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A MANAGEMENT MODEL FOR THE DESIGN PROCESS IN VEHICLE SAFETY DEVELOPMENT

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1. Introduction

1.1 Situation and industrial need

In today's turbulent business environment it is more important than ever to offer high quality products at the right price. This concerns especially the design process in the conflicting aspects of costs, quality and time, in which products have to be developed to offer a high benefit for the customer. Especially automotive industry is characterized by saturation of consumption in the triad markets, rising competition from Asian manufacturers and discount battles.

Hence, separate tasks of a business activity need to be interlinked and put into a common framework to satisfy the common goal, i.e. the customer. This impulse must come above all from management, whose task it is to incorporate the different partners in product development into the overall strategy.
However, particularly among smaller companies, there is still little knowledge about this strategic dimension of management. Common management models, often being rather abstract, do not reach this target group. In this research, the goal was therefore to design a more specific management model addressing small and medium sized companies in order to regroup all activities in design and development of automotive safety applications [Brewer 2005].

1.2 Project background

In cooperation with a major German automotive service provider (MVI Group GmbH, approx. 1000 employees), the Institute of Product Development at the Technische Universität München designed a common framework to interlink the design activities in vehicle safety with a substantiated management approach in order to render the design process more effective and efficient.

Having undergone a major restructuring and change of ownership, the MVI Group intends to become a premium service provider in automotive safety development and therefore expects new customers with the specific result of this research by showing a systematic management approach towards engineering projects.

1.3 Methodical approach and structure of this paper

The initial point was a short survey among eleven experts of well-known OEMs, suppliers and research institutes in German automotive industry. This was done to gather current and future requirements and challenges in vehicle safety, its design and management to assure a sound basis, reflecting the market's needs and developments, and to form requirements for the management model.

In a second step, requirements for a management model were defined both through analysis of existing management models as well as discussions with experts. The advantages and disadvantages of the

different prevailing models were compiled to form a common set of elements for the model to be designed. Reflecting on the (dis)advantages, the design of the new model was derived.

Eventually, the management model was suited to the characteristics of general product development design and in particular to the specification of product development processes in vehicle safety. For validation reasons, a short case study was carried out to mirror existing activities in automotive safety design using the guidelines and values offered by the management model. For reasons of nondisclosure, this can unfortunately only be presented in short.

This paper is structured accordingly. First, an overview of management models is presented, then their substance and an analysis of historic and current approaches are laid out in the next chapter. In the following section, the characteristics of management of engineering design are investigated closely, followed by the new management model presented in section four. This model is then applied, using a short case study on conceptual design. Ultimately, the results are summarized and discussed.

2. Management models

2.1 Management and management models

Management models serve as a help establishing an overall strategy and as a reference to frame decisions during different business processes towards this very strategy. Herein, management is a system of tasks, including design, controlling and advancing of organizations, characterized by a highly unpredictable environment, a multitude of simultaneous events, conflicting goals and ambiguity of tasks [Rüegg-Stürm 2005]. Management models permit considering complex challenges in the global context and handling them more effectively by sensitizing the manager for the most relevant aspects. They offer a general framework for displaying logical connections and impacts among important aspects to create the possibility for rapid orientation in situations of high uncertainty and ambiguity.

They help both in reducing complexity in an environment with rising customer, technology and market requirements and in distinguishing essential aspects from non essential ones. Through this, the user is supplied with a map for orientation in order to be sensitized for relevant correlations in management [Ulrich 1972]. Besides, a management model guides the manager in the direction of important phenomena, which support structuring organizational communication. In turn, improved (re)activity results from a consistently used management model, as it offers a common language and communicates a common set of goals and values. Hence, management models create a framework which enables a goal oriented solution of current and future challenges.

Established management models do not focus on a company's division; in fact they are a general management tool for a whole business company with its dependences to all stakeholders. This makes their application and acceptance difficult, as this generic aspect often entails a lack of understanding.

