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IDENTIFYING THE BEST OVERALL SOLUTION BY TEAM BASED EVALUATION AND DECISION TACTICS IN CONCEPTUAL DESIGN

Iris Graessler

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1. Introduction

Early phases in innovative product development projects are characterized by considerable degrees of freedom, conflicting sub goals and a variety of promising solution alternatives [Loch et al. 1997]. In spite of prevailing uncertainties, the best solution alternative must be identified step by step in order to concentrate the development effort on the most promising technologies. In this contribution, evaluation and decision tactics to be applied in interdisciplinary development teams are presented.

2. Area of application

The case study presented in the following comprises the development project of a proportional water valve as part of vehicle thermomanagement at the division Body Electronics of the Robert Bosch GmbH. The development task was characterised by a high degree of innovation resulting in the need to create new principle solutions. The overall solution consists of hydraulics and a combination of sealing, drive engine, electronics and fail-safe function (figure 1). This complex decision problem had to be handled by an interdisciplinary design team involving many different competencies (figure 2).

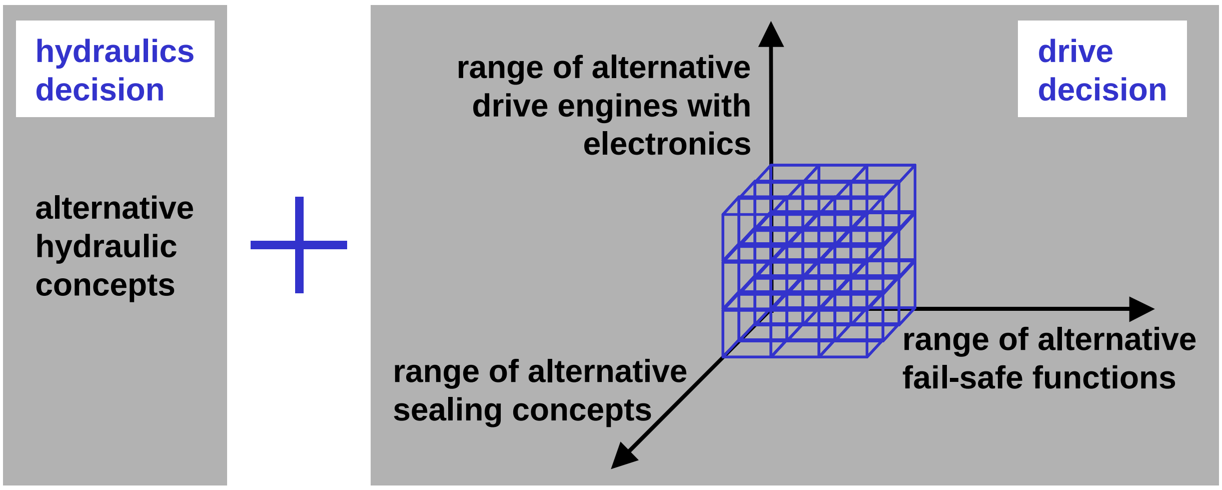

Figure 1. Complex decision problem requiring a multistage combination of partial solutions

involved disciplines:
- system engineering
- mechanical engineering
- electronical engineering
- drive engine engineering
- application engineering
- project purchase
- manufacturing planning
- assembly planning
- quality management
- electronical testing
- mechanical laboratory
- sales
- technical drawing

Figure 2. Interdisciplinary project team

3. Methodical approach

As a result of the complex decision problem, a methodical approach to support the systematic selection of conceptual alternatives in early phases of product development was needed. Existing evaluation methods, such as morphological box combined with a technical and economical evaluation, do not serve sufficiently enough in interdisciplinary team processes. The method created and applied by the Internal Consulting Group "Product Development Processes (PEP)" meets the following requirements. All disciplinary views are taken into account in order to identify the best overall solution and to induce a broad commitment among the team members. The method is designed to be applied in moderated team workshops. Thus intensive technical discussions can take place and the team building process is accelerated. Application of the method ensures a transparent and systematic decision process including meaningful documentation. Uncertainties typical of early development phases are made manageable by a multistage procedure.

