-project while Section 4 focuses is a discussions around major challenges in the project and how they are approached. Section 5 concludes.

2 Theoretical Perspectives

2.1 Innovation and Innovation Management Concepts

Innovation has been defined as the process of making changes in something established by introducing something new [6]. In an ever-changing economic landscape, innovation has become a key competitive factor in manufacturing. Continuous improvement and incremental change is not enough - companies also need to be part of major changes. Innovation is no less important in manufacturing than any other section of industry. Innovation in manufacturing can be either radical or incremental, but where most organizations are involved in both types of innovations [7] .

Arthur D. Little, describe five innovation management concepts on how innovations could be dealt with depending on strategic contexts [8]. *Customer-based Innovation* is about profoundly involving and engaging customers to create innovative solutions. In contrast to traditional innovation, *Frugal Innovation* have their basis from lower-income, emerging markets, which are then transferred and adapted into the more developed markets. *Proactive Business Model Innovation* focuses on developing mechanisms enabling the generation of new, innovative business models. In *High Speed/LowRisk Innovation* further development of approaches and tools to drive fast, de-risked product and service innovation are focused. *Integrated Innovation* is about taking innovation approaches from New Product Development (NPD) such as idea management, stage gates and portfolio optimization, and applying them consistently as an integral part of business strategy. [9]

2.2 Modularization Enabler for Efficient Product Development

Modularity allows part of the product to be made in volume as standard modules while product distinctiveness is achieved through combinations or modifications of modules [11]. Modularization could bridge the advantages of: (1) standardization and rationalization, (2) customization and flexibility, and (3) reducing complexity [10].

The cost effects through reduced product development lead time and volume effects from standardization are important, but there are also revenue aspects of modularization: With a modular product platform structure, a set of building blocks (modules) is created with which, through different combinations, a great number of final products can be built. Parts of the product that strategically should vary to satisfy customer needs are well defined and separated from the parts of the product that should be kept as common units. In this way, many variants of final products can be handled without increasing a company's internal complexity.

Parallel development activities are possible once the interfaces between the modules have been defined, and subsequent work conforms to the established interface specifications [14]. This reduces overall development time and resource requirements by eliminating the time-consuming redesigns when component interfaces are not fully defined and standardized during component development processes [13].

2.3 Functional Approach to Modularization

By breaking a complex product structure into smaller, manageable units, a company can regain control of the product and the product-related activities. Modularity aims at increasing efficiency by reducing complexity. We often find module-based design within incremental product development, where e.g. not all innovations or "novelties" are introduced at the same time. However, to exploit the benefits of modular product development, it is crucial to have modularization in mind from the start of the design process, and not only as an afterthought when all components are developed. If modularity is identified and exploited in the initial conceptual or reverse engineering effort, the immediate product design reaps benefits in several strategically important areas.

Modularity has often been about splitting up products systematically in logical/practical units and parts. Today modularization based on functionality is a common approach and methods have been introduced to cut out a module from function structures using module heuristics [14]. These methods such as Modular Function Deployment (MFD™), identify modules from a functional model of a product, create rough geometric layouts and group products into families based on function [12]. Rather than a fixed product platform upon which derivative products are created through substitution of add-on modules, this approach permits the platform itself to be one of several possible options. After comparing function structures for common and unique functions, rules are applied to determine possible modules. This "inverse" process defines possible architectures. This approach increase the flexibility as it also represents a modularization of the basic platform [16].

A systematic approach needs knowledge from people that knows customer demands, service requirements, and from those producing the products. Concurrent engineering could be a key to mobilize and capture this knowledge [15]. An important part of the knowledge of the company is embedded in the products and reusing modules knowledge saves time and money. Also reuse of engineering specifications, testing, process engineering etc, may lead to the desired effects by blurring the boundary between knowledge management and traditional modularization [17].

3 Marin Platform – the R&D Project

Marin Platform is a 4-year R&D project started in 2012. The overall objective of is to radically improve the product development process focusing on the critical and resource demanding phases related to the structural elements of the boat. The project aims to define the premises and solutions for a flexible structural platform. Focus is on design for manufacturing (DfM) and how to involve the operators (craftsmen) in improvement and development.

The project has four Norwegian industrial partners: two SMEs manufacturing leisure boats, one large partner in the professional market and one SME supplying boatbuilders. The SME boat-builders operate in different markets, where one is making GRP boats in the high- end markets for speedboats 24-33 feet. The other makes GRP and aluminum utility-boats in the same size-range. They both want to use the project as an enabler for product configuring for new markets, especially the professional market for smaller boats. The large partner is a world leading company producing advanced lifeboats, davits and a range of different products for, rescue, marine service and military markets. One of the main objectives for this company is to come up with better DfM. The SME supplier is a key actor in the boatbuilding industry as it is the biggest and most important supplier of their products in the Scandinavian boatbuilding industry. The company is within the mechanical engineering industry, but still has many of the same characteristics of craft manufacturing as the other partners.

SINTEF is project coordinator and two other research partners are also contributing to the action research, The University of Agder and Inventas. The project is co-financed by The Norwegian Research Council.

