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PREVENTIVE COST AND RISK MANAGEMENT IN THE EARLY PRODUCT DEVELOPMENT PHASE

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1. Introduction

A systematically planned, introduced and applied PLM system, that also considers preventive risk and cost management already in the early product development phase of a product, leads to a more rapid and complete provision of information, to secure decisions and processes and so to a reduction of both caused and planned costs, which arise during the following phases of the manufacturing process.

The request for lead time reduction and earlier market provision of products led to a changed product development process. Today, it is very important for managers of the engineering process to define innovative products in a complex and globalised environment. Each time they have to proceed in a better way, more rapidly, more low-cost and usually with less capacity in order to be able to survive successfully on the market.

The well-known question arises at the beginning of the product development process: How can I develop a "good product" in less time and with low cost? A new method for optimising the product development process to reduce product costs in the early product development phase has to be found. The new to be developed structure should include all important factors (costs, risks) whose modification and optimisation will have a positive influence on the product development process. Such an approach has a global impact on the company and necessarily involves collaboration between different actors from the early design phase on.

In the last years a permanent change has come up in the contents of the tasks of the engineer's activities and of the area of responsibility (covered by the engineer). This allows for different outside influences which act on the product development process (such as requirements from legislation and quality management) but primarily for the increasing importance of international collaboration between decentral development locations inside or outside of a company (customer/supplier relationship). The engineer is integrated in new processes because of the increasing parallelisation of the activities that previously ran sequentially, e.g. quality management, supply chain management and technical documentation. Additionally, also the requirements for lead time reduction and earlier market provision of products has led to a changed work situation of the product development.

The awareness that an even more premature application of improved methods, processes and IT solutions in the product development process causes the highest influence on the product costs led to the approach to apply the methods of the virtual product development already in the early concept phase. This is called Frontloading and contains functions of requirement, cost and risk management.

2. Process optimization in the early phase of the product development process

2.1 Frontloading

Frontloading contains an even more premature application of improved methods, processes and IT solution in the product development process. Exactly in that phase in which the highest influence of the product costs is caused [Eigner, 2005].

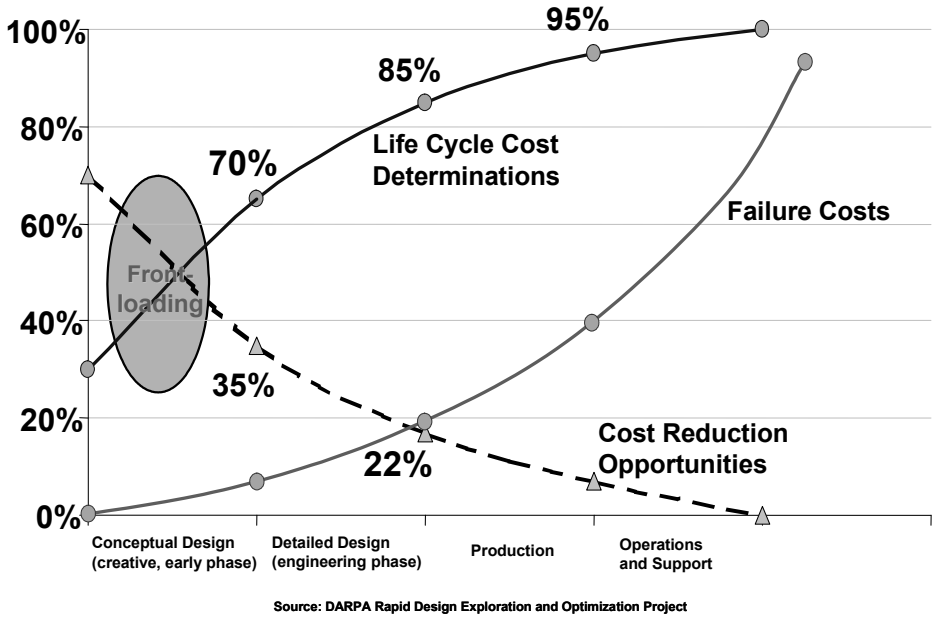

Figure 1. Frontloading

The early phases of the requirements clarification and the conceptual design have crucial influence on the quality of the solution and the height of costs. Here a lot of information must be processed in shortest time and relevant decisions are made. Up to 70-80 percent of the product costs are decided already during the first phase of the product development process [Ehrlenspiel, 2005]. At the same time here are still the biggest possibilities for corrections. Frontloading is realised in that phase of the product development process in which 70-80 percent of the product costs are fixed (cf. Figure 1).