The matrix-based decision method is applied in order to identify the best partial solution within each discipline and also to bring the selected partial solutions together to form the most promising overall solution. The main application steps of one evaluation run are illustrated in figure 3. An evaluation run consists of 2-3 evaluation cycles. As a result of conceptual brainstorming, literature investigation and analysis of competitor's products, a range of theoretical solution alternatives is generated by the responsible engineers. At the beginning of each workshop, developers introduce their actual development status and present the conceptual alternatives along with their advantages and disadvantages. This way all workshop participants have the opportunity to grasp the co-action of the entire system and to co-ordinate interfaces between the components for which they are responsible. After the developers are all equally informed, the solution area is discussed in teams and narrowed down step by step with the help of evaluation matrixes. The range of discussed solution alternatives and the evaluation criteria make up the two dimensions of the matrix. In addition, weight factors describing the priorities of the applied technical and economical evaluation criteria can be defined. One evaluation cycle is completed when all fulfilment degrees are filled in the matrix and the sum of weighted fulfilment degrees make up the ranking of solution alternatives.

Within one workshop, evaluation cycles of different partial solutions can be carried out. For instance, pre-selection of drive engine and final selection of hydraulics may take place in the same workshop. However, before the alternatives of the same partial solution are evaluated once again, time has to be spent on working out, simulating and prototyping the conceptual alternatives. Thus information relevant for further selection is provided. Highly interdependent partial solutions must be combined with each other before a comparison between the alternatives can be drawn.

