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Adaptation of Methods to Crises Situations in Product Development

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Abstract
This paper presents a trouble shooting methodology which contains suitable methods to be used in crisis situations. This trouble shooting methodology was developed and verified in cooperation with a component supplier in the automotive sector. An in-house survey was conducted in order to discover the company's specific crisis conditions. Besides, recent crisis were analysed to identify typical process patterns. Then, a range of methods was analysed and tested for their suitability in crisis situations. On the basis of the results found in the analysis of crisis and methods, a trouble shooting methodology to handle future crisis was developed.

Keywords: adaptation of methods, crises situations, trouble shooting.

Introduction
Products and processes in product development are getting more and more complex [1], which makes the appearance of failures, product failure or process failures, more likely. These failures can cause trouble in a company and can even lead to existence-endangering crises [2]. In order to prevent crises, companies have established risk management systems and variety of adequate methods [3] . These risk management systems often contain specific process structures and selected methods suitable for product development. So far we know by experience that a successful risk management system can reduce the probability of crises[4].

Despite all prevention actions, the occurrence of crises is still possible. Crisis situations in product development can be seen as a part of a regular product development process, and are mainly characterised by a lack of time [5]. Unforeseen scenarios take place and all the preliminary activities, undertaken to avoid the occurrence of a crisis, fail. For this reason new ways of handling the situation and of solution searching have to be elaborated. Examples exist how crises can be solved successfully. E.g. in an automotive company it becomes clear after the start of production that important components, embedded into a new type of automobile, do not work properly. Design engineers spend a lot of work on technical problem solving and an intensive communication with costumer and media is built up. By their joint efforts the company can finally close the crisis. As concerned engineers usually do not know how to start the problem-solving in a crises situation, a systematic procedure is necessary. This paper presents the development of a methodology for facing crises situation in product development. This methodology named "trouble shooting methodology" contains suitable methods, which have been adapted for the application in such specific situations.

Objectives
The focus of this research work is to provide support for product developers in trouble shooting situations. These crises situations are characterised by a high pressure of time and a high pressure to succeed [6] and show a big difference in relation to former design aims [4].
Other definitions exist in the field of crises such as the term of “critical situations”, introduced by Badke-Schaub and Frankenberger [7]. According to their understanding critical situations can be found in a development process and represent important situations including positive as well as negative aspects. Those critical situations may be predictable and can have either positive or negative consequences on the result of a design task. In opposite, unpredictable crises situations in this paper always pass a negative impact on the design process. I.e., designers have to deal with upcoming trouble. For this kind of crisis situations a trouble shooting methodology will be provided in this paper.

Method
This trouble shooting methodology was developed and verified in cooperation with an automotive supplier. In order to see the technical problems from a different angle a sequential processing of analysis and synthesis was applied for this methodology [8]. At first, crises situations were analyzed. Several design engineers were interviewed to sum up the company’s crises situations and its specific conditions. In addition, trouble shooting cases, which had affected the company recently, were reviewed. In the following, a selection of methods, suitable for the specific crises process, was adapted to the company’s conditions. Finally, the trouble shooting methodology was successfully applied to a current crises situation.

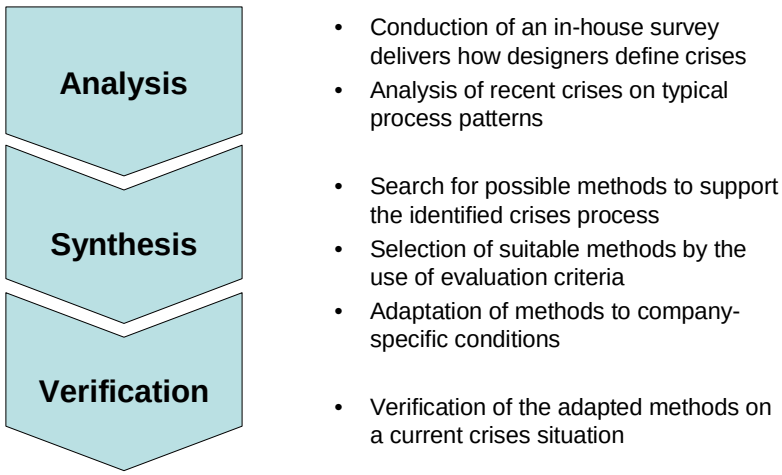

Figure 1. Development process of the trouble shooting methodology

During the phase of analysis employees were asked on characteristics of crisis situation, e.g. which had been the main problems in a trouble shooting situation. In addition, they were questioned about their experience with different product development methods. At the same time recent crisis were examined with the intention of identifying typical process patterns. All these different aspects represent the company’s specific conditions.