2.2 Conceptual product structure

The so-called conceptual product structure is turntable and connector for the integration of this phase with the following phases of construction and detailing. The characteristic of this structure is normally an industry specific general arrangement of a product, exactly like it is known from airplane construction (International Air Transport Association Bill of Materials = IATA BOM) and from automotive engineering (automotive Bill of Materials, BOM) (cf. Figure 2).

Since development projects, product costs and most notably requirements are also structured rather than function oriented, the conceptual product structure is the ideal connection from the concept phase to the detailing phase. Prerequisite for the integration is a connection and mapping to the construction Bills of Material (cf. Figure 3).

A conceptual product structure is noticeably less restrictive as a "real" Bill of Material (BOM), since it does not consist of real parts and assemblies but of generic product components (e.g. "Gear", for parts with similar properties) [Zagel, 2006].

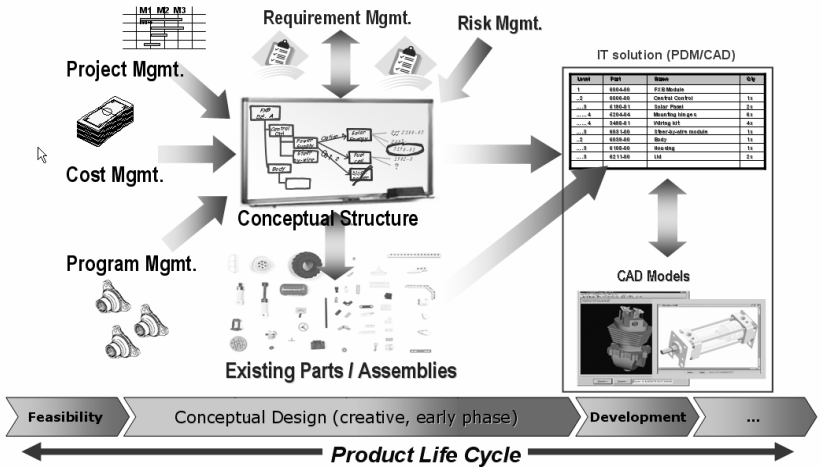

Figure 2. The conceptual product structure as turntable of functions in the concept phase [Eigner, 2005]

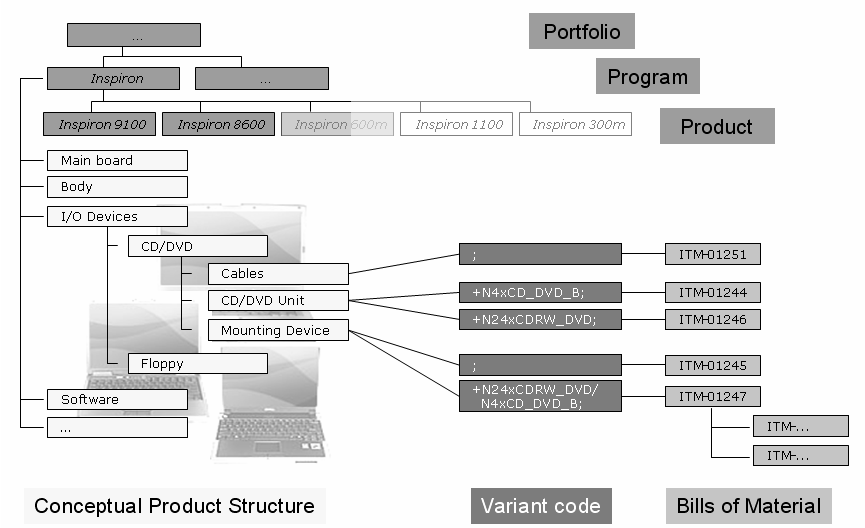

Figure 3. The connection of the conceptual product structure to the BOM [Zagel, 2006]

During construction by order (e.g. transmissions that should be adapted to the individual requirements of an OEM Platform and a particular car type), the conceptual product structure is used as a neutral basis for the derivation of individual BOMs. This process is more efficient and provides a higher quality, as if a "similar" BOM is searched, copied with all its mistakes and defects and then changed. This way it is easier and faster to access the knowledge of experienced engineers and to optimize the re-use of parts. Change processes are simplified since every product that is derived from the neutral BOM shows a fundamental same structure. The costs are reduced even more since also tools and appliances can be re-used.

The future functions of Frontloading will be mapped by modern Product Lifecycle Management (PLM) systems. For this reason PLM will make an important contribution to realise Frontloading as IT solution and to optimize the activities of the engineer [Eigner, 2005].

