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IMPLEMENTATION OF TARGET COSTS IN MASS CUSTOMIZATION DESIGN PROCESSES

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1. Introduction

1.1 Mass Customization

Product development is facing new challenges. In the last couple of years product markets are shifting from sellers to buyers markets and many companies are searching for new ideas to enhance their profit. “Individual configuration” and “product variants” are two of the key-words which seem to address this problem. The growing number of variants has become a significant problem in highly integrated and complex products of mechatronical engineering.
As a consequence, made-to-order strategies like mass customization try to combine the aspects of craft production and mass production systems, to create a high volume of varied products, with high quality at low costs [Ishii 1995]. The goal of mass customization is to get more personalization at mass-production prices by taking advantage of recent improvements in technology. While this concept has started and already is implemented in the apparel industry, processes, methods, tools, strategies, and principles have to be adapted and developed for mechanical engineering [Lindemann 2003].
Regarding literature of mass customization from product development perspectives, the aim is to design a well-balanced product variety in the preliminary stages [Piller 2001]. Later, the customer has the possibility to configure an individual product from a variety of stock parts and modules. Standardization and modularization lead to low costs, similar to mass-production. However, this procedure does not sufficiently fulfill the central idea of customization: it does not focus on the individual customer.
Acting as a “co-designer”, a customer can develop her or his own “personal solution” which merely goes beyond a combination of standard parts and modules. This is truly the most advanced embodiment of mass customization. In addition, successfully fulfilling customer wishes with a personal product presents an entirely new value proposition. This requires a comprehensive and integrated approach covering different aspects such as business administration, production and logistics, as well as product development. Thereby, product development might be divided into structure planning, i.e. the predominantly and customer independent preliminary development, and the adaptation processes, i.e. the derivation of the individualized product [Lindemann 2003].
This paper concentrates on the product development and focuses on target costing in mass customization. The paper proposes implementation of a target costing model and discusses the differences to ‘conventional’ target costing. The second part of this paper is the presentation of a cost estimation tool that has been developed for estimating the design and production process-costs during the product adaptation.

1.2 Characteristics of individual design

Considering mechatronical consumer products, the sample product of our research work is a commercial high pressure washer. Figure 1 presents this high pressure washer with different customization eventualities. This example reflects different characteristics of mass customization and exemplifies that they are not mutually exclusive but rather complementary. The picture summarizes four possible customization characteristics: 1) Design-Customization, e.g. the customer wants to adopt his favorite color for the product-body, 2) Form-Customization, e.g. the customer needs a special geometry according to storage issues, 3) Function-Customization, e.g. the customer wants less functions to save money or he needs more functions for special applications, and 4) Fit-Customization, e.g. personal anatomy requires additional modifications.

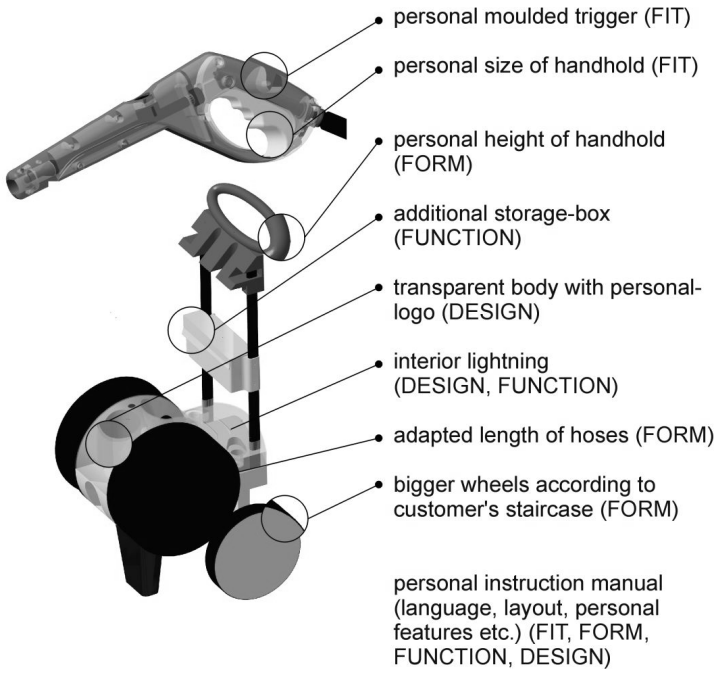

Figure 1. "Mass customized high-pressure washer"

Not presented is the potential to satisfy customer wishes and needs by personal services like financing-service, 24h repair-service etc.