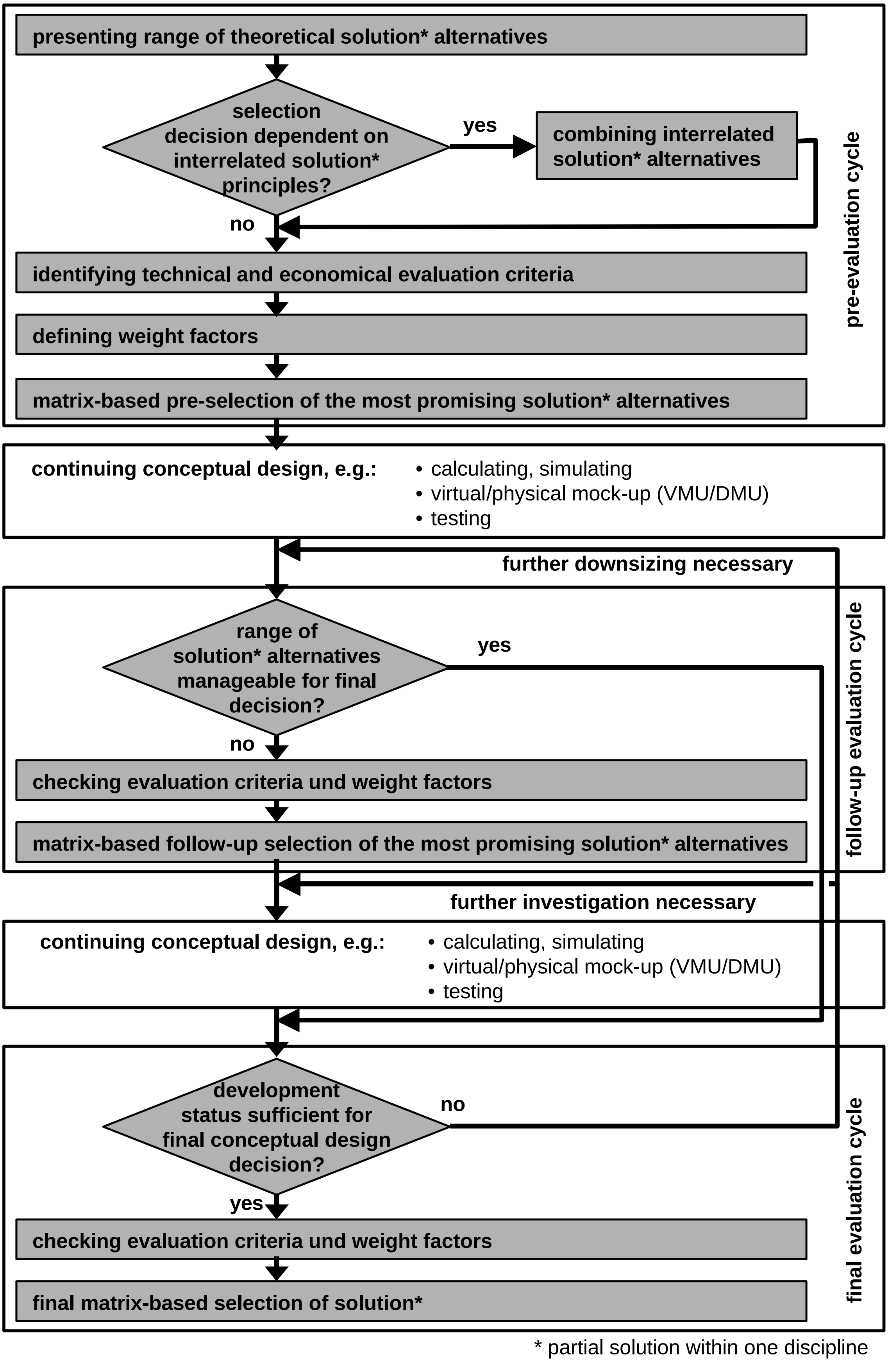

Figure 3. Overview of the evaluation run within one discipline

4. Workshop Concept

In the proposed case study, the applied concept of workshop series covers a time period of roughly one year starting with the project kick-off and ending with the concept review as a major project milestone. Within this time, four 1-2 day workshops were held. The key elements of each workshop are shown in figure 4. The focus of the first workshop lied on initial team building and hydraulics. The workshop took place 4 months after project start when the team line-up had been completed. Among the employed team building methods were workshop sequences of getting to know each other, analysing the status of team development as well as passing common team exercises which involve the abilities of each individual team member.

As first technical content, the development status of hydraulics was presented and explained by the mechanical engineers. On this basis, the whole team pre-selected the six most promising hydraulics alternatives. In the second workshop the solution area of hydraulics was reduced to 3 solution alternatives. Besides, partial solutions for drive engine, electronics and fail-safe function were discussed and combined to feasible solutions. In addition, the status of measures defined in the first workshop was checked. In between the technical contents, team building exercises were carried out to ease a concentrated atmosphere. In the third workshop the best partial solution of hydraulics was chosen and first ideas of integrating the fail-safe function into hydraulics were generated. Drive engines combined with electronics were pre-selected. Arguments for and against sealing were collected.

Further, the development status of gear-boxes was presented and a new team member was introduced to the project team. In the fourth workshop, all promising partial solutions were systematically combined to feasible overall solutions. The evaluation of overall solutions led to a clear ranking and identification of the most promising overall solution.