2.2 Requirements for management models

Before introducing the management model, general requirements are presented. Partly, they originate from [Rüegg-Stürm 2005] and preceding editions of his, further ones were compiled by studying and analyzing different management models and their impact on users in the partner company. Therefore, they represent a summary of all positive aspects of the prevalent management models taken into account. Table 2 shows an overview of these general characteristics and how each current model has to be classed with respect to the requirements.

The first two requirements in table 1 meet the need for ease of understanding, being most important for a common acceptance. Requirements three to six focus on including the whole company and its context. Numbers seven and eight address the general strategy of a company and how it is developed. Ultimately, the level of abstraction is addressed. Being a measure for decisions in the company, the management model addresses only strategic questions. Hence, the operational part of it refers to the means and methods of how to identify and implement a strategy for a company.

Table 1. General requirements to management models

	Requirement	Occurrence
1	simplicity	serves for handling complexity, distinguishing between essential and non essential aspects
2	clarity	serves for a fast orientation on a basis of a clear description, connection and denomination of the used elements
3	reference to context	illustration and emphasis of company-specific problems and key topics (challenges of the management)
4	holistic focus	serves for an integral description of all stakeholders and the environment
5	systemic focus	serves for broad use on all hierarchic levels
6	dynamic focus	representation of the development of a business company
7	normative / strategic level	setting the strategic basis for future identification, selection and implementation of success factors
8	operational level	methodical procedure to identify and implement the objectives of the normative/strategic level
9	flexibility	possibility to adapt the management model to the specific needs of a business
10	customer orientation	emphasis of the customer benefit in the management model

2.3 Prevailing management models

One of the most common models cited in research and industry is the St. Gallen Management Model by Ulrich [Ulrich 1972], which first addressed the character of a business as being a complex system. Yet, it remained on a very abstract and generic level. It did not address the different stakeholders in a business explicitly, which is why it later led to the new St. Gallen Management Model by Rüegg-Stürm [Rüegg-Stürm 2005], extending the original model's focus to all stakeholders and introducing a more process-like character at the same time, reflecting upon the fact that the time-to-market had become a most influential factor for success.

Table 2. Specific advantages and disadvantages of common management models

	advantages	disadvantages
St. Gallen Management Model [Ulrich 1972]	holistic approach	neglects an implementation level
	systemic approach	complex systemic approach reduces possible understanding
	social dimension	lack of possibility to consider the momentum of a business company
The new St. Gallen Management Model [Rüegg-Stürm 2005]	consideration of normative basics	negligence of an implementation level
	consideration of all stakeholders	stakeholder approach is problematic
	procedural character	lack of consideration of a company's dynamics
Management Model by Hax / Majluf [Hax 2004]	easy to understand	inflexible character
	integration of all hierarchy levels and managers	no holistic approach
	structured process of strategy planning	focus only on current potentials of success, neglects future success potentials
Management Model by Drucker [Drucker 2001]	easy description of complex correlations	neglects an implementation level
	focus on dynamics of environmental influences	no tools for visualization
	focus on the customer	different strategy alternatives, but no assignment of a alternative to a company

Hax and Majluf [Hax 2004] focused on creating a formal procedure to incorporate all different and necessary management functions into a common strategic planning; their core idea was to create discussion across different hierarchical and professional levels.
Drucker's [Drucker 2001] legendary dictum "management (i.e. strategy) is doing things right; leadership (i.e. operations) is doing the right things" characterizes his approach well: His core interest was to understand strategic analysis and decisions and their interdependencies. However, he never attempted to create a complete management model but only partial descriptions.
Each model has its own particular focus, all of which are elaborated in Table 2 summarizing the major advantages and disadvantages. The management model presented in section four takes into account these different advantages to fulfill the requirements set up earlier in this section. It hence combines parts of the different models into a new one customized to the specific needs of designing vehicle safety features. The characteristics of this design process are presented in the following section.