But what exactly is the difference of the mass customized (mechatronical) product to a conventional product? There are several distinguishing marks: 1) The mass customized product is a bundle of physical products and service-offers, 2) the product variability will not be determined completely during the planning phase due to the customer's co-design, 3) thus causes individual components which have to be adapted to individual customer wishes and needs, 4) thereby the conventional product development process has to be divided into a product planning phase and a product adaptation phase. 5) Eventually the mass customized product price is comparably low at serial production level.

2. Competitive pricing with target costing

2.1 Target Costing in mass customization

Target Costing is a management strategy and supports methodologies to achieve an affordable product by treating target cost as an independent design parameter that needs to be achieved during the development of a product. As shown by Ehrlenspiel [1998], approximately 70% of cost of the product on the company is determined during the planning and the design stage. Considering the cost determination, it is important to set target costs during the development stage to prevent the product from "over-engineering".

The general goals of target costing within mass customization are almost the same as published in target costing literature, such as: 1) Price led costing, 2) Focus on Customers, 3) Focus on Design, 4) Cross-Functional Involvement, 5) Life-Cycle Orientation, and 6) Value Chain Involvement [Horváth 2002]. The main differences and also new aspects arise by the implementation of target costing into the previously mentioned mass customization design processes with the product planning and the product adaptation process.
The product planning process puts up a product structure, which is essential for the following adaptation process. The product structure contains various objects e.g. degree of freedom of customer wishes, basic requirements, concrete product components and the possibilities of realization in concrete specifications. The main goal for target costing during the product planning process is to define and to control the monetary environment of the product structure and its objects. In contrast to 'conventional' target costing it is not only one singular product which has to be considered, but the whole product spectrum, i.e. many different product customization alternatives. Another aspect is that it is impossible to consider every customization possibility within the product spectrum and vice versa with target costing. Nevertheless, target costing must enable planning and control of overall costs in the product spectrum.
The second part of the development process is the individual adaptation process in interaction with the customer. Until then, the structure developed in the preceding process part is accessed so that complex relationships do not require re-mapping in this time-critical phase. Furthermore, the necessary real-time analysis of customer choice, e. g. analysis for plausibility, is based on the existing structure of the product spectrum developed in the process of structure planning [Pulm 2003]. However, additional design tasks can not be eliminated and have to be completed due to unpredictable customer wishes. In this case, setting up target costs is necessary to regulate the adaptation process efforts in a cost-value manner. Even early evaluation of costs provides a basis for decisions whether continuing the adaptation, i.e. the customer agrees with the product price, or not.
These two stages of the mass customization design process require both a new flexible and a semi-automatic approach of target costing in order to achieve competitive prices for the mass customized product.

2.2 Implementing target costing in mass customization design processes

In order to implement target costing into the design processes of mass customization, a model has been developed (s. Figure 2). On the one hand, this model contains the product life-cycle modified to mass customization and on the other hand the concept of target costing for customized products. This clarifies once again the importance of the life-cycle orientation and also illustrates the inputs and outputs of the target costing concept over different periods of time.
The life-cycle of mass customized products begins with the market research phase and ends with the product return phase. In between, the life-cycle contains the product planning phase, the customer reception phase, the product adaptation phase, the production phase and the service phase. The illustration also emphasizes the modified product development process. Among other aspects, the individual customer (e.g. customer reception) is an essential part during the engineering process and requires new approaches in costing methods.
The target costing model (s. Figure 2) consists of two layers (Costing Level I & II); whereas the second layer builds on the results/information of the first layer. This principle of 'cost-cascading' builds up extensive cost information during the product planning process and reduces calculation time during the time critical product adaptation by accessing the preceding calculations. However, the reduction of calculation time is dependent on the degree of recognition of the customer wish. In case of an unpredicted customer wish, standardized or semi-automated costing procedures have to be started during product adaptation (Level II), e.g. checklists, computer aided tools etc. A first approach of a computer aided cost estimation tool will be presented in the following paragraph.
The overall goal of Costing Level I is to set up target costs in the product planning phase and to manage the monetary environment. Hereby, the target costing starts with the target price acquired by market research and puts up a target costing frame containing all objects of the product spectrum, e.g.

degrees of freedom, standard components etc. The last step is to maintain the target costs during the planning phase by taking measures in case of deviation of target and actual costs.
As mentioned, the Costing Level II builds up on the cost calculation of Level I. In contrast to the first level, target costs are dominated by the individual customer. This causes the setup of individual target costs.