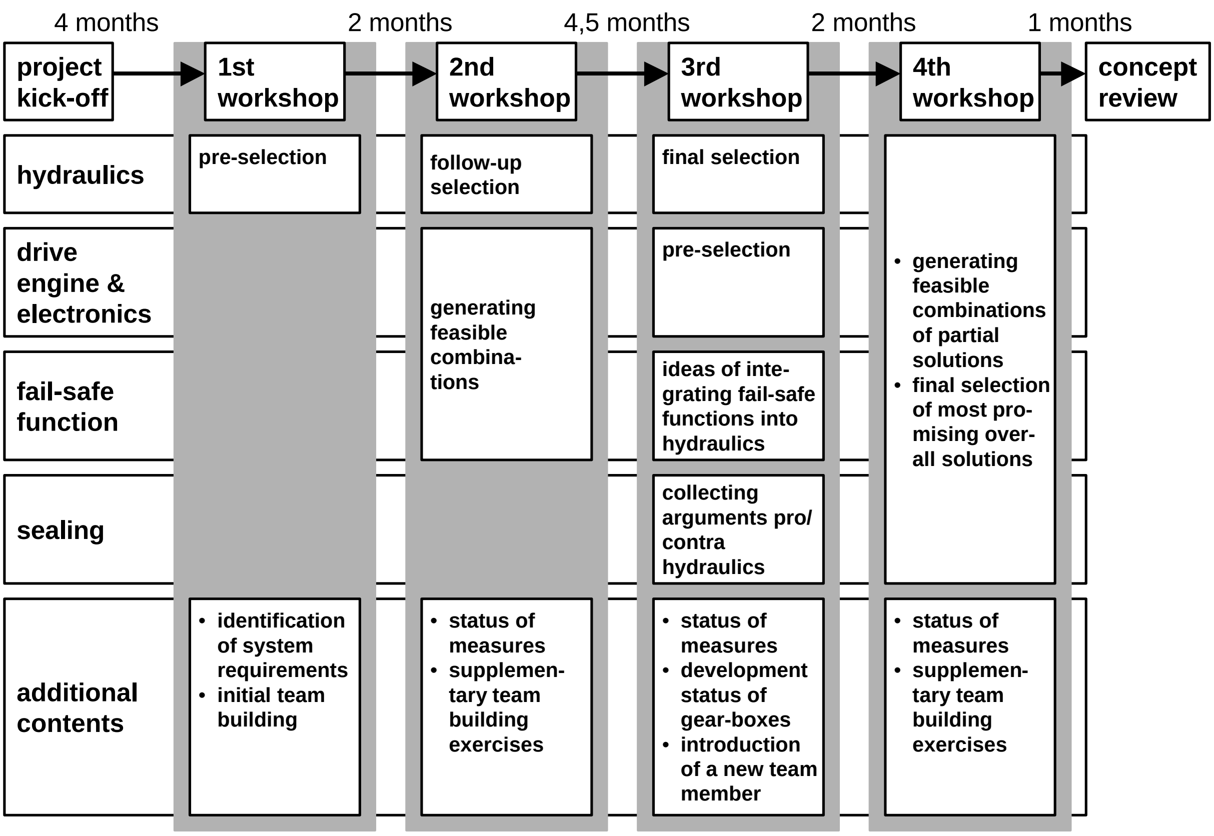

Figure 4. Concept of workshop series

5. Results

During application of the described evaluation method, a decision tree of partial solutions evolved (figure 5). According to existing interdependencies between disciplines, the illustrated sequence of decisions was determined. As starting point of the decision process an eccentric valve was chosen for hydraulics partial solution. The drive decision implied a shaft sealing supplemented by a direct current engine with affiliated electronics and springs as fail-safe function. The final evaluation matrix of overall solution alternatives is pictured in figure 6. The used evaluation scale deliberately lacks a "zero" in order to avoid undecided team behaviour. In the presented case study, both evaluation procedures - with or without weighting - led to selecting the same final overall solution.

In the case study, the main technical advantage of applying the matrix-based evaluation and decision method consisted in the systematic identification of the best overall solution with respect to all involved disciplines. Thus the development focus was continuously drawn on the most promising conceptual alternatives. Dependencies between sub-systems and their interfaces were early investigated and taken into account. Thus the moderated workshops provide a means of putting Simultaneous Engineering into action. The co-ordination effort invested during the workshops pays for itself in the pursuing months many times over. The solutions are thought over carefully from each discipline's angle and furthermore represent a decision which is supported by each individual team member. The broad commitment among team members helps to concentrate the spent efforts on the common goal during conceptual design. Due to the used evaluation matrixes, the decision process is documented in a transparent manner and comprehensible at any time. For instance, in case of changing restrictions or requirements, the consequences on the present development status can easily be identified and estimated. Furthermore, team members are fascinated and motivated by gaining insights into neighbouring sub-systems and disciplines.