3. Costs

3.1 What are costs?

An important function of Frontloading is the preventive costs and risk management. It is immensely important in this early phase to estimate how high the internal costs are ("make"=own production) in comparison to the external arising costs ("buy") for the development and production of an assembly, in order to be able to execute a cost estimation of the whole product early. In parallel, risks of outsourcing (e.g. by a supplier evaluation) can be analysed and evaluated.
In general, costs do mean something of value, usually an amount of money, given in exchange for something else, usually goods or services. All expenses are costs, but not all costs are expenses. (An expense is the cost of resources used to produce revenue) [Investordictionary]. For consumers, costs describe the price paid for goods and services. For producers, costs are the value of inputs that have been used to produce something, and hence are not available for use anymore. Production inputs are equipment, material, human work etc.

3.2 Early cost detection

During the classic procedure, a development project is often advanced until the complete production documentation (drawings, Bills of Material, etc.). Afterwards a precalculation of the product by production planning and calculation is generated. Changings are usually connected with a high investment of costs and time. The consequences are long and inefficient loops. Often there is not any feedback of costs to the development division. In contrast to this with this the results in the research are checked for the consideration of the total costs during all stages of the product development process. Detected deviations can immediately be corrected and the iteration loops will get as short as possible (short loop) [Ehrlenspiel, 2005]. Consequently development processes can become shorter in time while keeping the planned product costs. This has positive effects on the development costs (changing costs) and the market presence of a company (cf. Figure 4).

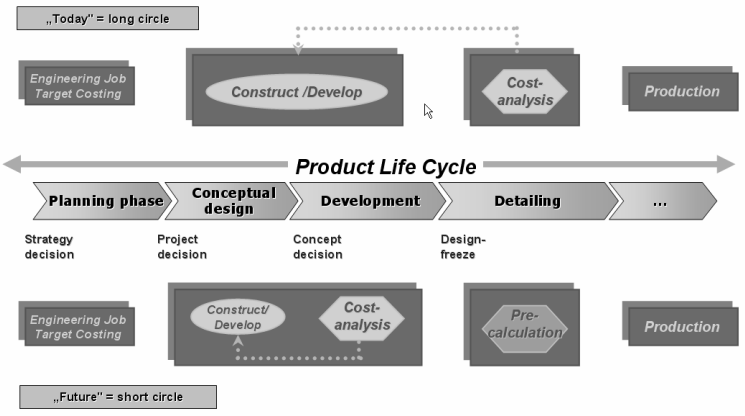

Figure 4. Early cost detection - Today and in the future

4. Goals

To be able to compete on the market, new methods are developed for another way of optimising business processes and for a continuous cost management [Spath, 1997]. This paper should give an overview about the topic area of construction-accompanying calculation and it should indicate methods relevant for practice which allow a process optimisation in the early phases of a product. Beside this, this paper should also deliver a view into development and into the practical usability of tools for the cost simulation during the product development.

4.1 Information about the "product"

As there is not enough information available during target costing in the early phases of the product lifecycle, the estimation of product costs in product development is often very difficult. To pursue the target of low costs in these early phases, suitable methods and tools must be developed and applied in order to make an as precise as possible cost forecast already at this stage. Although at this early stage not all product parameters are fixed yet it is necessary to make concrete and as precise as possible statements about the costs.

The engineer is in the centre of an information system in which, in contrast to former times, the information about the product must be stored not only in one single system but is referenced from third-party systems. By this he is enabled to compile the required information from internal sources of information - for example sales and distribution, logistics, purchasing, finances, production and maintenance - as well as from arbitrary external sources of information (by internet) - for example suppliers, standard part data-bases, licenses, patents and country-specific legal situations.

This type of provision of information improves the process of analysis and decision for the engineer and is essential for the requirements of the early phase of the product development process [Becker, 1997]. Suitable information should be provided already during the conceptual phase, in order to develop a cost-optimised product and to be able to produce a product at low costs. Failures in construction which require re-design or new design of the product and thereby would cause additional costs and loss of time can be avoided that way.

In the framework of a planned research project dealing with Frontloading, it should be analysed which possibilities exist to optimise and to reduce the costs and risk factors already in the early product development phase and how these factors can be defined consequentially already at the beginning of the conceptual phase.