In the phase of synthesis the focus has been set on finding suitable methods for the identified crises process and on adapting the methods to the company’s particular conditions. Therefore typical design activities, found in the crises process, were determined in detail and connected

methods were derived. The definition of design activities is according to the design activities as stated by Ponn and Lindemann in the Munich Procedural Model [9].

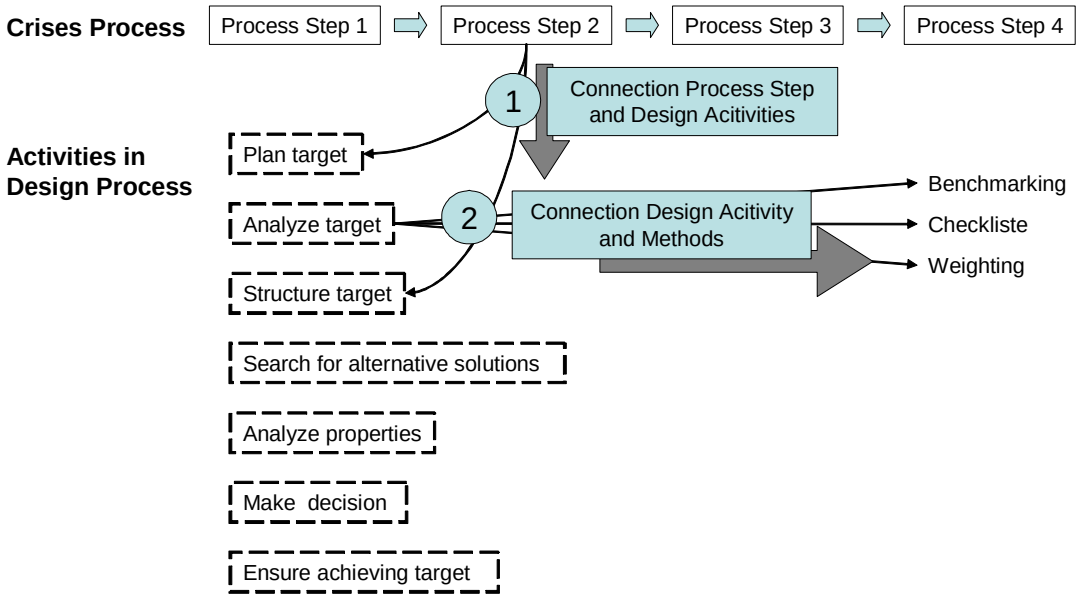

Figure 2. Search for possible methods

The selection of suitable methods was divided into two steps. At first, a qualitative preselection was carried out to establish methods, which are suitable for the general use in crises situations. In this preselection suitability in time-critical situations was applied as a situational criterion. Methods, which were unknown in the company according to the survey, were neglected in the final selection.

Secondly, the multitude of methods was limited further. As a preparation, preselected methods were numbered and put into relation with design process activities and different evaluation criteria. Design activities were described with the help of questions. Evaluation criteria took into consideration the specific application of methods in industries. Questions on design activities allow for mapping methods to different phases of the design process. When planning a target for example one will ask about the availability of problem-oriented information. With the help of available information and impact analysis the problem can be treated. Evaluation criteria are used to find methods with the most suitable properties. In case of a less complex problem to be treated during a trouble shooting situation, the use of plausibility analysis is advisable as long as the causality of the problem is clear. Further criteria focus on the suitability for informal or technical problems, the determination of constraints or dependencies, and the necessity of creativity or documentation.