3. Management of engineering design

3.1 The characteristics of engineering design processes

Design processes are characterized by a number of specific features. They are only amenable for planning on a very general level. As process steps result from preceding results of the process, detailed scheduling and informed decisions are often executed on a very granular level only. This is done mainly because of uncertainty about the outcome of a process step [Ponn 2005]. Often, this leads to cycles and iterations in the execution of design tasks.
Furthermore, innovative product development usually is an interdisciplinary task in a concurrent engineering environment. Communication and a continuous exchange of information are essential, as is the early collaboration during the concept phase, often cited as "frontloading". Communication also serves the follow-up of moving targets and changing requirements.
Ultimately, recent product design in industry is more and more faced with outsourcing and offshoring as well as integration projects that interlink different partners in the design process more closely.
For the case regarded, the development of automotive safety is especially characterized by the need for extensive testing of prototypes, e.g. in crash tests, a close eye onto legal requirements, e.g. occupant safety as given by the FMVSS 201, and functional integration, as safety functions rarely concern a single component. These characteristics were mainly stated by experts on car design.

3.2 Management models for engineering design processes

Bearing reference to the overall product when considering single tasks in product design is often cited as a key for success [Carlson Skalak 2002]. Furthermore, to satisfy the needs of product design engineering, management needs to bear in mind the particularities given above.
Looking at existing management models, the reference to the product is particularly considered by Drucker, who understands the product as a solution to a customer's goals. The multiple levels of communication during a design process are in a feature of the holistic model of Ulrich, stressing communication across all levels of hierarchy. Flexibility is needed to cope with uncertain planning and scheduling of design processes. However, it is little addressed at all, as all models are derived from business processes and not development processes. The common integration of different partners in development is what Rüegg-Stürm sees as the purposeful, not compellingly equally-balanced consideration of all stakeholders, which is needed on the long run for the success of a business, according to his model.
It can therefore safely be stated that common management models are not suited to represent the challenges of product development as each prevailing model either only represents minor subsets of the features necessary for this purpose or only embodies them on a very abstract and generic level.

4. The management model

The management model proposed encompasses the majority of the aspects regarded by other management models, stressing the multiple facets of management. Yet, it is reduced to a more simple

design that was chosen for the ease of understanding. To achieve this, fewer components than in the more generic management models were incorporated. From the outside, different external influences, above all the customer benefit, are embedded. Internally, a distinction is made between the strategic and operative dimension. The model is centered on the design process, as it is the successful management of this process that will yield the results desired.