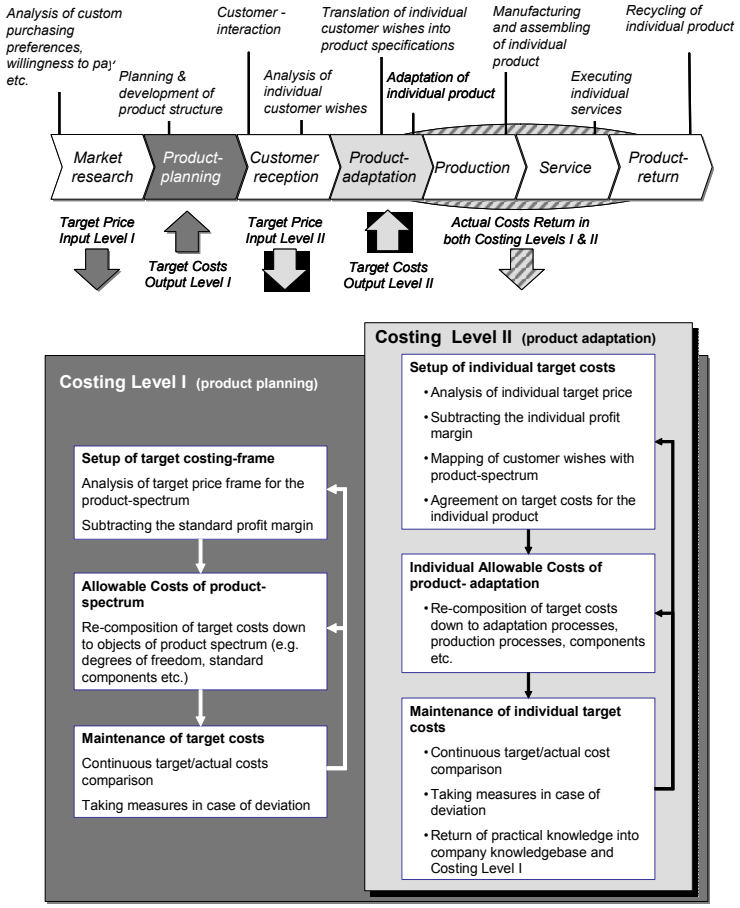

Figure 2. "Model of Target Costing for individualized products"

Once the targets are known the costs have to be decomposed down to components, adaptation and production processes in order to control the customization efforts. Last but not least, it is also important to maintain the individual target costs.

3. Cost estimation for customized products

3.1 Requirements of the calculation tool

There are many objectives the tool has to cope. Each mass customized product is characterized through its overall costs. The main demand of the tool is to calculate the known cost factors based on the data of completed projects or on the personal experience of the user. The result will be the estimated costs of the customized product and the level of forecast uncertainty for the overall costs as well as for the direct costs. The forecast uncertainty is comparable to the Risk Priority Number (RPN) of the Failure Modes and Effects Analysis (FMEA) methodology, and identifies factors such as main costs activities, strategic project activities, uncertainty cost factors etc., and keeps the control of the whole estimated costs repartition. It is a mathematical product of cost estimation impreciseness and the cost-proportion of each activity relating to the overall costs.
Further the integration of overhead costs has to be realized by integration both, the product and process costs in the calculation. As far as there are many common activities for product development projects similar from project to project, the tool can be used as a check-list where all obligatory

activities are already stored and can simply be adapted for the current case. It will help not only reducing the volume of work but also to standardize the description of planning or adaptation activities. It is very important that all of the data from the previous projects can be used as a basis of information for the future work. The tool requires access to information on completed projects, e.g. already known costs, obligatory activities, existing components, etc. It uses this information for new customization projects and again stores them as a future source of information.
In the early design phases, decisions have to be taken rapidly. For this reason, the tool has to offer good visualized and easily interpretative results, which are understandable without special training of users. Meaning navigation through the whole cost structure, its manipulation and interpretation must be intuitive and clear. It is the only way to keep control over the whole project, its costs and activities structure.

3.2 Implementation of the tool

The tool was created by means of MS Access and Visual Basic. It consists of two main parts: the front-end, which is individual for the each customization project, and the back-end, where all information from previous projects is stored. The GUI of the tool can be divided into three main parts with its functionalities (s. Figure 3).