For the development of a product whose generic structure is known and from which a conceptual product structure can be developed (e.g. Transmission) [Eigner, 2005], the deterministic costs and risks are derived in a first step. These costs and risks could emerge during the development of this product, especially by considering also the aspects of in-house or external production ("Make or buy").

4.2 Several types of costs and possibilities to influence costs

First, the types of costs are defined which are well influenceable at the beginning of the product development process. In order to find out these types of costs, first the whole product lifecycle is analysed. The most important costs which appear during the different activities of the product development are shown in the following illustration (cf. Figure 5).

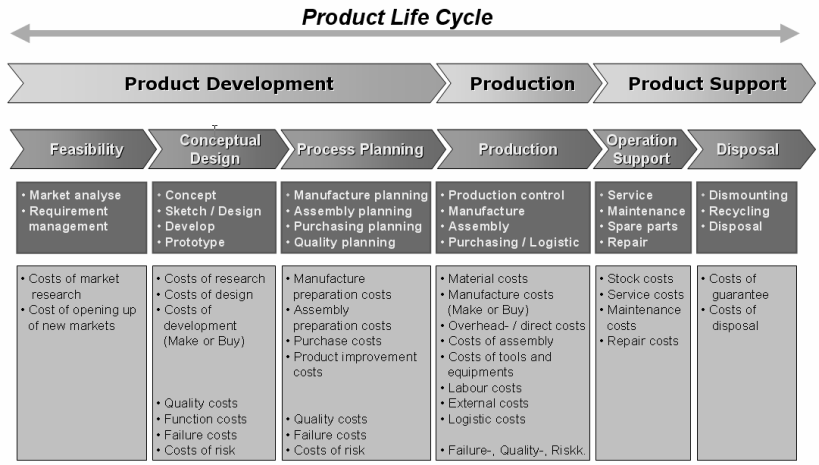

Figure 5. Types of costs during the whole product lifecycle

The knowledge about these costs and their origin is pre-condition for cost management. The origin of costs is mapped during product costing. Here, the main focus is on the calculation of costs for the creation of a product within the framework allowed by the company.
The manufacturing costs that are assigned directly to the production process of a product build the core of the product-related origin of costs. The material costs and the production costs of the product are essentially included within it. In addition, there are costs that cannot be implicated directly with the creation of the product (e.g. administration costs) [Burger, 1999]. They are summarised together with the production costs to the original costs of a product (cf. Figure 6).

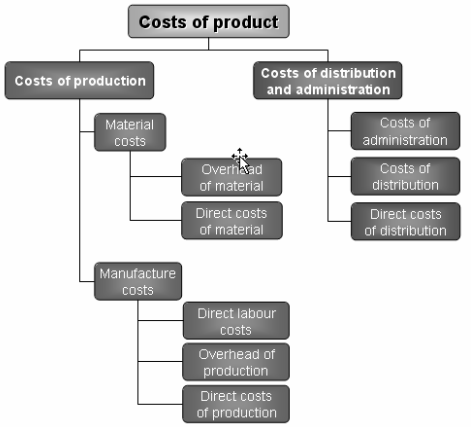

Figure 6. Possibilities to influence production costs [Ehrlenspiel, 2005]

For examining and influencing the costs for an entire company, advanced considerations are necessary because the costs to be considered at a time and the methods of cost calculation to be used depend on the situation of decision-making .
This known basic model (cf. Figure 6) is enhanced and completed in order to estimate the product costs better and more exactly at the beginning of the product development process. Figure 7 shows a possibility for this new development restructuring. There you can see both how the existing cost model is completed with new cost factors and the allocation of other occurring costs beside the production costs, which appear during the other phases of the product development process.

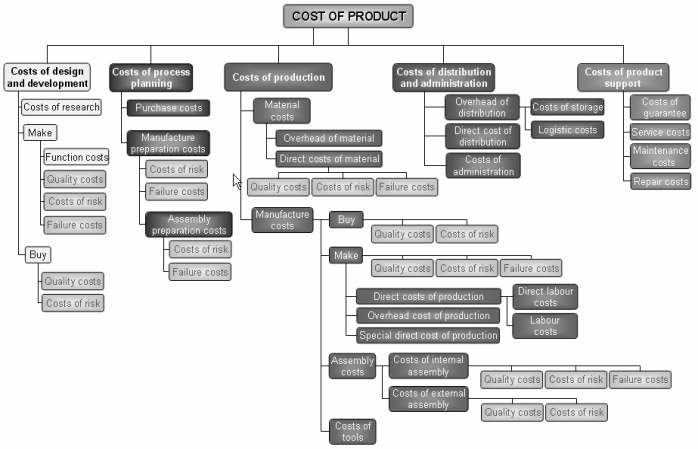

Figure 7. Cost structure

4.3 Research goals

In general, the claim for preventivly estimated product costs is reasonable. The earlier the changes can be made in the product development process, the less expenses (in time and costs) these interventions will cause. On the other hand it does not make sense to make ultimate decisions on basis of costs in the very early phases when the calculation result is still not exact enough because of an unprecise product description. This action could lead to false decisions [Reischl, 2000].