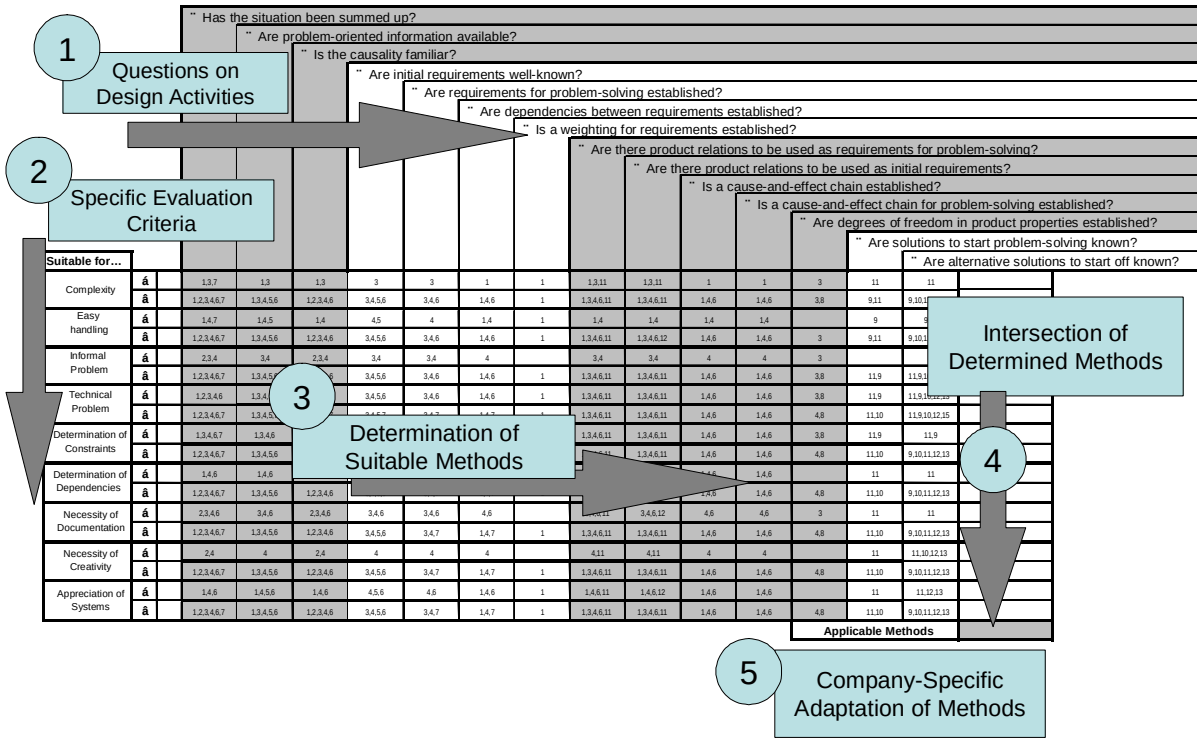

Figure 3. Selection of methods, suitable for crises situation (2nd step)

Bringing together preselected methods and recent crises a limited number of suitable methods was established. The remaining methods were adapted to the company's specific conditions.

Results

Due to secrecy agreements, a big part of the results is described at an abstract level, and detailed results are mentioned exemplarily only.

Results of Analysis

In order to get acquainted with the supplier company's specific conditions in crises situations an in-house survey with 20 engineers and the examination of four real trouble shooting cases were carried out.

As a result of the conducted interview, the following weak points appearing during crises situations were determined:

- Lack of knowledge: In a crises situation both supplier and clients get aware that know-how to manage the technical problem is missing.
- Difficulties in the execution of tests: Several characteristics can be found in the field of testing. Possibilities to provide evidence are missing, wrong measuring methods are applied, the commitment on parameter values to be tested is complicated, and the reproducibility of test often is not assured.
- Lack of resources
- Difficulties in coordinating teams
- Lack of systematic procedures
- Non-specific targets

These aspects represent the supplier specific conditions, which will be regarded further when choosing and adapting methods.