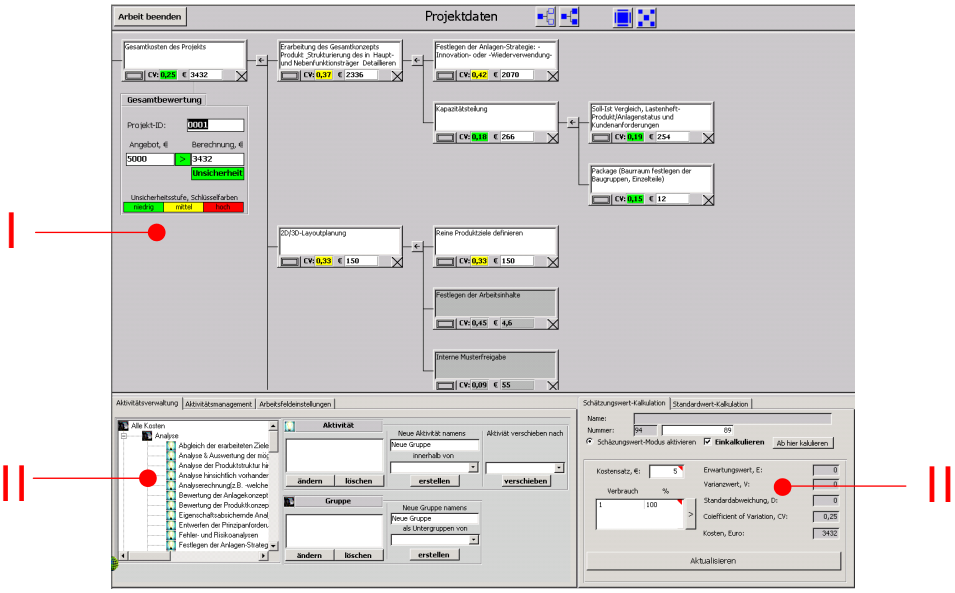

Figure 3. "The overall GUI of the tool"

Costs visualization area (I): The whole structure of the project activities is visualized in order of a hierarchical flow tree. All activities can be manipulated (delete, activate, hide, show) in order to represent exactly the project structure. The estimated costs and its forecast uncertainty are given for each activity. The color indicators are used to visualize the different levels of uncertainty; it allows concentrating user's attention on the critical activities. It is similar to visualization in other technical software solution like IT-supported FEM-analysis. Because of the high quantity of activities which can be involved in a project there is danger of user's overwhelming with data and as a consequence loss of the overall view. For this reason, the tool offers two different visualization modes of the project structure (s. Figure 4). The detailed structure view contains a comprehensive amount of information but needs a lot of scrolling in the case of large projects. The compact structure view allows identifying the critical modules immediately as result of its simplified data representation.
Costs Calculation Area (II): This part of GUI contains the detailed information of calculations and its parameters. Based on the input data costs and uncertainty of each activity will be calculated. There are different ways to evaluate the input information, e.g. according to personal estimation, statistical data from previous projects or costs repartition laws. At the moment only the first calculation method is realized.

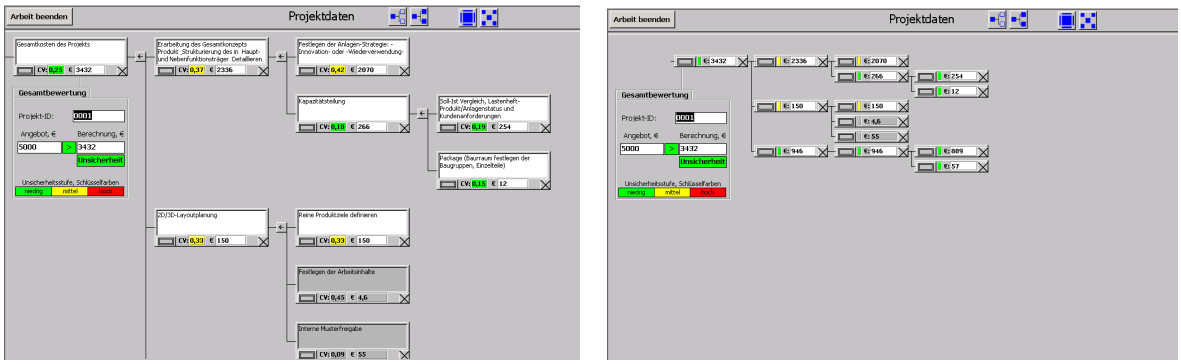

Figure 4. "Detailed structure (left) and compact structure (right)"

Activities Vault (III): All activities from previous projects are shown in a hierarchical form in this vault. Users have access to the enterprise information basis helping them to use existing information and avoid doing old calculation mistakes. Preventing from skipping essential activities, the user is guided through the obligatory project activities (check-list function) or can use the existing activities of previous projects. It is also possible to create new activities, to delete the old ones or to group activities in different modules.

3.3 Development possibilities

The created prototype can already be used for project calculations. Nevertheless, additional functionalities have to be developed in the future. Some further improvements include new calculation modes, e.g. evaluating the project costs with the help of different methods to check the correlation of the calculation result, new data visualizations to analyze the project with charts, e.g. abc-analysis etc. Further activities include the interaction with MS-Project.

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