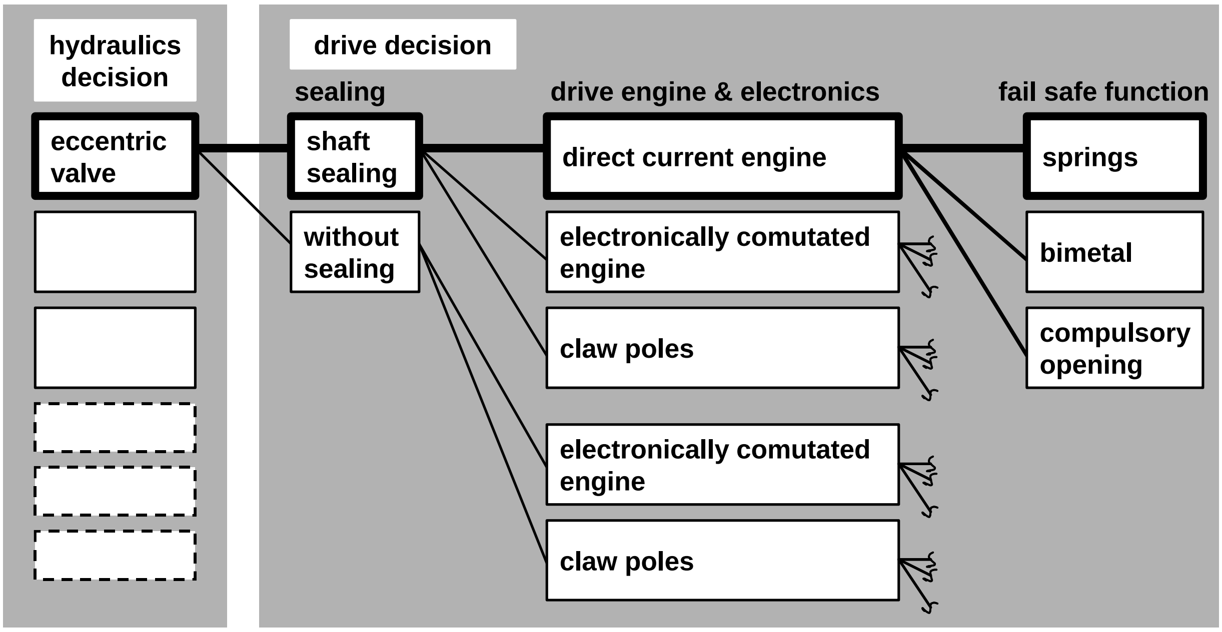

Figure 5. Decision tree of the proportional water valve

6. Conclusions

The proposed matrix-based evaluation method can be applied in case of high degrees of innovation in early phases of product development to support interdisciplinary development teams. The method is part of the consulting portfolio of the PEP-Group. Besides Simultaneous Engineering, other core topics of improvement activities are Reducing Time to Market, Project Management, Robust Software Development and Mass Customization. The PEP-Group is embedded into the Network of Continuous Improvement Process (CIP) and part of Corporate CIP Coordination [Graessler 2001].

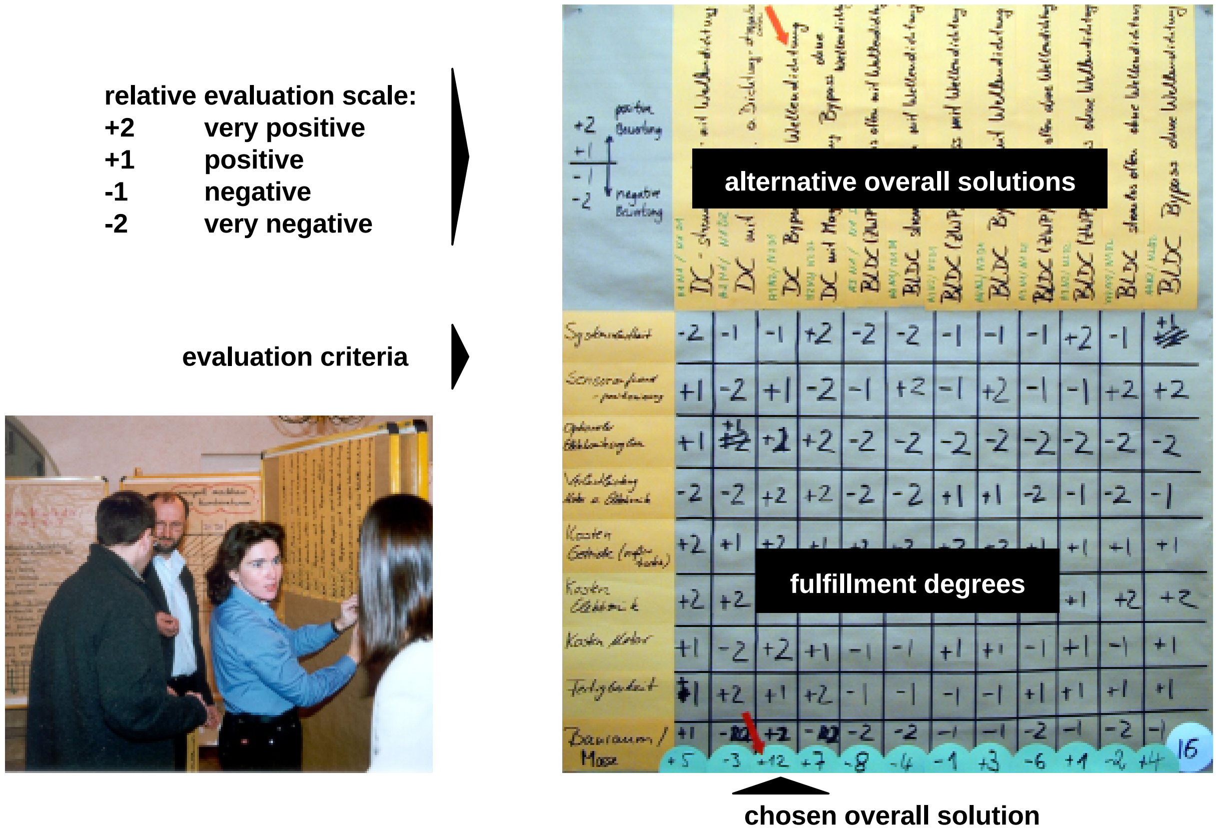

Figure 6. Final evaluation matrix

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Dr.-Ing. Iris Graessler
Robert Bosch GmbH
Corporate CIP-Coordination
P.O.Box 300220
D-70442 Stuttgart
Germany
Telephone: ++49/711-811-37788
Telefax: ++49/711-811-37777
Email: iris.graessler@de.bosch.com