The analysis of four recent trouble shooting cases brought up a typical process pattern (Figure 4), which is similar to a normal product development process. In the regarded cases technical problems were often identified during a test run shortly before start of production. An analysis on components, processes, and testing condition was carried out with the intention of finding causes of the occurred problem. On the basis of educated guesses the solution search was started, defining actions to develop an immediate solution on one hand, and working on further analysis and various solutions in terms of finding a long-term solution. According to a sequential process the solution should be finish by verification via measurement. But iterations were occurring during the phase of solution searching and verification. This circumstance made the crisis solving process last even longer.

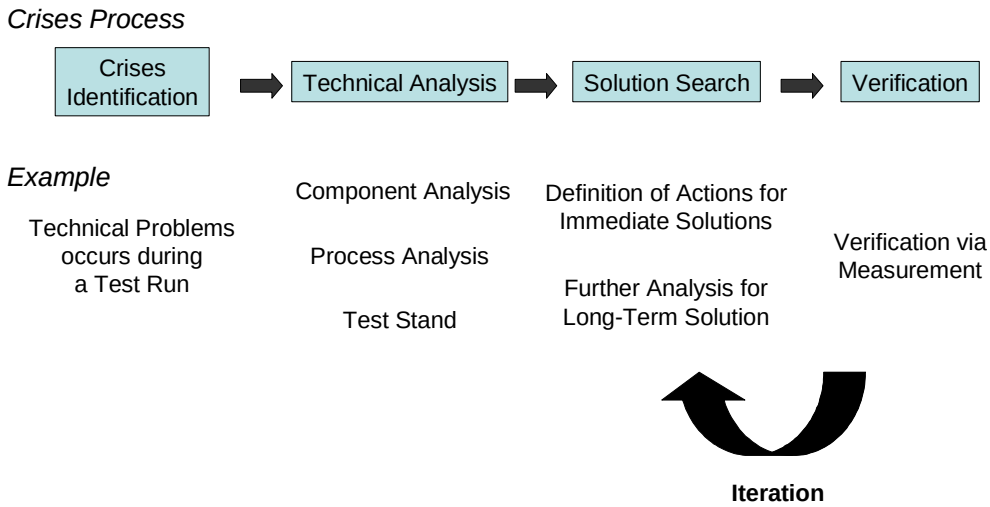

Figure 4. Pattern of analysed crises process

Due to the fact, that the search for solutions was less successful in the past, it became evident that the trouble shooting methodology should focus on analysing targets. I.e. examining and structuring of a problem have to be supported. As a consequence iterations can be limited, and thus, needs of time and resources will be reduced.

Results of Synthesis

A range of methods was regarded with the purpose of finding methods suitable for crises situations. Methods such as benchmarking or FMEA (failure mode and effects analysis) were excluded, because the application of these methods takes a lot of time. Other methods e.g. fault tree analysis or brainstorming were neglected due to the fact the company's employees were less familiar with these methods. According to their methodological experience the surveyed engineers preferred e.g. checklist-like methods.

As a result of the preselection the following possible methods were determined.

– Impact Analysis – Plausibility Analysis – Similarity Analysis – Cause-Effect Analysis – Reverse Engineering – Functional modelling – Black box	– Degree of Freedom Analysis – Design Catalogue – Variation – Structuring Scheme – Effect list – Principles

Against the background of recent crises cases the following suitable methods were identified as most suitable for the company's troubleshooting situations:

- Plausibility Analysis
- Similarity Analysis
- Cause-Effect Analysis

Impact analysis and functional modelling would have been suitable methods. But the case study showed that they could be used less frequently. So the methodology was established on the basis of the three methods listed above.

The trouble shooting methodology takes into consideration the crisis situation: Engineers face a problem and have to deal with time pressure and pressure to succeed. Besides they experience the company-specific conditions, especially the lack of systematic procedures, knowledge, and resources ought to be met. All these aspects were regarded while establishing this systematic procedure.

The methodology is preceded in two steps. At first, a plausibility analysis is carried out. It is possible the background of a problem is clarified at that point already. Next, either a similarity analysis or a cause-effect analysis is put into practice. Whereas the similarity analysis is of a more intuitive character and focuses on mechanical components and assemblies, the cause-effect analysis has a very systematic character and focuses on functions.