4 The Key Areas of Research

4.1 Customization and Product Development

Craft manufacturing industries such as the Norwegian leisure boat industry has been characterized by small-scale production and high levels of customization. With limited resources for R&D and investments the development processes have been incremental where changes have been carefully introduced in new or modified products. Today, the need for "news" and more radical product innovations rocks this picture.

An advantage of craft manufacturing is the involvement of the persons actually making the product, but also by the customers and has resulted in high quality and a high degree of customization. However, the extensive use of tacit knowledge when it comes to sharing design requirements and good practice, and standardization.

Marin Platform has used MFD methodologies to define customer requirements as a starting point for the innovation- and product development- process. These requirements are then prioritized and extracted into a design brief describing the new concepts, setting the direction for the product development. Figure 1 illustrates the conceptual model describing how customization trigger the process for developing module based design, flexible structural platforms and module based production.

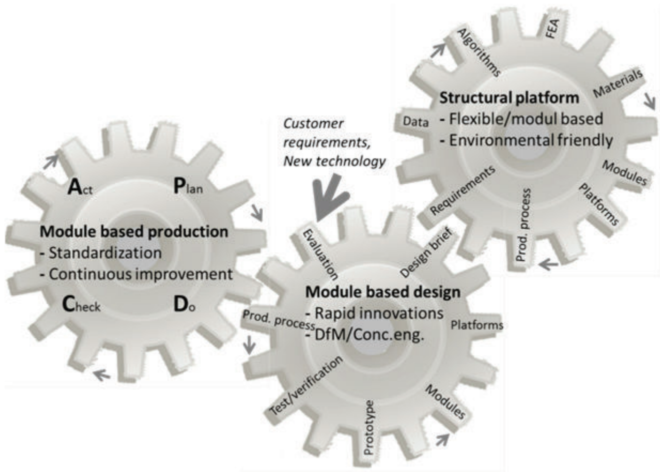

Fig. 1. The conceptual model of Marin Platform

At the early stages of the product development process it is important to check out the business effects of the customer requirements and new concepts. Marin Platform has conducted BEEM (BEEM: Business Effect Evaluation Methodology)-analyses in all companies to get an early picture of expected effects on; customer value; (internal) cost/efficiency; growth (new revenue streams); sustainability [18]. BEEM is based on workshops involving people from technical departments, production, market/business, and to some extent also external people (customers, suppliers and consultaints). Table 1 illustrates effects on cost described by one of the companies.

Table 1. BEEM Marin Platform, excerpt cost effects

Business outcome - Structural platform	Weight 1=low, 6= high	Stay even Score=1	Significant advance Score=3	True tech. break-through Score=9	Company target	Primary risk(s)
Cost reduction associated with materials and optimation of laminate (hull, deck etc osv)	6	20% average reduction all models	40% average reduction all models	60% average reduction all models	40% average reduction all models	* To finance a complete redesign
Reduced number of components new models, right use of materials (aluminum, stainless etc)	5	0 %	10 %	40 %	20 %	* loose "design"-signaturen * Being to much product-oriented
Increase reuse of components new design	4	20 %	30 %	75 %	30 %	* Being to much product-oriented * Finance the initial change
More efficient variant handling/tailoring	6	0% cost reduction customer handling	20% cost reduction customer handling	45% cost reduction customer handling	35% cost reduction customer handling	* Communication to customer * Coordination sales-production etc
Reduced development "soft" cost hull (software/drawing/spec/calculating)	5	0 %	20 %	50 %	30 %	* Unable to develop calculation-modules * Education of personel
Reduced development "hard" cost. hull (physical)	6	0 %	20 %	50 %	30 %	* Not able to develop dynamic mould * Theoretical basis for new mould
Number of platform-variants from each mould	6	1 platform-variant	2 platform-variants	10 platform-variants	3 platform-variants	* Not able to develop dynamic mould
Reduction in resources used for CE-cetification new models	4	same as today	30% reduction in resources used	70% reduction in resources used	50% reduction in resources used	* More and more complex standards * Lack of competence at authorities

4.2 Flexible Structural Platform as the Basis

The product development of leisureboats has been characterized by a lack of well-defined phases, roles, resource control, documentations etc. The product development is so resource demanding that even the prototype has to be sold to a customer. The (first) customer is often highly involved in the development process making design freeze to an irrelevant term and could overshadow the general customer requirements.

One of the consequences of this diffuse process is that the required structural elements have been added to the design at a very late stage - sometimes as "trial and error". Even though the result of this process has been boats of high quality, the products could be even better with another approach to the structural solutions. For certain a more resource efficient way to develop them is needed.

One of the ways Marin Platform aim to improve the product development process is to introduce more systematic approaches such as MFD. MFD has the following basic steps: (1) design requirements, (2) identification of functions that fulfill the demands and their corresponding technical solutions, (3) technical solutions are analyzed regarding their reasons for being modules, (4) module concepts are then generated and the interface relations of the modules derived are evaluated. In the final step, (5) a specification is established for each module.