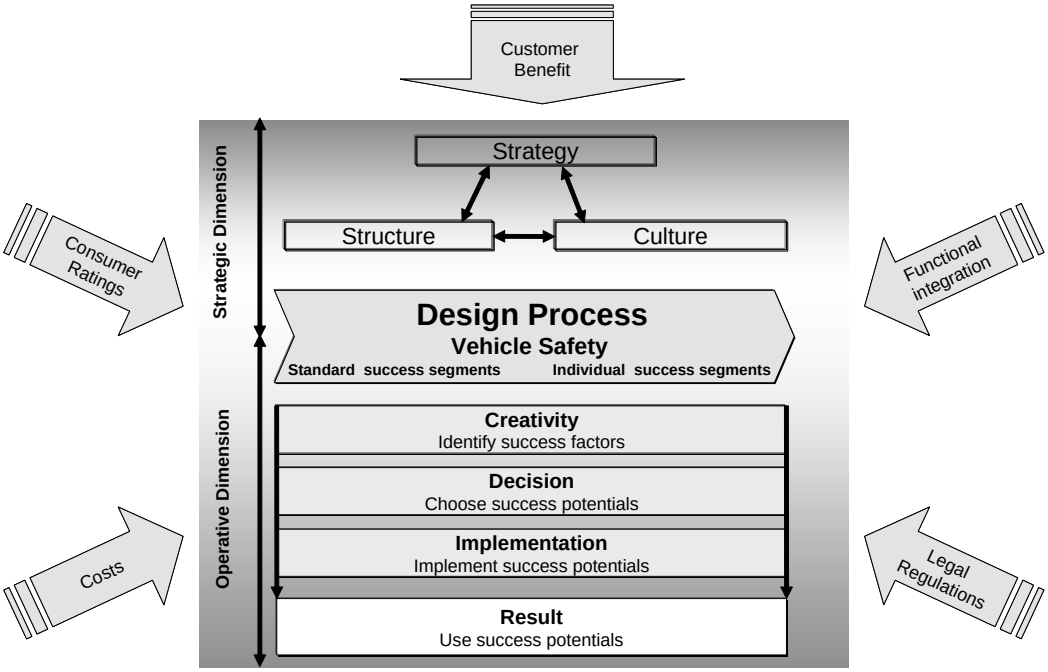

Figure 1. Management model for vehicle safety developmen

4.1 External influences

As external influences, the customer and the environment of the company are being represented. With the customer benefit as the core strategic requirement, the other possible requirements remain open, according to the case in question. For the represented case of automotive safety design, in particular the typical external influences, i.e. functional integration, consumer ratings, costs, and legal standards are represented.

These requirements have a strategic and an operational character, because they influence the design process, i.e. the interface between operative and strategic dimension. Therefore the described requirements have both an operative and a strategic character. The list of requirements in the management model is not necessarily exhaustive. It rather serves both as a basis of information and as an assistance for structuring.

4.2 Strategic dimension

On the strategic level, the three elements strategy (long term planning for action), structure (organization of company) and culture (standards, values and abilities of the employees) describe the minimum of holistic management in a company. Between these elements there are distinctive interdependencies, which have to be considered, e.g. a new innovation driven strategy cannot be realized without adjusting the company's organizational structure as well as the employee's skills and attitudes. The management always has to reflect its decisions against the background of these elements, whether the consequences harm or harmonize the basic structure of holistic management.

To keep these three elements up to date, success potentials for each single element need to be identified, chosen and implemented, a fact which is represented by the operational dimension. The sources for success potentials are represented by standard and individual success segments, given e.g. by Bleicher [Bleicher 2004]. Extensive research is done in this field, which is why the different segments and factors will not be more closely regarded in this paper.

4.3 Operative dimension

The operative dimension has a twofold interest. First of all, it serves to identify, choose and implement the success factors based on the success segments necessary for the company to form an overall strategy. This way, it serves as a prescription to formulate the strategic dimension, as proposed by the rather procedural management model by Hax and Majluf [Hax 2004]. Secondly, the operative dimension also means to stimulate the people involved in designing a new product to reflect upon their behavior in the process.
As research has shown [Lindemann 2002], the procedure of designing a product as well as that of developing a strategy is not necessarily linear but needs to be adapted. However, as implied in the triple jump of the phases “creativity”, “decision” and “implementation”, the authors have decided to use the linear presentation, as in the current project it received a much higher acceptance. This visualization, however, is not meant to deny the existence of others.

4.4 Design process

The design process is the interface between the strategic and operative dimension, because it impacts on both dimensions. On the one hand, the design process demands for a number of success segments, inside which success potentials can be found. For this reason the design process has to be a part of the strategic dimension. On the other hand, the success potentials have to be implemented into the design process. Therefore it has a relation to the operative dimension.
In this context it is important to distinguish between standard success segments and individual success segments. There are general success segments, which are equal to a certain extent for every company division, e.g. “communication”, “employees” etc. However, depending on each department’s focus, individual success segments have to be taken into account, as e.g. virtual product development, including virtual design, simulation, the reduction of prototypes and the need for validation through quick hardware tests with high informational value in automotive safety development.