If the products are designed similarly to existing products it is absolutely possible to receive precise enough cost prognosis for the decision-making with few describing product parameters about "cost estimation relationships" and so early cost factors on the development can flow in.

Also the method of Target Costing can be used if the planned costs are already defined in the construction phase [Horvath, 1992]. Any sub-segment intervention in the product design can only be realised with additional time and costs. Costs for changing the product often neutralise the possible reduction of product costs as the "Rule of ten" indicates.

The "Rule of ten" was formulated by experiences out of practice. It should provide the exponential growth of the costs about the product lifecycle. Changes are the more cost-intensive the later they happen. If a change cost 1 DM during the feasibility, these would be during the construction 10 DM, during the manufacturing preparation 100 DM, during manufacturing 1,000 DM and after the delivery 10,000 DM [Ehrlenspiel, 1995].

The new concept for a preventive cost calculation is an instrument for multi-periodic planning, controlling and monitoring of costs with the goal to achieve a market-driven optimisation for the total costs of a product. This is a forward looking calculation model for a product and system specific identification of costs. Target cost management, whose focus is on influencing costs during product development, does mean a time restricted calculation model which comes from an assumed market as well as from customer requirements. It supports the product oriented determination and division of costs as well as the control of the appearance of costs. The comparison of the two approaches shows, that both the new concept of cost calculation integrated in the development and the target cost management possess a large market and customer orientation. Both try to influence costs in the early phases of the product development process.

The essential difference between the two methods consists in the temporally expansion of the consideration area. With target cost management, the target production costs for individual product functions of the total product are defined in the sense of a to be filled target from examinations of the market as well as from the analysis of the customer requirements. The new method of cost calculation determines the costs caused by the product during the phase of manufacturing and furthermore also in all other phases of the product development process for all lifecycle phases of the product (TCO = Total Cost of Ownership). So, a temporally expansion of the target costs requirements is realized during the whole product lifecycle.

Based on these findings a generic cost structure is build up which describes at the same time cost and risk factors, which adapts to the existing digital product model and, in a later step, can be integrated in the conceptual product structure (cf. Figure 8).

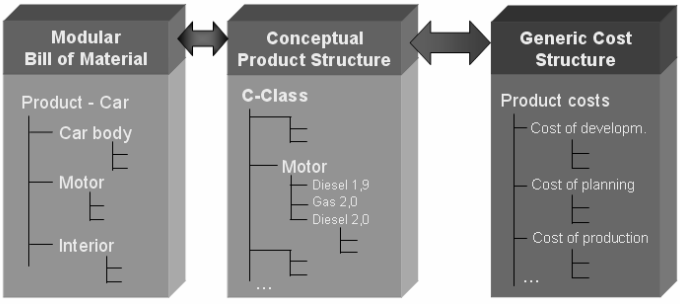

Figure 8. Research goals

An essential component of the research project is to find a solution for the connection between generic cost structure and generic product structure. In either case the generic cost structure must be built up in a way that the dependencies between the cost factors are clearly represented.
The conceptual product structure is a component of the PLM solutions, so in the future a provision of the functions costs and risk management will be possible in the PLM framework. As soon as a digital product model is available that contains all data of costs and risks beside the general data of the product, this new generic cost structure will be integrated into the existing system landscape (e.g. PPS-System).

5. Summary

During the last 20 years, a permanent change in the product development process has taken place. An optimisation approach resulting from this is the so-called Frontloading. With Frontloading, a process optimisation can be achieved in the product development. Hereby companies shift profit-critical decisions into the early phases of the product development process, in which about 70-80 percent of the product and project costs are defined. In this phases the costs for alterations are still very low and the potential for cost reduction is accordingly high.
Modern solutions for Product Lifecycle Management map the mentioned functions of Frontloading and integrate them via the conceptual product structure with the subsequent phases of the product development process. Typical extensions of functions in this segment are Requirement Management and Tracing, Project, Program and Portfolio Management as well as the estimation of costs and risks.

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