For boats and other complex marine products there are to a standards and requirements issued by regulatory bodies (EU-standards), classification agencies or key customers that could limit modularity options within critical areas such as interfaces/connections of modules. However, these requirements when captured in the initial step (1) of the MFD process could also indicate options in functionality and modules.

Table 2 illustrates design requirements for a boat that is to be designed and developed both for the leisure- and professional market (rescue boat).

Table 2. Excerpt design requirements

Customer/market requirements	Weight 1=low, 10=high	Basic functionality														
		Mould for different configurations: define basic principles, geometry	Common solution for pentry and toilet with other products/areas	Common solution: benches, tables etc	Fixing/interfaces: flexibility vs. Robustness	Structural modules - flexibility across models and fields	Technologies for surveillance of quality,service needs etc	Materials, coating adjustable for different climate and conditions	Equipment for survival	Driverless technologies	Navigation, communication	Flexible driveline	Ergonomy/HSE/smartness	Speed/seaworthiness	Quality/durability	Design/coolness
		7	7	5	9	9	9	8	7	5	5	7	7	9	8	8
MOB 6-10 meters: waterjet for the range	9	o	o	o	o	o		o		o		o		o	o	o
Freefall 16-21 meters	4	o	o	o	o	o	o	o			o		o	o	o	
MOB: 22-36 persons	8		o	o		o			o					o		
Freefall: 16-40 persons	3					o			o					o		
Configurable for: cruise, cargo and tankers, as well as police/amb./military/etc. and	9	o	o	o	o	o	o	o	o	o	o	o	o		o	o
Quality (doc) according to North see/Solas	9	o				o	o	o					o	o	o	
Transparent production process	5															
Alternative material: alum. GRP..	5	o	o	o	o	o	o	o			o	o	o	o		
Good interfaces with davit -upgradable	8	o			o											
Flexible solutions for production (capacity)	7		o	o	o	o			o		o	o	o			
Certified before customer takeover	7	o			o	o	o		o					o		
Technologi vs robustness	5		o	o	o		o	o		o		o				o
Solutions for surveillance/self-testing	7									o	o	o		o		
Easy to operate	9						o			o				o		
Effective testprogram	3								o	o	o	o			o	
Be used in different climat zones	8		o	o	o		o	o	o	o	o	o	o	o	o	
Produced in Europe	5	o										o	o	o	o	o
"Safety" feeling for people/passengers	4		o	o			0		o	o	o		o	o		

Structural elements are critical in the development of boats and Marin Platform focus on how structures could be developed more efficiently and be the premises for the rest of the product development. The idea is that once the basic requirements of the boats are defined (Table 2) and described in the design brief, the structural performance should quickly be developed through structural modules. Structural modules could be; (part of) inner liners; stringers; windows/doorframes etc. Research activities in Marin Platform will conduct stress-strength analysis of these elements to understand how they could represent modules in flexible structural platforms. It requires extensive data collection, testing and simulations to develop algorithms/models for different configurations and structural platforms.

4.3 Module Based Design and Production

The structural platform defined through structural modules represents the "room to maneuver" for the rest of the module based design process. The basic design requirements are taken into account in the structural platform, and the rest of the modularization process will focus on optimization of modules and functionality for example through the MFD-steps.

The modularization represents to some extent constraints for the customization but could also give a clearer picture of the opportunities and choices for customers. The positive effects on product development time and -cost are expected to more than offset the negative effects. However, to realize and exploit business effects described in the BEEM exercise, Marin Platform also involves production and other functional units in the conceptual model for product development (Figure 1). This implies standardization of processes but also continuous improvement. Concurrent engineering is a key for a broad and structured involvement [15]:

- increased role of manufacturing process design in product design decisions
- formation of cross-functional teams to accomplish the development process
- focus on the customer during the development process
- use of lead time as a source of competitive advantage

A significant part of concurrent engineering is that the individual employee is given much more say in the overall design process due to its collaborative nature. Modularization is also important for the people in the production since it to a large extent is about DfM and standardization of production. Knowledge about these aspects will often be found at the shop floor.

5 Conclusion

Innovations and high speed product development is more and more important in manufacturing industries. Customization and flexibility have for many companies been the strategic response to challenging competitive situations. Modularization has been launched as an enabler for customization and resource effective product development and production. These ideas and strategies have also been adapted by boat builders that have traditionally been characterized by craftsmanship.

Marin Platform is a 4-year research project where boat builders and suppliers together with research institutes focus on the critical parts in product development – the structural elements. The project aims to develop modules that could "easily" be put together into different structural platform for boats. This is difficult as it requires research in fields such as material technology, hydrodynamics, and dynamic stress-strength analysis.

There is a risk for not finding the "right" answers, but also for not being able to develop prototypes and physical manifestations of the research. The research project started in 2012 and so far the activities have mainly been preliminary analysis. However, this initial phase has already shown that we are on the right track where modularization is important for customization and mass customization strategies. We are also more confident that to optimize the effects of modularization we have to attack the most critical and difficult parts in the product development, which for the boat builders are the structural elements.

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