5. Applying the management model to an exemplary concept design process

Based on an exemplary concept design project, the application of the management model presented above was done in cooperation with external project partners of the MVI Group, namely in the context of a consulting project run with a major German premium automotive manufacturer.
The concept design process in automotive development describes all steps between the idea for a new vehicle up to the specifications summing up all major requirements to be achieved and conflicts involved, e.g. a large engine versus a low overall weight. In this phase, the main criteria regarding technological product and process innovations, road performance, packaging, target customer ratings, and design are defined. Modifications concerning the concept later in the process often cause high financial expense.
Using the management model, the manager is consequently sensitized for considering his actions and their implications by the strategic dimension. Its elements, i.e. strategy, structure and culture, are implemented deducing their actual content considering the success segments. Concretely, the in-time integration of all customers, the use of efficient development tools for the virtual validation, improvement of communication between all development divisions, efficient communication that frontloading avoids problems in later phases, installation of a reporting mechanism for the management in order communicate product functions transparently, and implementation of a separate interface supervision increased information content in the concept design process were taken into consideration as success segments. With respect to each one’s interrelation with the company’s strategy, structure, and culture, efficient communication in combination with teams centered on the

product's core functions were chosen to be most promising with a particular focus to the customer's benefit and the other external influences. Other success potentials were considered, too.
The implications appeared visible on multiple hierarchical levels: Globally, a more tangible communication structure was established, putting the product's functions more into focus. On a smaller scale, less far-reaching actions of the management were also better framed. Formerly loosely interconnected activities, e.g. the separate activities in embodiment design and simulation departments, were now re-checked for their impact onto strategy, structure, and culture; in turn, through mutual training, cooperation between these departments was improved.
The results achieved were perceived by the project managers as better focused and well-centered on the core interest of the vehicle safety design division.

6. Discussion

In comparison to the analyzed management models, the proposed new model has a strong emphasis of implementation of strategy. Other management models only provide the user with a general framework of sensitization for relevant challenges in a business.
Each phase of the implementation being supported by a set of methods (not represented in this paper), the complete model is primarily meant to be a guideline for the important facts on managing a specialized division of a company, hence it does not concern the whole company. For this reason the new management model is able to consider specific requirements of this division as well as its particular characteristics. However, the more general aspect of management models, here only represented by the standard success segments, is lost for the sake of easier understanding. This makes the management model more useful in terms of managing product development processes. To adopt the model to a particular department of a business, however, the individual success segments and the external influences need to be newly researched.
Yet, the new management model remains rather abstract. In fact, it is not fully possible to bridge the gap between representing all different aspects in a common model while keeping it simple enough to be understood easily. Nevertheless, it is less general than the other models cited, which are often much more beyond are an engineer's way of thinking.
So far the new management model received positive feedback from the partner in the industry. On the basis of a small validation within the scope of a development project, the management model showed both a high pertinence as well as a high potential for a holistic improvement of product development processes. On the other hand the management model is not self-explanatory; on this account explanation is needed in order to communicate the management model.
Evaluation sessions with the industrial partner revealed a number of aspects which are perceived as an added value for the company. These were particularly the emphasis of the customer benefit, the focus on the design process, the systemic character, the incorporation of standard and individual success segments, the strategic and operative dimension, the emphasis of the customer benefit, and the possible application on all hierarchic levels.

7. Summary and conclusion

In a project with a partner from industry, a study to create an integrated model for the management of automotive safety design was undertaken. Based on specifications deduced from the most common management models and from actual demands in industry, requirements were formed, incorporating the characteristics of the design process and important features of prevailing management models. The new management model distinguishes between an operative and a strategic dimension to promote a more holistic view onto management of the design process. The model was then put into application using a case study during the concept design phase of an automotive manufacturer.
Feedback from partners in industry has been very promising, showing that a substantial approach to subsume separate management tasks in a common framework is highly in demand. Especially the fact that the model attempts to bridge management and engineering thinking is a major advantage. However, the management model still needs refinement; especially to better represent the link to the design process.

The experience gathered during the project has shown that, especially when it comes to contact with customer, the management model helps considerably to raise credibility through simple representation of the core elements of a field of business. This is also true for the internal action within the company, as the model raises common understanding about the decisions and strategy taken. The use of a more adapted management model for each field of activity in a company therefore appears to be recommendable.

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