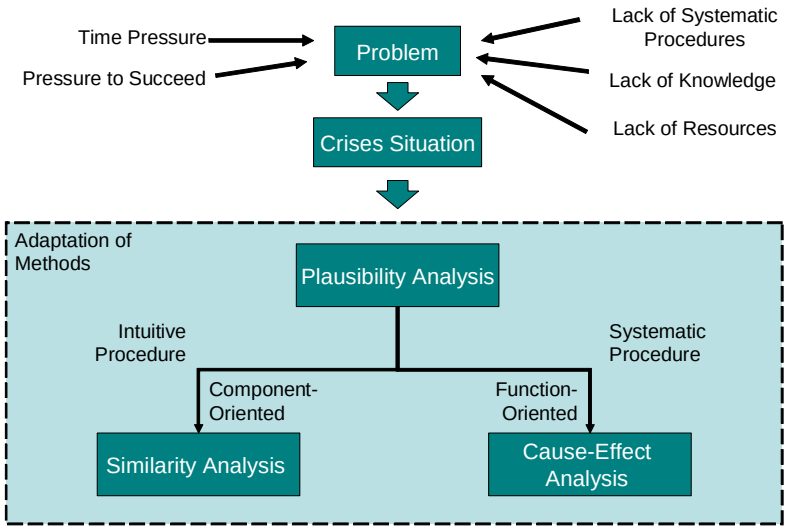

Figure 5. Established trouble shooting methodology

For every method checklist-like templates are provided in order to support systematic work. The plausibility analysis asks whether regulations were applied properly, and whether the achieved results are sensible. In addition, an analysis of possible failures is integrated to improve the understanding of all people involved in the trouble shooting case. The similarity analysis searches for failures that have occurred within similar components in other projects. In the cause-effect-analysis questions on special fields are brought up to check different possible cause-effect-chains. A big part of the used templates is filled with significant points elaborated with the help of the company's different divisions.

Verification

This approach was successfully verified in a current trouble shooting case. A completely designed component was tested negative. It became clear that the high durability of the component, known from the past, was not given any more. As the component possesses a characteristic function, plausibility analysis and cause-effect-analysis were applied. Thus, it could be investigated that a vibration produced by a neglected system component was the reason for the crisis-causing problem.

Discussion

In the established methodology the focus is placed on trouble shooting situations, and on the accomplishment of crises. There are many aspects of crises situations, which have been not been regarded further within this project, such as the avoidance or the identification of crises.
The main target of the presented trouble shooting methodology is to support the solution search, and therefore to analyse the technical background of a problem. For the avoidance of crises it would be necessary to establish main influencing factors as well as fix conditions, which have to be observed. This procedure is used in many risk management systems. Using this knowledge gained from observing influencing factors can lead to more stable processes. Less product and process failures would occur, which would lead to a reduction of crises situations.
The identification of crises was neglected also within this project, due to the focus on solution search. Company-specific criteria, which are applicable for identifying crises, might exist already. With the help of such identification criteria, crises could be discovered early and systematically. The earlier a crisis can be identified, the sooner the trouble shooting can start. Thus, a limitation of time, required to accomplish a crises, should be possible.

Conclusions and Outlook

On the basis of the results found in the analysis of crisis and methods a trouble shooting methodology to handle crisis was developed. The established methodology is based on three single methods and contains the use of several checklist-like templates in order to support systematic work during the crisis situation. The approach was successfully verified in a current trouble shooting case.

The introduced methods can be helpful to solve problems in a trouble shooting situation. It would be of further interest, to look at the results generated when using this methodology in the future. Maybe solutions produced during a crises situation are less innovative than other product development solutions.

Apart from the developed trouble shooting methodology with adapted methods, other approaches would have been possible for the accomplishment of crises. A lot of problems, which come to appearance in a crises situation, have their origin in determinations made in the early phase of product development. These determinations include information on

products and processes. It might be possible to find important connections between product information and process information, which can support the trouble shooting process.

Finally the exposure to crises is still a contemporary issue not in only in product development but in society and politics. Summit meetings discussing specific crises e.g. food scandals or natural disaster as a central theme take place frequently these days. Approaches in crises situations have to be regarded in detail and examined weather they are suitable aspects to be applied to product development.

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